

**Advancing the determinants of risky decision  
behaviour using conjoint and multi-level  
moderated mediation analysis**

Michael Karl Bailey

University College London (UCL)

Thesis submitted for the degree of

Doctor of Philosophy

December 2020

## Declaration

I, Michael Karl Bailey, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed: M. K. Bailey

---

Date: 11 December 2020

---

## Abstract

Investment decision-making is an everyday activity within society. When these decisions involve innovation and require a willingness to innovate, additional complexities arise concerning uncertainty and decision irreversibility. This thesis investigates to what extent predictions of investment decision-making behaviour may be made based upon how varying levels of uncertainty and irreversibility affect perceptions of risk, how this may affect decision behaviour and how the strength of this effect may vary depending upon decision-maker risk propensity. In doing so, this thesis addresses important gaps found to exist at an intersection of the theory of innovation diffusion, the basic theory of irreversible investment under uncertainty and prospect theory.

The research methodology employed for this purpose comprises full-profile conjoint value analysis and multi-level moderated mediation analysis. An online survey comprising ten conjoint tasks enables the conjoint analysis and provides the means to measure both perceptions of risk and risk propensity. The online survey itself relies upon an established case study titled 'Carter Racing'. The results of this research find that a comprehensive set of relationships exist among the variables in question, from which valid and useful predictions may be made.

Where a risk-averse relationship is shown to exist between decision-making behaviour and measures of uncertainty and irreversibility, it can also be shown that these relationships are exerted through and explained by perceptions of risk, with decision-maker risk propensity serving to influence the strength of the effects. In these cases, a significant positive correlation is observed between perceptions of risk and both uncertainty and irreversibility. A significant negative correlation is also observed between perceptions of risk and a willingness to innovate, this being the means through which innovativeness is measured. However, where a risk-seeking relationship is shown to exist, no significant correlations or effects are observed. These findings have important implications for theory and practice.

## Impact Statement

This thesis addresses important gaps found to exist at an intersection of the theory of innovation diffusion, the basic theory of irreversible investment under uncertainty and prospect theory. The key variables of the thesis are innovativeness, uncertainty, irreversibility, risk perception, risk propensity and option value.

This thesis makes an important contribution to knowledge across four fields. First, this thesis makes important contributions to the theory of innovation diffusion. It demonstrates that perceptions of risk serve to mediate relationships between innovativeness, which is measured in terms of a willingness to innovate, and measures of uncertainty and irreversibility in cases where risk-averse relationships are observed. This thesis also demonstrates how variation in decision-maker risk propensity moderates the strength of the relationship between perceptions of risk and innovativeness through an amplification and attenuation effect. Importantly, however, where a risk-seeking relationship is observed, no corresponding mediation or moderation effects are noted. These findings are significant because they provide a new set of important predictive and explanatory capabilities concerning innovativeness and the adoption and diffusion of innovation that have hitherto not been examined or modelled.

It is this delineation across the two observed domains of risk-averse and risk-seeking behaviour that identifies the second important contribution of this thesis. Specifically, where risk-averse relationships are observed, they can be explained by perceptions of risk and the risk propensity of the decision maker. However, this is not the case where risk-seeking behaviour is observed that is a consequence of a high probability of loss. This delineation between the two observed domains focuses attention upon an intersection between the theory of innovation diffusion and prospect theory. The findings enable the claim that within a decision-making domain framed by a high probability of loss, neither perceptions of risk nor risk propensity bear a significant relationship to decision-making behaviour. Where this is not the case, these two psychographic variables can be shown to act as behavioural determinants. The significance of this claim stems from its potential to extend the body of knowledge surrounding prospect theory and create linkages between prospect theory and the theory of innovation diffusion.

The third contribution to knowledge made by this thesis is through the novel combination of full-profile conjoint value analysis and multi-level moderated mediation analysis. The purpose of this is to determine respondent preferences relative to a subject of interest, calculate the associated utility values and then, through multi-level moderated mediation analysis, establish predictive capabilities. This thesis demonstrates the manner through which this may be achieved and makes suggestions for future research where this method may be applicable.

The final contribution to knowledge concerns the practical implications of the conclusions that may be drawn from this thesis. This study provides novel insights to the executive leadership of BHP, and to those interested in decision making more generally, from which valuable knowledge can be gained, leading to personal development and improved decision processes.

## Acknowledgements

The creation of a thesis such as this is by necessity an individual pursuit, and it is the result of a considerable period of effort, perseverance and endeavour. The writing of this thesis has had a profound influence upon me, and I am without doubt much the richer for the experience. It is vital to recognise that regardless of the individuality of the work, it nevertheless comes about through the collective effort and interest of many people, the majority of whom have no knowledge of each other. Hence, I believe it is important within this acknowledgements section to recognise those who have materially contributed to the production of this work and, in doing so, identify and give a sense of the diverse international team who have supported me in my goal.

It would be improper to not first mention my wife and family. Without the support, patience and sacrifice made by Maryanne, Tucker and Essington over a period of years, this thesis would not have been possible. It is my sincere hope that from the perseverance and effort I have demonstrated through its creation, both Tucker and Essington may find inspiration in their lives to pursue challenges that from the outset appear to be of the utmost difficulty. In parallel to the support of Maryanne, Tucker and Essington, I am extremely grateful for the superb guidance, support and insights provided to me by my academic supervisors Associate Professor Adrian James and Associate Professor Michael Emes. I have learnt much from you both, and because of this I owe each of you a debt of gratitude. I would also like to recognise Professor Tim Mazzarol and Professor Geoff Soutar, both of whom are from the University of Western Australia, for fostering the initial spark that subsequently led to the development of this thesis.

An important thank you is extended to BHP for permitting me to conduct my survey within the organisation and for giving me access to an ideal population from which to draw my sample. Without this, the execution of my methodology would have been far more challenging and time consuming. I would especially like to thank Laura Tyler and Maya Donevska for their valuable assistance with the coordination of the approvals process, Mike Henry for his endorsement and promotion of my online survey within the BHP organisation, and former Chief Executive Officer Sir Andrew Mackenzie for his interest in my thesis and his encouragement.

This acknowledgements section would be incomplete without mention of Professor Andrew Hayes of The Ohio State University and Dr Nicholas Rockwood formerly of The Ohio State University. My understanding of the methodology employed within this thesis for the analysis of mediation and moderated mediation effects was greatly enhanced by the willingness of Professor Hayes to help me learn the mechanisms of analysis and the freedom with which Dr Rockwood shared his knowledge of multi-level modelling based upon his own research. I would also like to thank Sawtooth Software Inc for granting me an academic software licence that enabled my methodology through the use of their full-profile conjoint value analysis software. My sincere thanks go to Professor Sim Sitkin of The Fuqua School of Business, Duke University, for providing me with a copy of the original 'Carter Racing' case study, which, in an adapted form, is the centrepiece of my methodology. Similarly, I would like to sincerely thank Professor Vithala Rao of Cornell University for his valuable advice concerning rating scales and sample size adequacy when using full-profile conjoint value analysis.

Lastly, I would very much like to recognise and thank the former staff of UCL Australia for the important contribution they have made to this endeavour.

## Table of Contents

Declaration.....	2
Abstract.....	3
Impact Statement .....	4
Acknowledgements.....	6
Table of Contents.....	8
List of Figures .....	13
List of Tables .....	15
Definitions.....	17
Abbreviations.....	21
1. INTRODUCTION.....	22
1.1 Introduction to the thesis .....	22
1.2 Purpose .....	23
1.3 Background to the research.....	27
1.3.1 Innovation.....	28
1.3.2 Uncertainty, irreversibility and investment decision making.....	29
1.4 Research problem and research questions .....	30
1.5 Justification for the research .....	35
1.6 Methodology.....	36
1.7 Outline of the thesis.....	37
1.8 Limitations of scope and key assumptions .....	39
1.9 Chapter summary .....	41
2. LITERATURE REVIEW: PARENT DISCIPLINE FIELD.....	42
2.1 Introduction .....	42
2.2 Aspects arising from the theory of economic development .....	42
2.2.1 Circular flow within an economic system in which change is absent.....	46
2.2.2 Innovation as the causative factor in change .....	48
2.2.3 The entrepreneur as the causative factor of change .....	56
2.3 Risky decision-making behaviour.....	59
2.4 Decision risk trade-offs .....	67
2.4.1 The basic theory of irreversible investment under uncertainty .....	67
2.4.2 Uncertainty .....	69
2.4.3 Irreversibility.....	72



2.5 Option value.....	75
2.6 Research gaps .....	78
2.7 Chapter summary .....	81
3. LITERATURE REVIEW: IMMEDIATE DISCIPLINE FIELD .....	83
3.1 Introduction .....	83
3.2 Setting the scene for the immediate discipline field .....	84
3.3 Risk and uncertainty juxtaposed.....	86
3.4 The integration of uncertainty within the definition of risk .....	89
3.5 Framing a contemporary definition of risk .....	90
3.6 Distinguishing between risk and risk perception.....	95
3.7 A definition of risk.....	98
3.7.1 The operationalisation of risk.....	100
3.7.2 Risk perception .....	102
3.7.3 Risk propensity.....	105
3.8 Conclusion.....	111
4. ANALYTIC MODEL DEVELOPMENT AND HYPOTHESES.....	113
4.1 Introduction .....	113
4.2 The analytic model.....	113
4.3 Contextualisation of uncertainty and irreversibility .....	121
4.4 Categorisation and development of the hypotheses .....	125
4.4.1 Preferences for conditions of uncertainty and irreversibility.....	126
4.4.2 Predictors of risk perception .....	131
4.4.3 Predictors of innovativeness .....	135
4.4.4 Mediation effects.....	137
4.4.5 Moderated mediation effects.....	140
4.4.6 Option value effects.....	141
4.5 Chapter summary .....	143
5. RESEARCH METHODOLOGY .....	144
5.1 Introduction .....	144
5.2 Research design overview .....	144
5.3 Research methodology employed .....	146
5.3.1 Carter Racing case study.....	147
5.3.2 Justification of the methodologies employed .....	149
5.3.3 Justification of the unit of analysis .....	151
5.4 Conjoint analysis .....	152
5.4.1 Selection of attributes and attribute levels.....	155

5.4.2 Choice of conjoint methodology .....	157
5.4.3 Selection of a preference model.....	159
5.4.4 Design of stimulus presentation .....	160
5.4.5 Selection of measurement scales .....	162
5.4.5.1 Measurement scale: innovativeness .....	163
5.4.5.2 Measurement scale: risk perception .....	164
5.4.5.3 Measurement scale: risk propensity .....	165
5.4.6 Estimation method and estimation of utility values .....	166
5.4.7 Goodness of fit evaluation.....	169
5.5 Survey execution.....	169
5.5.1 Pilot study pre-test .....	169
5.5.2 Pilot study execution .....	170
5.5.3 Sample size considerations for full-profile CVA.....	171
5.5.4 Main survey implementation .....	172
5.5.5 Consideration of non-response and common method biases .....	173
5.6 Multi-level modelling.....	175
5.6.1 Multi-level regression analysis .....	177
5.6.2 Multi-level moderated mediation analysis.....	180
5.6.2.1 Rebuttal of the causal steps approach of Baron and Kenny .....	180
5.6.2.2 Mediation analysis.....	183
5.6.2.3 Moderated mediation analysis.....	185
5.6.2.4 The multi-level mediation and moderated mediation methodologies .....	188
5.7 Ethical considerations.....	190
5.8 Conclusion.....	191
6. DATA ANALYSIS AND RESULTS .....	193
6.1 Introduction .....	193
6.2 Survey response analysis .....	193
6.2.1 Survey response rate .....	193
6.2.2 Survey respondent demographics .....	194
6.2.3 Non-response bias .....	197
6.3 Examination of the data.....	199
6.3.1 Common method bias .....	199
6.3.2 Correlation between the two dependent variable scales .....	201
6.3.3 Unidimensionality and internal consistency of the psychometric scales .....	202
6.3.3.1 Risk propensity: unidimensionality and internal consistency .....	202
6.3.3.2 Risk perception: unidimensionality and internal consistency .....	205

6.4 Testing of hypotheses .....	207
6.4.1 Analysis of preferences for conditions of uncertainty and irreversibility .....	208
6.4.2 Analysis of predictors of risk perception .....	213
6.4.2.1 Analysis of predictive capability: solution uncertainty.....	214
6.4.2.2 Analysis of predictive capability: problem uncertainty.....	214
6.4.2.3 Analysis of predictive capability: irreversible consequence failure .....	215
6.4.2.4 Analysis of predictive capability: irreversible consequence postponement ..	215
6.4.2.5 Analysis of predictive capability: risk propensity .....	216
6.4.3 Analysis of predictors of innovativeness .....	216
6.4.3.1 Analysis of predictive capability: risk perception .....	217
6.4.3.2 Analysis of predictive capability: risk propensity .....	217
6.4.4 Analysis of mediation effects.....	218
6.4.4.1 Analysis of mediation effect: solution uncertainty.....	219
6.4.4.2 Analysis of mediation effect: problem uncertainty.....	221
6.4.4.3 Analysis of mediation effect: irreversible consequence failure .....	223
6.4.4.4 Analysis of mediation effect: irreversible consequence postponement.....	225
6.4.5 Analysis of moderated mediation effects.....	226
6.4.5.1 Analysis of moderated mediation effect: solution uncertainty.....	228
6.4.5.2 Analysis of moderated mediation effect: problem uncertainty.....	230
6.4.5.3 Analysis of moderated mediation effect: irreversible consequence failure ..	233
6.4.6 Analysis of option value effects .....	235
6.4.6.1 Analysis of moderated mediation effect: solution uncertainty.....	236
6.4.6.2 Analysis of moderated mediation: problem uncertainty .....	238
6.4.6.3 Analysis of moderated mediation: irreversible consequence failure.....	241
6.5 Summary of hypothesis-testing outcomes .....	243
6.6 Conclusion.....	245
7. DISCUSSION OF RESULTS, CONCLUSIONS AND IMPLICATIONS .....	246
7.1 Introduction .....	246
7.2 Conclusions about research questions based upon hypothesis testing.....	247
7.2.1 Respondent preferences for conditions of uncertainty and irreversibility .....	248
7.2.1.1 Respondent preferences: solution uncertainty and problem uncertainty.....	248
7.2.1.2 Respondent preferences: irreversible consequence failure.....	250
7.2.1.3 Respondent preferences: irreversible consequence postponement .....	251
7.2.1.4 Conclusions about respondent preferences.....	253
7.2.2 Predictors of risk perception .....	253
7.2.2.1 Predictors of risk perception: solution and problem uncertainty .....	254

7.2.2.2 Predictors of risk perception: irreversible consequence failure .....	255
7.2.2.3 Predictors of risk perception: irreversible consequence postponement .....	256
7.2.2.4 Predictors of risk perception: risk propensity .....	257
7.2.3 Predictors of innovativeness .....	258
7.2.3.1 Predictors of innovativeness: risk perception .....	258
7.2.3.2 Predictors of innovativeness: risk propensity .....	259
7.2.4 Mediation effects of risk perception .....	259
7.2.4.1 Mediation: risk perception and irreversible consequence postponement....	260
7.2.4.2 Mediation: risk perception and other predictor variables .....	261
7.2.4.3 Conclusions: mediation effects of risk perception .....	262
7.2.5 Moderated mediation effects of risk propensity.....	262
7.2.5.1 The moderating effect of risk propensity .....	263
7.2.5.2 Conclusions: moderation by risk propensity .....	264
7.2.6 Moderated mediation effects of irreversible consequence postponement .....	264
7.2.6.1 The moderating effect of irreversible consequence postponement .....	265
7.2.6.2 Conclusions: moderation by irreversible consequence postponement.....	267
7.3 Conclusions about the main research problem.....	268
7.4 Implications for theory from conclusions about the main research problem.....	274
7.4.1 Mediation of risk-averse relationships by risk perception .....	278
7.4.2 Moderation of the mediation effect by risk propensity .....	279
7.4.3 Innovativeness and the domain of high-probability losses .....	280
7.5 Implications for practice from conclusions about the main research problem .....	281
7.6 Reflections and limitations arising from these reflections .....	284
7.7 Implications for further research.....	285
APPENDIX A - Literature review gap verification.....	288
APPENDIX B - Carter Racing case study .....	293
APPENDIX C - CVA survey questionnaire specification .....	298
APPENDIX D - Participant information sheet.....	308
REFERENCE LIST .....	312

## List of Figures

Figure 1.1: The basic analytical model examined by this thesis .....	25
Figure 1.2: Illustration of the relationships between the variables under examination .....	33
Figure 1.3: Chapter structure of this thesis excluding appendices.....	39
Figure 2.1: The structural model.....	44
Figure 2.2: Economic system in circular flow highlighted within the structural model .....	46
Figure 2.3: Innovation highlighted within the structural model.....	48
Figure 2.4: The entrepreneur highlighted within the structural model .....	57
Figure 2.5: Innovativeness highlighted within the structural model.....	60
Figure 2.6: Depiction of Rogers' innovation decision process.....	61
Figure 2.7: A representative diffusion curve showing relation to adopter categories.....	64
Figure 2.8: Adopter categories partitioned according to innovativeness .....	65
Figure 2.9: Depiction of the basic theory of irreversible investment under uncertainty .....	69
Figure 2.10: Uncertainty and irreversibility highlighted within the structural model.....	70
Figure 3.1: Risk perception and risk propensity highlighted within the structural model ..	102
Figure 3.2: The fourfold pattern of risk attitudes .....	110
Figure 4.1: Simple mediation model in conceptual form .....	114
Figure 4.2: Sitkin and Weingart's model of risky decision-making behaviour.....	115
Figure 4.3: Simple mediation model of study one from Sitkin and Weingart (1995).....	116
Figure 4.4: Simple mediation model of study two from Sitkin and Weingart (1995).....	118
Figure 4.5: The analytic model of this thesis .....	121
Figure 4.6: Hypothesised relationships—innovativeness, uncertainty and irreversibility ..	131
Figure 4.7: Hypothesised relationships—risk perception, uncertainty and irreversibility ..	133
Figure 4.8: Hypothesised relationship—risk propensity and risk perception .....	135
Figure 4.9: Hypothesised relationship—risk perception and innovativeness .....	136
Figure 4.10: Hypothesised relationship—risk propensity and innovativeness.....	137
Figure 4.11: Hypothesised mediation effects—risk perception and uncertainty.....	139
Figure 4.12: Hypothesised mediation effects—risk perception and irreversibility .....	140
Figure 4.13: The analytic model showing all hypotheses to be tested.....	143
Figure 5.1: Overview of the research design .....	145
Figure 5.2: Six stages of the conjoint analysis process .....	155

Figure 5.3: The nine-point scale used for the measurement of innovativeness .....	163
Figure 5.4: The dichotomous forced choice measurement scale of innovativeness.....	164
Figure 5.5: The risk perception measurement scale.....	165
Figure 5.6: The risk propensity measurement scale .....	166
Figure 5.7: The multi-level nesting structure of the design showing levels one and two ...	176
Figure 5.8: Relational structure of cases <i>i</i> and entities <i>j</i> .....	178
Figure 5.9: Path diagrams for the Baron and Kenny method .....	181
Figure 5.10: Conceptual diagram of a simple mediation model.....	183
Figure 5.11: Statistical diagram of a simple mediation model .....	185
Figure 5.12: Conceptual diagram depicting the moderation effect of W upon M to Y .....	186
Figure 5.13: Statistical diagram of a simple moderated mediation model .....	187
Figure 6.1: The demographic characteristics of the respondent group .....	196
Figure 6.2: Factor analysis scree plot output - risk propensity scale.....	203
Figure 6.3: Factor analysis scree plot output - risk perception scale.....	206
Figure 6.4: CVA coefficient of determination ( $R^2$ ) spread for all respondents .....	209
Figure 6.5: Results obtained from the testing of hypothesis <i>H4a</i> using random slopes .....	221
Figure 6.6: Results obtained from the testing of hypothesis <i>H4b</i> using random slopes .....	223
Figure 6.7: Results obtained from the testing of hypothesis <i>H4c</i> using random slopes .....	225
Figure 6.8: Depiction of the relationships relevant to Section 6.4.5 .....	228
Figure 6.9: Moderation effect of risk propensity upon <i>b</i> and <i>ab</i> for hypothesis <i>H5a</i> .....	230
Figure 6.10: Moderation effect of risk propensity upon <i>b</i> and <i>ab</i> for hypothesis <i>H5b</i> .....	232
Figure 6.11: Moderation effect of risk propensity upon <i>b</i> and <i>ab</i> for hypothesis <i>H5c</i> .....	235
Figure 6.12: Depiction of the relationships relevant to Section 6.4.6 .....	236
Figure 6.13: Moderation effect of PIC upon <i>b</i> and <i>ab</i> for hypothesis <i>H6a</i> .....	238
Figure 6.14: Moderation effect of PIC upon <i>b</i> and <i>ab</i> for hypothesis <i>H6b</i> .....	240
Figure 6.15: Moderation effect of PIC upon <i>b</i> and <i>ab</i> for hypothesis <i>H6c</i> .....	243
Figure 7.1: Conclusions drawn in response to the main research problem .....	272
Figure 7.2: The structural model repeated from Figure 2.1 .....	276
Figure 7.3: The results from this thesis integrated with the structural model.....	278

## List of Tables

Table 1.1: Uncertainty and irreversibility attribute and level descriptions .....	32
Table 2.1: Contemporary examples of the means through which innovation is defined .....	55
Table 4.1: The attributes and levels for uncertainty and irreversibility .....	124
Table 5.1: Demonstration of conceptual interdependence of attributes .....	156
Table 5.2: Attribute and attribute levels employed within this thesis .....	157
Table 6.1: Respondent demographics by category in total and percentage terms.....	195
Table 6.2: Descriptive statistics for non-response bias .....	197
Table 6.3: Descriptive statistics for non-response bias partitioned by group .....	197
Table 6.4: Normality test results—race probability, risk propensity and risk perception...	198
Table 6.5: Output of Mann–Whitney test for non-response bias .....	198
Table 6.6: Results from Harman’s single-factor test.....	201
Table 6.7: KMO test results and Bartlett’s Test of Sphericity - risk propensity scale .....	203
Table 6.8: Results of factor loading - risk propensity scale.....	203
Table 6.9: Risk Propensity scale item identifier .....	204
Table 6.10: Risk propensity corrected item correlation and Cronbach’s alpha if deleted ..	204
Table 6.11: Risk propensity scale inter-item correlation matrix.....	205
Table 6.12: KMO test results and Bartlett’s Test of Sphericity - risk perception scale.....	205
Table 6.13: Results of factor loadings - risk perception scale.....	206
Table 6.14: Risk perception scale item identifier.....	207
Table 6.15: Risk perception corrected item correlation and Cronbach’s alpha if deleted ..	207
Table 6.16: Risk perception scale inter-item correlation matrix .....	207
Table 6.17: CVA coefficient of determination ( $R^2$ ) outcomes for all respondents .....	209
Table 6.18: CVA results showing the average raw utilities for each attribute level .....	210
Table 6.19: Most and least preferred levels for each attribute.....	211
Table 6.20: Attribute and attribute levels employed within this thesis .....	212
Table 6.21: Summary of mediation analysis outcomes for hypothesis <i>H4a</i> .....	220
Table 6.22: Summary of mediation analysis outcomes for hypothesis <i>H4b</i> .....	222
Table 6.23: Summary of mediation analysis outcomes for hypothesis <i>H4c</i> .....	224
Table 6.24: Summary of mediation analysis outcomes for hypothesis <i>H4d</i> .....	226
Table 6.25: <i>H5a</i> within-respondent estimates for the risk propensity score range .....	229

Table 6.26: <i>H5b</i> within-respondent estimates for the risk propensity score range .....	232
Table 6.27: <i>H5c</i> within-respondent estimates for the risk propensity score range .....	234
Table 6.28: <i>H6a</i> within respondent estimates for the PIC score range .....	237
Table 6.29: <i>H6b</i> within-respondent estimates for the PIC score range.....	240
Table 6.30: <i>H6c</i> within-respondent estimates for the PIC score range .....	242
Table 6.31: Results from hypothesis testing contained in Chapter 6 .....	244



## Definitions

Below are the operational definitions for the key terms employed within this thesis, arranged in alphabetical order.

**Additive Model** is a conjoint model composition method whereby the total utility value for a conjoint scenario or stimulus is calculated as the sum of the part-worth estimates for the attribute levels that define it (Hair et al., 2006, Orme, 2014).

**Antecedent variable** is any variable that precedes and mathematically contributes to the magnitude of a consequent variable within a statistical diagram (Hayes, 2018).

**Attribute** describes a characteristic of interest that is represented by at least two mutually exclusive levels and is manipulated to evaluate respondent preferences (Hair et al., 2006, Orme, 2014).

**Balance (design)** is a desirable property of conjoint design whereby each level within an attribute appears an equal number of times across the conjoint tasks (Hair et al., 2006).

**Conceptual diagram** is a graphical depiction of the relationships inferred to exist within a mediation or moderated mediation model to convey ideas about the relationships between the variables within the model, whether causal or otherwise (Hayes, 2018).

**Conjoint task** denotes a scenario presented to conjoint survey respondents that depicts a unique combination of levels associated with the attributes of interest. In response, an evaluation is sought from respondents concerning the desirability of the combination of levels shown (Hair et al., 2006, Orme, 2014).

**Consequent variable** describes a dependent variable within a statistical diagram, the magnitude of which is determined by the antecedent variables that share a mathematical relationship with it. A consequent variable may also act as an antecedent variable depending upon the mathematical relationships it forms with other variables within a statistical model (Hayes, 2018).

**Design efficiency** is a measure of how well a set of conjoint questions estimates the parameters of interest being measured. It is typically assessed using a percentage scale

ranging from zero to one hundred, with one hundred representing an optimal design (Hair et al., 2006, Orme, 2014).

**Innovation** is operationally defined as ‘an idea, practice or object that is perceived as new by an individual or other unit of adoption’ (Rogers, 2003, p. 12).

**Innovativeness** is operationally defined as the degree to which a decision maker is more or less willing to adopt, use and rely upon an innovation, at a given point in time and within a specific context, relative to other members of a social system (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962).

**Investment** is operationally defined as the act of incurring an expense or liability in the present with the expectation that future rewards will be forthcoming as a consequence of that decision (Dixit and Pindyck, 1994).

**Irreversibility** is operationally defined as the degree to which the consequences of an investment decision can be reversed or substantially reversed after an investment decision is made (see Baldwin and Meyer, 1979, Bernanke, 1983, Bronfenbrenner, 1945, Dixit and Pindyck, 1994, Hanemann, 1989, Henry, 1974a, Marschak, 1949, Pindyck, 1991).

**Irreversible consequence failure** is a dichotomous attribute of irreversibility, the specification of which is contained in Table 1.1.

**Irreversible consequence postponement** is a dichotomous attribute of irreversibility, the specification of which is contained in Table 1.1.

**Level** is a description or value that defines an attribute (Hair et al., 2006, Orme, 2014).

**Main effect** refers to the estimation of the part-worth estimates associated with one attribute independent of any possible interaction effects from other attributes (Hair et al., 2006, Orme, 2014).

**Mediation** is an indirect effect said to occur if the influence or effect of one variable upon another variable is transmitted indirectly via a third intervening variable (Hayes, 2018).

**Moderated mediation** is a combination of the processes of mediation and moderation whereby the strength or sign of a mediation effect is itself a function of a moderating variable (Hayes, 2018).

**Moderation** occurs when the strength or sign of association between two variables varies depending upon a third variable (Hayes, 2018).

**Option value** refers to the worth of that which is made possible by postponing an irreversible or semi-irreversible investment decision until a later date to preserve alternatives, maintain flexibility and derive benefits from the flow of new information. This has the effect of reducing the level of uncertainty surrounding an investment decision (Arrow and Fisher, 1974, Dixit and Pindyck, 1995, Hanemann, 1989, Henry, 1974a).

**Orthogonality** refers to the extent to which the effect of change in the level of one attribute can be measured independent of the effect of change in the level of another (Hair et al., 2006).

**Outcome variables** describe dependent variables and are denoted within a conceptual diagram as variables that are said to be affected by another. Outcome variables from one relationship within a conceptual model may also serve as predictor variables for other relationships within the same model (Hayes, 2018).

**Part-worth estimates** are numerical values calculated through conjoint modelling that represent the desirability of discrete attribute levels determined from choices made by survey respondents (Hair et al., 2006, Orme, 2014).

**Predictor variables** are denoted within a conceptual diagram as variables that are said to have an effect upon another (Hayes, 2018).

**Problem uncertainty** is a dichotomous attribute of uncertainty, the specification of which is contained in Table 1.1.

**Prohibited pair** is a specified pair of levels from two separate attributes that are prohibited by design from being presented at the same time within a single conjoint task (Hair et al., 2006, Orme, 2014).

**Rational** describes behaviour that coheres with an individual's personal standards or belief systems, and from which a sense of comfort and stability is created, despite what analysis or the opinion of others may say concerning the behaviour (Gilboa, 2010).

**Risk** refers to the combination of uncertainty about future outcomes concerning events or possible future states of the world, uncertainty surrounding the consequences arising from those uncertain outcomes, and the severity of those consequences, in regard to something that is of human value or of value to humanity (Aven and Renn, 2009).

**Risk perception** is an individual's intuitive evaluation of the risk associated with a circumstance based upon predefined parameters and measurement scales (Aven, 2010b, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995, Slovic, 1992).

**Risk propensity** is an attitudinal measure of the current tendency of an individual to take or avoid risks within a predefined domain (Hatfield and Fernandes, 2009, Hurt et al., 1977, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995).

**Risky decision-making behaviour** refers to the act of choosing a course of action when there is perceived uncertainty about possible future outcomes, and the potential consequences of possible future outcomes are considered material relative to that which is of human value (Aven and Renn, 2009, Sitkin and Pablo, 1992, Trimpop, 1994).

**Solution uncertainty** is a dichotomous attribute of uncertainty, the specification of which is contained in Table 1.1.

**Statistical diagram** is a graphical representation of the set of equations that correspond with an associated conceptual diagram. It depicts how the relationships within it would be mathematically estimated (Hayes, 2018).

**Uncertainty** is operationally defined within this thesis as the degree of confidence that can be assigned to estimates of values or criteria subject to evaluation, assessment or measurement (Duncan, 1972, Thompson, 2011).

**Utility** represents the desirability of an overall concept or alternative that is equal to the sum of its part-worth estimates (Hair et al., 2006, Orme, 2014).

## Abbreviations

CVA	conjoint value analysis
LL	lower level of confidence interval
MCLL	Monte Carlo lower limit
MCUL	Monte Carlo upper limit
MLmed	multi-level moderated mediation macro for SPSS
UL	upper level of confidence interval

# 1. INTRODUCTION

## 1.1 Introduction to the thesis

The subjects of investments, investment decision making and innovation arise commonly in the language of private and business conversations. But how are investment decisions that involve innovation of some form—and that present varying levels of both uncertainty and an inability to reverse once made—decided upon by decision makers who possess varying levels of risk perception and risk propensity? How does the interplay between these characteristics play out and lead to a decision to either advance an innovation-related investment decision or defer the option until a later date? This thesis seeks to better understand the perspectives that surround this phenomenon.

Throughout my two-decade-long career as a business leader within the mining and resources sector, I have developed a particularly strong interest in the causes and manner in which investment decisions are made. This is especially so for those decisions that are not suited to resolution through the application of neo-classical economic analysis. The class of investment decisions for which no clear decision-making pathway exists is of particular interest because the decision problems are often ambiguous in nature, their causes are unclear, and essential pieces of information required to solve them are often contradictory or unavailable. Personal experience suggests that each person brings to decisions of this class their own unique perspective on the matters under consideration. From this, they develop, form and hold beliefs regarding the correct course of action in the face of such uncertainties. This thesis is motivated by the desire to better understand decision-making processes and how they may lead to decision outcomes, combined with a deep interest in how the effects of decision outcome irreversibility may influence decision making within uncertain contexts.

My interest in the subject of decision irreversibility originates from exposure to questions concerning the merits of destroying ancient forests and irreplaceable landscapes to enable industrial development to satisfy society's demands for energy generation at the expense of environmental conservation. As a child born in Tasmania towards the end of a multiple decade-long period of large-scale hydro-electric development and industrialisation, I witnessed the apex of a series of battles between government, industry and the developing conservation movement. This exposure materially influenced my interest in how irreversible decision outcomes may affect decision-making behaviour.

## **1.2 Purpose**

The purpose of this thesis is to examine to what extent predictions of investment decision-making behaviour may be made based upon how varying levels of uncertainty and irreversibility affect a decision-maker's risk perception, how this in turn may affect actual decision behaviour and how the strength of this effect may vary depending upon the decision-maker's risk propensity. From an analytical perspective, the purpose of this thesis is to examine to what extent predictions of investment decision-making behaviour may be made based upon indirect effect relationships between actual risky decision-making behaviour and variables concerning decision uncertainty and decision outcome irreversibility. This is done using decision-maker risk perception and risk propensity as a psychographic mediator and moderator respectively. The research methodology employed for this purpose is a combination of full-profile conjoint value analysis (CVA) and multi-level moderated mediation analysis. The unit of analysis for this thesis is a population of 400 executive leaders employed by the global resources company BHP during the period October to December 2018.

Mediation occurs if the indirect effect of one variable upon another is transmitted via a third, whereas moderation occurs if the strength or sign of association between two variables is dependent upon another (Hayes, 2018). For example, in terms of mediation, Pollack et al. (2012) showed that entrepreneurs who experienced greater levels of depression from stress caused by an economic downturn were more likely to express an intention to withdraw from entrepreneurial activity. That is, the effect of the economic downturn upon the strength of their intention occurred via the level of depression experienced through a mediation effect (Pollack et al., 2012). An example of moderation is income inequality between sexes for identical work performed on account of gender. In this case, gender is the moderating variable (see Easton, 2015, Ferrant and Thim, 2019).

In regard to an investment decision opportunity, the characteristics of interest are the level of uncertainty surrounding the investment opportunity and the degree to which the decision can be reversed once made. The degree of confidence that can be assigned to estimates of values or criteria subject to evaluation, assessment or measurement is representative of uncertainty (Duncan, 1972, Thompson, 2011). Uncertainty therefore concerns the level of doubt generated by incomplete knowledge. Contemporary examples of uncertainty are the long-term health effects of the COVID-19 (SARS-CoV-2) virus, the duration of over which economic activity will be suppressed because of the pandemic, and the geopolitical

ramifications that will flow from it. The effect of uncertainties such as these upon investment decision making stimulated one of the two primary motivations for this thesis, as mentioned in Section 1.1. The other motivation is the effect of decision irreversibility.

The degree to which the consequences of an investment decision can be reversed or substantially reversed after the decision is made describes the extent to which it is irreversible (Dixit and Pindyck, 1994). An example of an irreversible decision is one that results in the destruction of an ancient rainforest for the purpose of woodchip production to manufacture paper. Another example is the decision to undertake blasting within a mining lease area that results in the destruction of ancient rock shelters used by the indigenous landowners' ancestors. These decisions are irreversible because it is not possible to reverse their consequences. Conversely, a decision to preserve an area considered to have possible cultural or environment significance until uncertainties surrounding it are resolved is reversible because no options for the future are extinguished as a result. These types of issues, and how they influence investment decision-making behaviour, are important considerations that have motivated the development of this thesis.

The decision-maker's perception of the risk associated with the investment decision opportunity and their own risk propensity represent the characteristics of interest. Whereas risk propensity may be considered a measure of the decision-maker's tendency to take or avoid risks, risk perception refers to their evaluation of risk concerning a specific instance or circumstance based upon a relevant means of assessment (Sitkin and Weingart, 1995). Both are attitudinal-based psychographic measures that concern risk through the effect of uncertainty upon possible future outcomes, the potential consequences of possible future outcomes and the severity of those potential consequences (Aven and Renn, 2009). Both risk perception and risk propensity have been shown to be determinants of decision-making behaviour (Garvey, 2010, Hatfield and Fernandes, 2009, Sitkin and Weingart, 1995). Accordingly, both bear a strong relationship to the motivations that have led to this thesis.

When contextualised in terms of innovation-related investment decisions, decision-making behaviour can be considered in regard to the level of innovativeness demonstrated through it (Rogers, 2003, Yu and Tao, 2009). Innovativeness is the dependent variable of this thesis. It refers to the degree to which a decision maker is more or less willing to adopt, use and rely upon an innovation, at a given point in time and within a specific context, relative to other members of a social system (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962). Innovativeness is therefore a measure of a



decision-maker's appetite to engage with and embrace innovation relative to others who comprise a defined group of interest (Sundbo, 1998). For this thesis, innovation is defined as 'an idea, practice or object that is perceived as new by an individual or other unit of adoption' (Rogers, 2003, p. 12). A distribution of innovation adopter category exists that enables the categorisation of innovativeness. It is bounded by very early adopters at one end of the range and those who may be described as 'adoption laggards' at the other (Rogers, 2003).

On a global scale, the rate of electric vehicle uptake within countries may be used as a macro-level example to illustrate innovativeness. Differing levels of demand growth for electric vehicles, differing levels of enablement by governments and differing rates in the diffusion of the necessary recharging infrastructure between countries demonstrate a range of appetites for electric vehicles. For example, Norway, where the penetration of electric vehicles represents almost 60% of new vehicles sold in 2019, may be thought of as having a higher level of innovativeness than Australia, where the proportion of electric vehicles sold was negligible for the same period (see BITRE, 2019). In this macro-level example, the innovation is the electric vehicle, and the relevant social system, which is essential to the definition of innovativeness employed in this thesis, is the country's population.

Figure 1.1 outlines the basic analytical model for the variables and relationships that are mentioned within this section and examined by this thesis. Justification for examining the relationships between these variables is provided in Section 1.5. The analytic model shown in Figure 1.1 is justified in Section 4.2.

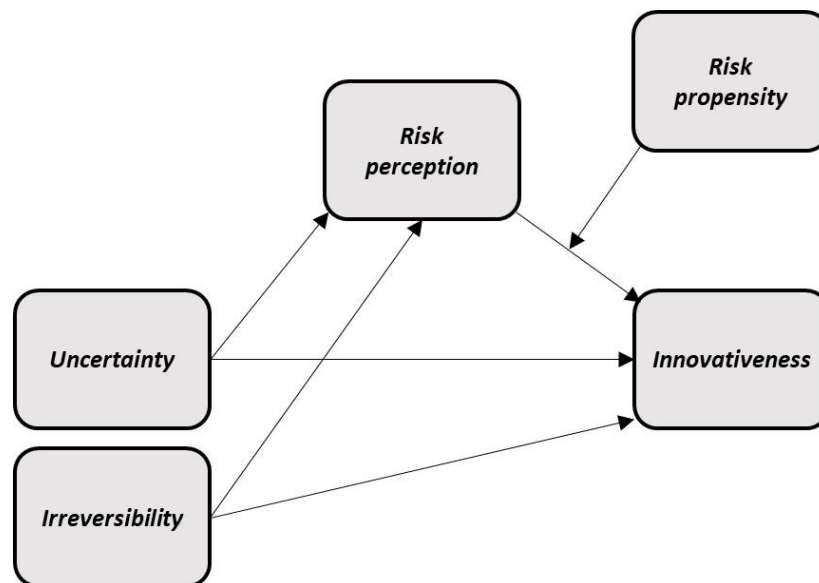


Figure 1.1: The basic analytical model examined by this thesis

It is important to mention that while the subject of innovation is of interest at both the personal and professional levels, its inclusion within this thesis is not for the purpose of examining innovation in and of itself. Rather, the inclusion of innovation enables the variables of interest to be brought to life through a case study that has, at its heart, an innovation upon which a business-critical investment decision relies and through which the testing of risky decision-making behaviour is enabled. The case study titled 'Carter Racing' is contained in Appendix B.

The 'Carter Racing' case study is centred upon a critical time-bound investment decision for the owner of a professional racing car business. The decision may lead to either the creation of a serious threat to the ongoing viability of the business or to the realisation of a major commercial breakthrough for the racing team depending upon its performance in the next race. A number of uncertainties surround this critical decision, including the level to which a new innovative engine gasket sealing arrangement has prevented engine failure in recent races. These uncertainties, combined with a range of possible responses from essential sponsors if engine failure should occur, determine the degree to which the consequences of the investment decision are irreversible. While a set of engine performance results are provided within the case study content across a range of ambient temperatures, this information is largely inconclusive. The original 'Carter Racing' case study was written based upon the facts and circumstances surrounding the Challenger Space Shuttle disaster that occurred on 28 January 1986 (McDonald and Hansen, 2009).

The relationships under examination within this thesis have their genesis in the work of:

- Bernanke (1983), Dixit and Pindyck (1994) and Marschak (1949) in regard to risk-based investment decision making under conditions of uncertainty and irreversibility
- Hurt, Joseph and Cook (1977), Midgley (1978), Rogers (2003) and Tarde (1903) regarding innovativeness and the timing of innovation-related adoption decisions.

The psychographic determinants of risky decision-making behaviour, as well as the measurement scales for these determinants, originate from Brittain and Sitkin (1990), Sitkin and Pablo (1992) and Sitkin and Weingart (1995), as does much of the case study content upon which the research methodology relies. Attention will now turn to the research background.

### **1.3 Background to the research**

Central to the field of economics, and particularly the field of economic development, are the elements of investment, the act of investment decision making, and the application and effect of innovation (see Damanpour and Wischnevsky, 2006, Diamond Jr., 2003, Godin, 2008a, Mansfield, 1961, Samuelson, 1948, Schumpeter, 1951, Sweezy, 1943). The expansion of the production possibility frontier is fundamental to the growth and development of economies (Williams and Lawrey, 2000). Central to that growth and development is the emergence of relevant technological advancement stemming from investment in innovation, which enables outcomes to be achieved that were previously not attainable (Diamond Jr., 2003, Dosi, 1982, Samuelson, 1948, Williams and Lawrey, 2000). This thesis concerns:

1. decision uncertainty surrounding the nature and causes of problems described within the 'Carter Racing' case study
2. decision outcome irreversibility and the application of an innovation for the purpose of advancement beyond what has previously been possible
3. the actual investment decision-making behaviour of survey respondents.

This thesis is therefore grounded within the literature of economics and economic development. For the purposes of this thesis, investment is defined as the act of incurring an expense or liability in the present with the expectation that future rewards will be forthcoming as a consequence of that decision (Dixit and Pindyck, 1994).

Within the field of economics, Joseph Schumpeter is widely considered a seminal and pioneering figure (Becker et al., 2012, Croitoru, 2013, Gordon, 1952, Hansen, 1938, Sundbo, 1998, Sweezy, 1943). While Schumpeter was primarily recognised as a business cycle theorist (Sweezy, 1943), it was his work concerning the theory of economic development that is considered one of his most influential achievements (Sundbo, 1998). At the heart of Schumpeter's theory of economic development (Schumpeter, 1951) are three fundamental concepts that are vital to both that theory and to the parent discipline fields that provide the background to this thesis.

The first concept is the abstract notion of an economic system within which change, but not growth, is absent, insofar as the economy continues to run year after year, with little difference between years because the causes of change have been removed (Kuznets, 1940,

Schumpeter, 1951, Sweezy, 1943). This system is described as one of circular flow (Schumpeter, 1951, Sweezy, 1943). The second concept is what has been referred to as the causative factor in change by Sweezy (1943), which, when introduced to the abstract system of circular flow, causes sufficient disruption to bring about lasting change. Sweezy (1943) described innovation as the causative factor in change, as it is an injection of innovation into an economic system, functioning in circular flow, which may cause it to be permanently disrupted (Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943). The third concept is that of the entrepreneur, who represents those accountable for bringing innovation to bear upon the economic system in circular flow. In doing so, they bring forth materially impactful change for reasons such as commercial speculative benefit or for simple economic survival within a capitalist economy (Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943). It is for this reason that Sweezy (1943) describes the entrepreneur within Schumpeter's theory of economic development (Schumpeter, 1951) as the causative factor of change.

### **1.3.1 Innovation**

Over the passage of time there has been considerable variation in both the manner in which innovation is defined and the limitations within which the phenomenon is said to occur (Sundbo, 1998). There is neither a simple unidimensional definition applicable to the notion of innovation, nor a definition that describes it in a neat homogenous and orderly form (Goldsmith and Foxall, 2003, Kline and Rosenberg, 1986). The existence of a range of contemporary definitions serves to illustrate this point (see Taylor, 2017). Nonetheless, what is generally agreed upon within the literature is that to be categorised as an innovation, it is not critical whether the good, service or process is new in terms of its creation or discovery. Rather, it is dependent upon whether the good, service or process is new to the individual or unit of adoption within a given context (Rogers, 2003, Sundbo, 1998). Notwithstanding that the genesis of all innovations can be traced to an invention of some form (Kinnunen, 1996, Rogers, 2003, Tarde, 1903), in the majority of cases an innovation is not also an invention (Kinnunen, 1996, Sundbo, 1998). The process by which an innovation is communicated among and spread through a given social system via channels relevant to that social system is defined as the process of diffusion (Goldsmith and Foxall, 2003, Kinnunen, 1996, Rogers, 2003, Ryan and Gross, 1943, Sundbo, 1998). The diffusion of an innovation comes about as a consequence of a series of adoption decisions, with the rate of diffusion dependent upon and proportional to the rate at which adoption decisions are made by those

who represent the population of the relevant social system (Griliches, 1957, Rogers, 2003, Ryan and Gross, 1943, Sundbo, 1998, Tarde, 1903).

The point at which a decision is made to adopt an innovation by an individual member of a social system, relative to other members within that social system, was conceived as the measure that describes the degree of innovativeness for the unit of adoption (Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers, 2003). However, within the literature it is argued that this definition does not provide a predictive capability. Other definitions have been put forward that emphasise the notion of a willingness to adopt change or advance a decision for change in the face of uncertainty or in the absence of the communicated experience of others (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978). For this thesis, innovativeness is operationally defined as the degree to which a decision maker is more or less willing to adopt, use and rely upon an innovation, at a given point in time and within a specific context, relative to other members of a social system (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962).

### **1.3.2 Uncertainty, irreversibility and investment decision making**

Uncertainty associated with innovation-related investment decisions may arise from a range of sources (Rogers, 2003). The magnitude of uncertainty and patterns of change in that magnitude over the passage of time, including expectations of the rate of new information flow relevant to the investment, is important to the decision-making context because of its association with perceptions of risk (Aven and Renn, 2009, Bernanke, 1983, Dixit and Pindyck, 1994, Rosa, 1998, Solberg and Njå, 2012). As discussed by Baldwin and Meyer (1979), Bernanke (1983), Dixit and Pindyck (1994) and Marschak (1949), the irreversibility of an investment is a measure of illiquidity. It is operationally defined as the degree to which the consequences of an investment decision can be reversed or substantially reversed after an investment decision is made (see Baldwin and Meyer, 1979, Bernanke, 1983, Bronfenbrenner, 1945, Dixit and Pindyck, 1994, Hanemann, 1989, Henry, 1974a, Marschak, 1949, Pindyck, 1991). The interaction of the constructs irreversibility and uncertainty, when combined within an intertemporal framework that explicitly recognises changes to the apparent risk profile of a potential investment over the passage of time, is described by the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994).

According to this theory, investments display three important characteristics to varying degrees: a level of irreversibility, should this be required; a level of uncertainty regarding and surrounding them; and the ability to vary the time at which a decision to invest is made (Dixit and Pindyck, 1995). The interaction of these three characteristics largely governs the optimal time at which an investment decision should be made based upon the objectives and characteristics of the decision maker and the trade-off between potential returns from an early commitment against the value of new information gained from waiting (Bernanke, 1983, Dixit and Pindyck, 1994, Hanemann, 1989). Investment uncertainty and irreversibility, combined with the risk perception and risk propensity of the decision maker, represent key attributes of this thesis. As such, each plays a central role within the main research problem that this thesis sets out to address. The main research problem is described within the following section.

#### **1.4 Research problem and research questions**

As stated in Section 1.2, the purpose of this thesis is to examine to what extent predictions of investment decision-making behaviour may be made based upon indirect effect relationships between actual risky decision-making behaviour and variables concerning decision uncertainty and decision outcome irreversibility. This is done using decision-maker risk perception and risk propensity as psychographic mediator and moderator respectively. Accordingly, based upon this purpose and the unit of analysis, the main research problem addressed by this thesis is as follows.

*To what extent may predictions of innovativeness be made determined from relationships between actual risky decision-making behaviour and measures of decision uncertainty and irreversibility, using risk perception and risk propensity as psychographic mediator and moderator respectively, based upon data generated from a full profile conjoint analysis survey and drawn from a population of 400 executives employed by the global resources company BHP?*

This thesis has two primary aims. The first consists of using full-profile CVA to create an online survey and, consequently, determine respondent preferences and calculate utility values that measure innovativeness based upon conjoint tasks that describe differing combinations of uncertainty and irreversibility. A further objective of the first aim is to gather responses through the online survey to measure both risk perception and risk propensity, which will be used as inputs to address the second aim. The second aim of this thesis is to examine relationships between innovativeness, the measures of uncertainty and irreversibility, and risk perception and risk propensity using appropriate multi-level regression methods to establish to what extent predictions of innovativeness may be made based upon these variables.

The variable uncertainty is operationalised within this thesis as both 'solution uncertainty' and 'problem uncertainty'. Similarly, the variable irreversibility is operationalised as both 'irreversible consequence failure' and 'irreversible consequence of postponement'. Solution uncertainty and problem uncertainty refer to aspects of uncertainty within the 'Carter Racing' case study contained in Appendix B. Solution uncertainty refers to the level of doubt over the efficacy of the innovative engine gasket arrangement being used based upon the number of times it has been successfully relied upon since its introduction. Similarly, problem uncertainty refers to the 'Carter Racing' case study, but in terms of the degree to which ambient temperature is related to past engine failure cases. Irreversible consequence failure and irreversible consequence postponement also refer to the 'Carter Racing' case. Irreversible consequence failure concerns the degree to which future sponsor funding outcomes may be withdrawn if the outcome of a decision to race in the Ponoco event results in engine failure. Irreversible consequence postponement is also a measure of sponsor funding, but instead refers to sponsorship outcomes if the decision is not to race in the Ponoco event. Table 1.1 describes the attributes and levels of uncertainty and irreversibility as applicable to this thesis. It is important to note that the value of the initial investment—namely the \$32,500 Ponoco race entry fee—does not vary.

Returning to the two aims of this thesis mentioned above, the main research problem will be answered using an online full-profile CVA survey involving ten conjoint tasks. This survey will gather the necessary data from members of the population to enable the calculation of part-worth estimates and utility values for each conjoint task. Justification for the choice of ten conjoint tasks is provided in Section 5.4.4.

	<b>Uncertainty</b>		<b>Irreversibility</b>	
<b>Attribute of uncertainty or irreversibility</b>	Solution uncertainty	Problem uncertainty	Irreversible consequence failure	Irreversible consequence postponement
<b>Attribute description within CVA survey</b>	# of races completed using new gasket arrangement since last failure using old gasket	% of finished races in season with air temp in 18–24° C range	Sponsor funding outcomes if decision is to race and then blow up racing car engine	Sponsor funding outcomes if decision is not to race
<b>Levels of higher uncertainty or greater irreversibility</b>	2 races	60% of races	Lose both oil and tyre sponsorships	Retain option to negotiate oil sponsorship next season but lose tyre sponsorship
<b>Levels of lower uncertainty or lesser irreversibility</b>	5 races	73% of races	Lose oil sponsorship but retain option to negotiate tyre sponsorship	Retain options to negotiate both oil and tyre sponsorships next season

Table 1.1: Uncertainty and irreversibility attribute and level descriptions

The utility value calculated for each conjoint task represents the level of innovativeness demonstrated by the respondent for that conjoint task. It is calculated from responses provided by respondents through a probability-based measurement scale, the purpose of which is to enable respondents to express the likelihood that they would elect to race in the Ponoco race. In parallel, a dichotomous forced choice ‘yes or no’ question is also provided for verification purposes. Through the online survey, the required data for the psychographic variables of risk propensity and risk perception are also captured. The relationships between the variables that are under examination are illustrated in Figure 1.2. As the purpose of Figure 1.2 is to depict the relationships of most interest to this thesis, it excludes the editing and evaluation phases of decision behaviour as defined in prospect theory (Levy, 1992, Kahneman and Tversky, 1979). The effects of these phases are nonetheless appropriately considered within this thesis.



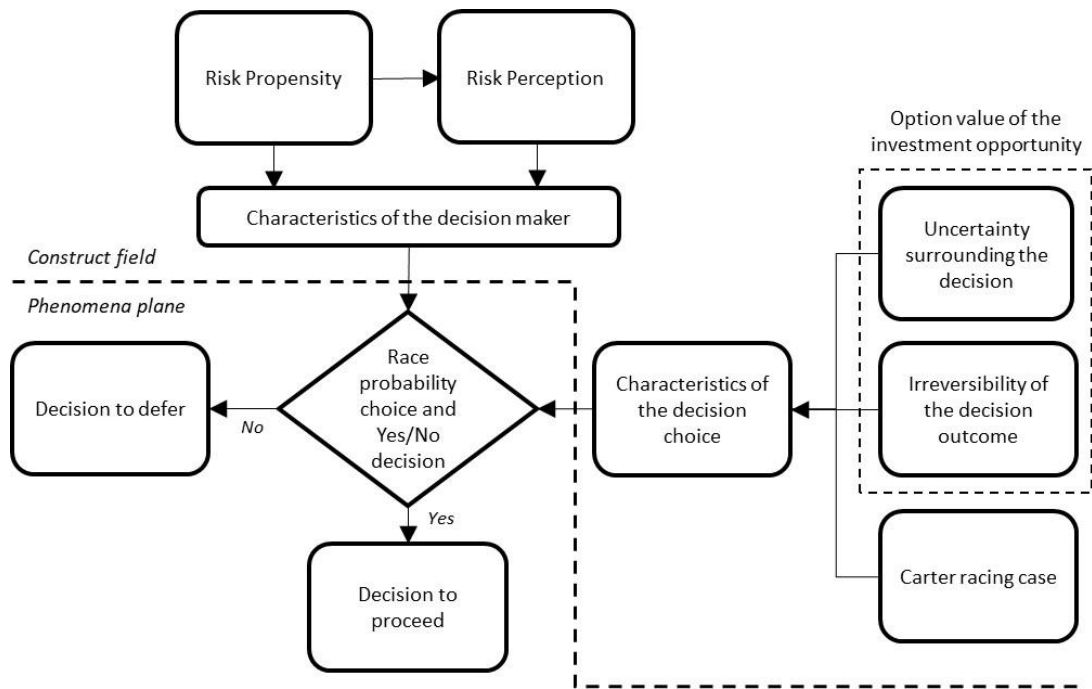


Figure 1.2: Illustration of the relationships between the variables under examination

A combination of CVA, multi-level regression, multi-level mediation and moderated mediation analysis, as appropriate, is used to answer the six research questions that are listed below, which follow from the main research problem stated earlier. The research methodology employed in this thesis is summarised in Section 1.6 and subsequently explained in full in Chapter 5.

The main research problem of this thesis is addressed by answering the following six research questions:

1. To what extent do respondents' decision choices demonstrate preferences that enable predictions of decision-making behaviour based upon variations in the level of the predictor variables of problem uncertainty, solution uncertainty, irreversible consequence failure and irreversible consequence postponement?
2. Can solution uncertainty, problem uncertainty, irreversible consequence failure, irreversible consequence postponement and risk propensity each be shown to be a predictor of risk perception?
3. Can risk perception and risk propensity each be shown to be a predictor of innovativeness?

4. Does risk perception mediate the effect of solution uncertainty, problem uncertainty, irreversible consequence failure and irreversible consequence postponement upon innovativeness?
5. Does risk propensity moderate the mediating effect of risk perception and the predictor variables of solution uncertainty, problem uncertainty, irreversible consequence failure and irreversible consequence postponement upon innovativeness?
6. Does irreversible consequence postponement moderate the mediation effect of risk perception and the predictor variables of solution uncertainty, problem uncertainty and irreversible consequence failure upon innovativeness?

These six research questions originate from important gaps identified following a review of the literature from the parent discipline fields as described in Section 2.6. In Chapter 2, following the summation of three relevant theoretical constructs drawn from Schumpeter's theory of economic development (Schumpeter, 1951), constructs from Rogers' theory of innovation diffusion (Rogers, 2003) are examined. This is followed by consideration of the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994) together with related theoretical content concerning option values. It is from this analysis that the main research problem of the thesis is defined.

This thesis argues that a decision-maker's risk perceptions and risk propensity play important roles as mediator and moderator respectively of relationships between attributes of uncertainty and irreversibility and the level of innovativeness demonstrated by respondents through actual decision-making behaviour. This thesis claims that where a risk-averse relationship exists between innovativeness and measures of uncertainty and irreversibility, this relationship is exerted through and explained by risk perception, with decision-maker risk propensity serving to influence the strength of the effects. However, where a risk-seeking relationship exists, no such effects are observed. This predictive and explanatory capability represents the primary contribution made to the relevant bodies of knowledge, which is summarised within the following section.

## **1.5 Justification for the research**

The justification for this thesis stems from important gaps identified in the relevant literature, as discussed in Chapter 2. By framing an appropriate research problem to reflect these gaps, explanatory and predictive capabilities are developed that build upon existing bodies of knowledge concerning innovation adoption, innovation diffusion and human decision-making processes more generally.

From the perspective of theoretical relevance, this thesis is justified in that it builds upon existing knowledge by connecting what have been largely independent concepts derived from separate theories into a novel framework that may enable predictions of investment decision-making behaviour to be made. Members within a social system do not adopt an innovation at the same time, and their adoption rate can be grouped into different categories according to the time delay they accept before making a decision to adopt (Mansfield, 1961, Rogers, 1962, Romeo, 1975). However, while the literature surrounding and substantiating the classification of adopter categories is voluminous (Rogers, 2003), no literature has been found that examines relationships between innovativeness and differing combinations of uncertainty, irreversibility, risk perception and risk propensity based upon primary data. This thesis contributes to the relevant body of literature by providing a novel explanatory and predictive framework that combines innovativeness, uncertainty, irreversibility, risk perception and risk propensity within the context of actual investment decision-making behaviour.

The practical relevance of this thesis is that it seeks to provide new insights into how the psychographic attributes of a group of decision makers, employed by the global minerals company BHP, influence their decision-making behaviour. That is, it is concerned with the consideration of factors over which managers may exercise judgement and implement routines and systems to control and improve investment decision-making processes. Similar to the way in which personality type can help improve the quality and nature of personal interaction between individuals within teams, the way in which risk perception and risk propensity influence investment decision-making processes under conditions of uncertainty and irreversibility may also improve team member behaviour and interaction. This serves to justify the thesis from a practical perspective.

From a methodological perspective, justification for this thesis flows from the novel use of a combination of full-profile CVA and multi-level regression techniques to answer the research

questions, which concern relationships that affect risky decision-making behaviour and the measurement of innovativeness.

## **1.6 Methodology**

The methodology employed in this thesis combines full-profile CVA with multi-level regression analysis to test the relationships of interest via an online survey hosted by Sawtooth Software, which provides conjoint analysis software. The specification of the survey can be found in Appendix C. The unit of analysis is a population of 400 executive managers employed by the global resources company BHP during October to December 2018. They are collectively defined by BHP as the 'Top 400' and accessed via email. The hypothetical case study titled 'Carter Racing' provides the necessary background and situational context to enable the survey. As mentioned previously, the case study is centred upon a critical time-bound investment decision for the owner of a professional racing car business. The case study is contained in Appendix B.

The full-profile CVA component of the methodology, enabled by the case study, requires that each respondent complete ten single-concept conjoint tasks. Each task presents a unique combination of uncertainty and irreversibility attributes that enrich the information provided within the case study. For each of the ten tasks, respondents are required to use a nine-point scale to assess the probability that they would decide to race in the Ponoco event. They are also required to respond to a forced-choice dichotomous 'yes or no' question concerning participation in the race. For each conjoint task scenario, respondents must also provide their perception of the risk arising from the scenario using a four-item seven-point semantic differential scale. For each completed survey, the respondents are also required to self-report their own risk propensity using a five-item seven-point Likert scale.

The information gathered through the CVA survey provides the data for subsequent analysis for the purpose of answering each of the six research questions mentioned in Section 1.3. These questions are addressed in rank order using analysis of decision preferences based upon the outputs of the conjoint analysis software, simple multi-level analysis, multi-level mediation analysis and multi-level moderated mediation analysis as appropriate. Multi-level regression methods are necessary given that each respondent provides ten separate response sets within each completed survey. A comprehensive analysis of the research methodology is provided in Chapter 5.

## **1.7 Outline of the thesis**

This first chapter provides the introduction to the thesis. It describes and justifies the main research problem and the research questions that the thesis seeks to answer together with the necessary definitions, justifications and delimitations of the work. A brief description of the research methodology employed within this thesis is provided within this chapter. The next two chapters provide a review of the literature that form both the parent and the immediate discipline fields relevant to this thesis. Chapter 2 addresses the parent discipline field commencing with the theory of economic development (Schumpeter, 1951). From this, the structural model is drawn, which forms the conceptual foundation for the literature review. The chapter then examines three parent discipline themes: risky decision behaviour, decision risk trade-offs and option value. The final section of Chapter 2 addresses four important research gaps identified from the literature review and from which the main research problem of this thesis emerges.

While Chapter 2 focuses upon the parent discipline field, the purpose of Chapter 3 is to build upon this through an examination of the literature associated with the immediate discipline field. The chapter commences with a justification for the inclusion of risk, risk perception and risk propensity within the immediate discipline field. The chapter provides a justification for the definition of risk employed within this thesis based upon the body of literature relevant to this subject commencing with Knight (1921). The chapter also provides a justified distinction between this definition and that of risk perception based upon relevant literature. Following this, both risk perception and risk propensity are examined.

The focus of Chapter 4 transitions from the literature review chapters to the empirically based sections. The chapter commences with the development of the analytic model that guides the empirical sections of the thesis. Then the means through which the variables of uncertainty and irreversibility are operationalised within this thesis are described. In the final section of the chapter, the necessary hypotheses are developed, each of which links to the main research problem stated in Section 1.4 via the six research questions contained within that section.

Chapter 5 commences with a description of the research methodology of the thesis and a discussion concerning the case study content. This is followed by justification of the methodology and the unit of analysis. Thereafter the chapter provides a comprehensive analysis of the research methodologies employed, with justifications provided as appropriate. Chapter 5 concludes with a discussion of relevant ethical considerations.

A summary of the data analysis and the results of the analysis are provided in Chapter 6. The chapter addresses response rates, respondent demographics, non-response bias, common method bias and the performance of the psychometric measurement scales prior to undertaking analysis of the results obtained from hypothesis testing. The chapter concludes with a summary of the hypothesis-testing outcomes.

The final chapter provides a thorough discussion of the results, conclusions that may be drawn from these results and implications arising for future research. The results associated with each of the six research questions from Section 1.4 are considered in rank order and, from this, conclusions are drawn concerning the main research question of this thesis. The implications of these conclusions for both theory and practice are then comprehensively discussed. The chapter and the thesis then conclude with a discussion of implications for further research.

The chapter structure of this thesis as described above, excluding appendices, is shown in diagrammatic form in Figure 1.3.

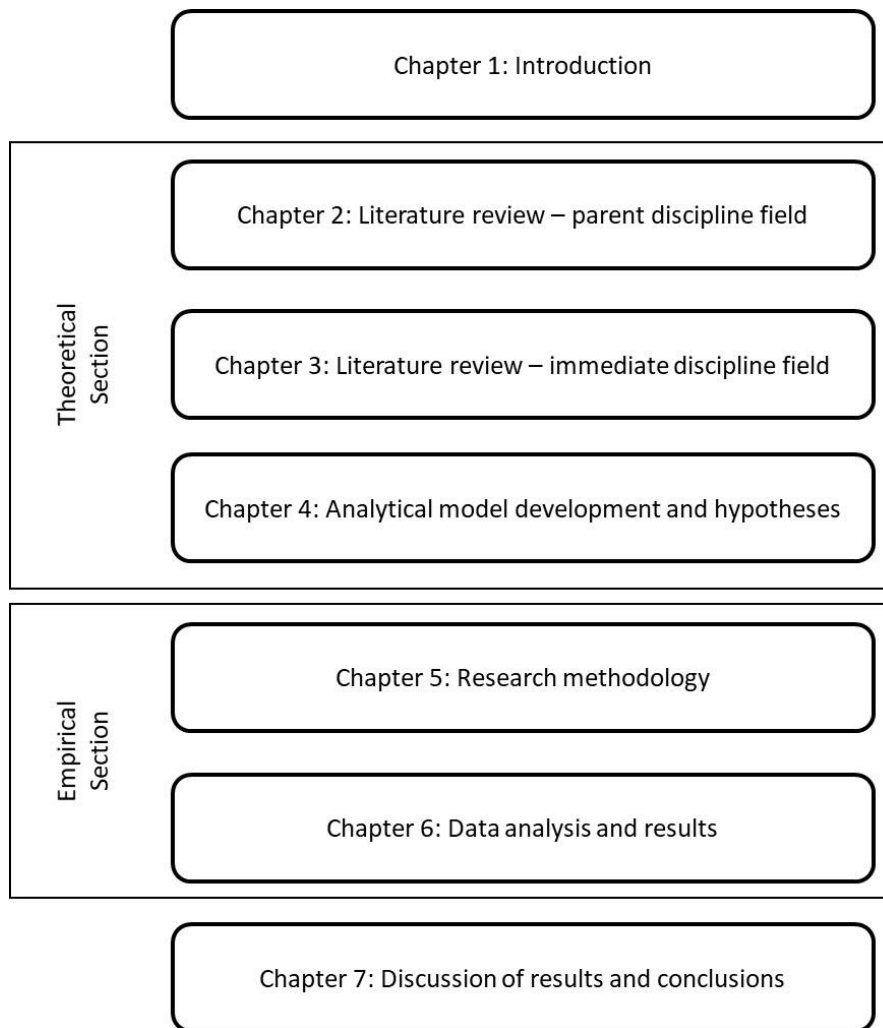


Figure 1.3: Chapter structure of this thesis excluding appendices

### **1.8 Limitations of scope and key assumptions**

The findings of this thesis are limited to the unit of analysis to which it refers, the nature of the analytic model employed within the methodology and the variables under consideration. Therefore, while the findings and relationships described within this thesis concerning the variables of uncertainty, irreversibility, risk perception, risk propensity and innovativeness may be extended to other circumstances in a generalised sense, the findings may not be universally relevant or correct. This is the first important limitation of the work. The sample upon which the findings are based was drawn from a population of 400 executive-level managers employed by the global resources business BHP, in part as a sample of convenience rather than from a random sample across a broader population. Therefore, additional care must be taken when considering the findings in terms of a different or larger population. Stating this does not infer that the results and findings of this study are in any way

compromised because of these limitations. However, recognition of this at the outset is important so as not to suggest that the results and findings of this thesis can be directly applied within a context beyond that which is applicable.

A second important limitation of the work is that it relies upon a fictitious case study and associated online survey. While all attempts have been made within the thesis and its methodology to ensure that the respondents made their selections based upon what they would have done in real life, the results and findings may not reflect actual behaviour under conditions of stress. It is important to note that the findings of this thesis reflect considered responses within an abstracted context rather than a real-life context in which time pressures, distractions, the weight of the actual decision and the potential decision consequences may cause different behaviours to be observed.

The third important limitation reflects the methodology employed, as each respondent was required to undertake ten choice-based conjoint tasks. This requirement may have resulted in respondents developing heuristic processes in response to the question sets contained within each task, and response fatigue may have caused some respondents to make selections that did not reflect their true beliefs. The full-profile CVA methodology employed within this thesis purposefully identifies those respondents for which little variation is noted across conjoint tasks to enable further examination of each instance.

Several important assumptions have been made in the preparation of this thesis. The first assumption is that the population of 400 executive managers employed by BHP are not materially different in their decision-making behaviour from other executive leaders employed within other organisations. Within the dataset collected, information was gathered that provided insights into each respondent's tenure in their current role, their tenure as an employee of BHP and the duration of their working career measured in years. Analysis of this dataset demonstrates that a sufficient level of diversity exists among the survey respondents to justifiably claim that, on average, they have spent considerable periods within their working careers outside the BHP organisation. The importance of this assumption arises from its ability, to some extent, to address the first limitation mentioned previously. The second assumption is that for all conjoint tasks completed, each response provided was considered rational by the respondent and reflected, as far as possible, what they personally believed to be the best choice in each instance.

It is also assumed that no respondent possessed information about the 'Carter Racing' case study, or motor racing generally, that would give them a material advantage over other



respondents. This assumption is in part justified on the basis that much of the information necessary to understand the background to the 'Carter Racing' case study is not freely available in the public domain, as demonstrated by the need to correspond directly with the author of the material to obtain the necessary content for this thesis. It is therefore assumed that those who successfully completed the entire survey may resemble and reflect the general level of knowledge possessed by a broader population group concerning these subjects.

Finally, it is assumed that awareness of chronic unease as a safety leadership philosophy, which is known to exist across the surveyed population as a consequence of BHP promoting the principles of chronic unease among all leadership levels, has not materially skewed the findings of the thesis. The principles of chronic unease, drawn from the literature and management theory surrounding safety leadership, encourage the conscious promotion of a heightened sense of vigilance, discomfort and concern among organisational leadership so as to introduce a greater level of behavioural rigour to risk-based decision-making processes (see Flin and Fruhen, 2015, Fruhen and Flin, 2016, Fruhen et al., 2014). The promotion of chronic unease within BHP commenced during 2017.

## **1.9 Chapter summary**

This chapter has introduced the thesis and provided a clear explanation of its purpose. It has summarised the background literature and positioned this thesis within that background. The main research problem addressed by the thesis was outlined within the chapter, followed by the set of research questions upon which the thesis is focused. Justification for the thesis then followed, together with a summary description of the methodologies that will be employed to address the main research problem. Finally, the limitations and key assumptions upon which the thesis relies were mentioned. The next chapter provides a thorough review of the parent discipline field literature relevant to the thesis, commencing with Schumpeter (1951) and the theory of economic development.

## 2. LITERATURE REVIEW: PARENT DISCIPLINE FIELD

### 2.1 Introduction

The purpose of this chapter is to provide the necessary theoretical foundations for the thesis. The chapter grounds the work within the broader theoretical background, provides a sense of place for it within that background and identifies the opportunities that justify it. After providing a thorough grounding for the thesis among the literature surrounding the theory of economic development (Schumpeter, 1951), this literature review explores the three parent discipline themes of this thesis: risky decision-making behaviour, decision risk trade-offs and option value. Following this, the focus of the chapter turns to important gaps identified within the literature. These gaps are considered important because they represent opportunities for the development of valuable empirically based capabilities that may enable both the prediction and explanation of risky decision-making behaviour. It is from these gaps that the main research problem addressed by this thesis emerges. As stated in Section 1.4, the main research problem that this thesis seeks to address is as follows.

*To what extent may predictions of innovativeness be made determined from relationships between actual risky decision-making behaviour and measures of decision uncertainty and irreversibility, using risk perception and risk propensity as psychographic mediator and moderator respectively, based upon data generated from a full profile conjoint analysis survey and drawn from a population of 400 executives employed by the global resources company BHP?*

### 2.2 Aspects arising from the theory of economic development

Joseph Schumpeter is widely recognised as a seminal figure within the field of economic study, especially in regard to his wide-ranging analysis of the place occupied by the entrepreneur and technological innovation both within that field of study and within a capitalist society (Becker et al., 2012, Croitoru, 2013, Hansen, 1938, Sweezy, 1943, Sundbo, 1998). Among the considerable volume of work generated by Schumpeter throughout his academic career—much of it pioneering in nature (Godin, 2017, Sundbo, 1998, Sweezy,

1943)—it is the theory of economic development, which was published early in his career, that is considered one of his most important achievements and contributions (Becker et al., 2012, Croitoru, 2013, Sundbo, 1998). While Schumpeter provided little, if any, analyses of the processes of innovation (Godin, 2008a, Sundbo, 1998), central to his arguments concerning the system described within the theory of economic development (Schumpeter, 1951) is the vital role of entrepreneurship and its inseparable relationship with innovation within an economic system (Croitoru, 2013, Sundbo, 1998, Sweezy, 1943). It is not the purpose of this literature review to provide an in-depth analysis or critique of the works of Schumpeter, or indeed an analysis of all the elements that comprise the theory of economic development and the relationships that exist between them. Rather, what is relevant to this study are the three specific constructs that are widely considered the foundation elements of much of Schumpeter's work (Becker et al., 2012, Croitoru, 2013, Godin, 2008a, Sundbo, 1998, Sweezy, 1943). These three constructs are as follows:

1. Circular Flow. The abstract notion of an economic system within which change, but not growth, is assumed to be absent yields an outcome described as circular flow. It is characterised as a system running in the same track year on year, with a limited number of materially influential external forces effecting it (Hansen, 1938, Schumpeter, 1951, Sweezy, 1943).
2. Innovation. This is the introduction of a new external force sufficiently large to not only influence but also disturb the equilibrium that characterises the notion of circular flow within the abstracted economic system. This new force brings into being a new combination or combinations of possibilities that represent causative factors in change that are accordingly denoted as innovation (Courvisanos and Verspagen, 2002, Hansen, 1938, Rogers, 2003, Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943).
3. The Entrepreneur. Entrepreneurs are those accountable for introducing innovation to an economic system, either for speculative advancement or for pure survival within a capitalist system. In doing so, they are responsible for introducing causative factors in change to what is otherwise believed to be an economic system in stable circular flow. In their absence, change, and the external forces that create it, are also considered absent (Courvisanos and Verspagen, 2002, Hansen, 1938, Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943).

Each of these three constructs represents a foundation element of both Schumpeter’s theory of economic development and the main research problem that this thesis sets out to address. Accordingly, an examination of each is justified as part of this literature review, as each represents a cornerstone of the theoretical foundations. Figure 2.1 provides a graphical interpretation of the three elements of Schumpeter’s theory of economic development (Schumpeter, 1951, Sweezy, 1943). It also depicts the relationships between the constructs, together with other salient dimensions that are vital to this thesis—namely uncertainty, irreversibility, risk perception and risk propensity. The structure of Figure 2.1 provides an important reference point for the content of Chapters Two and Three; henceforth, it will be denoted within this thesis as the structural model.

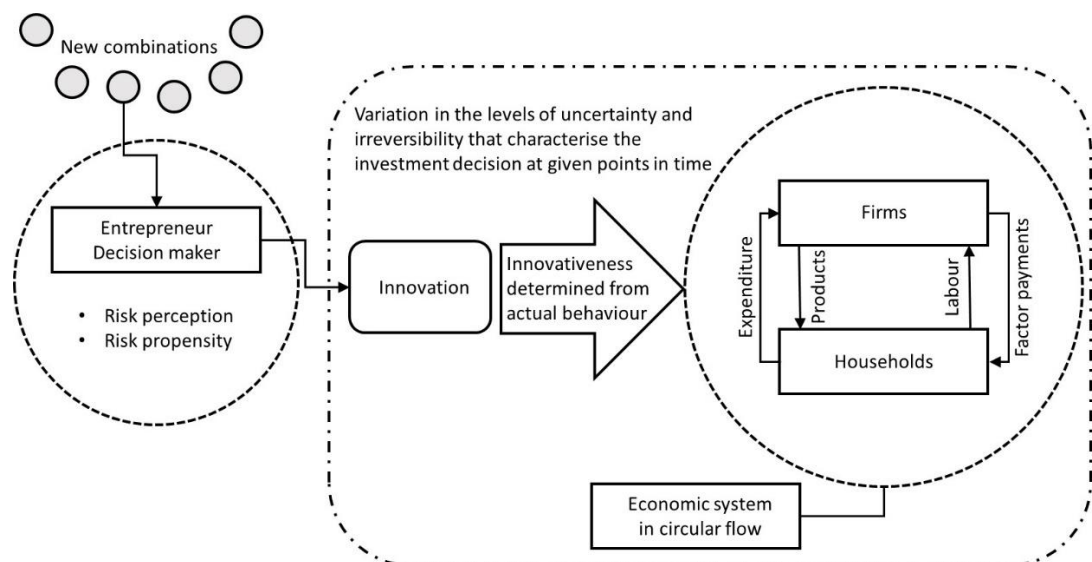


Figure 2.1: The structural model

Before progressing further, it is important to provide a summary outline of how these three elements in combination come to cause, according to Schumpeter (1951), either immaterial or material change in the short or long term. Schumpeter (1935) argued that the effect of innovation, and the investment associated with its adoption, is to upset the equilibrium of a relevant economy or social system (Hansen, 1938, Sweezy, 1943). The level of disruption created by the innovation, in combination with the entrepreneur, is proportional to the degree of departure from contemporary practices and the stage of overall diffusion of the innovation within the relevant economic system (Damanpour, 1988, Dewar and Dutton, 1986, Gopalakrishnan and Damanpour, 1997, Schumpeter, 1935). Schumpeter (1935) also argued that the most radical and revolutionary innovations are the source of the business

cycles (Godin, 2008a) responsible for the generation of what Kondratieff and Stolper (1935) described as long economic waves or 'Kondratieff cycles' (Courvisanos and Verspagen, 2002, Gordon, 1952, Schumpeter, 1935, Sundbo, 1998). These innovations were claimed to create the forces that led to or were part of the rhythm of the long-wave revival phase (Schumpeter, 1935), and, accordingly, to periods of general economic expansion (see Courvisanos and Verspagen, 2002, Gordon, 1952, Kondratieff and Stolper, 1935, Samuelson, 1948, Sundbo, 1998, Sweezy, 2004). As explained by Sundbo (1998), innovations such as these have been rare, but their adoption and progressive diffusion have punctuated a series of industrial revolutions over past centuries (Gordon, 1952, Hansen, 1938, Schumpeter, 1935).

This is demonstrated in the development and diffusion of the steam engine (Condor, 1983, Savage, 1959) and in the means of manufacturing iron and steel to support this mode of transport (Savage, 1959, Schumpeter, 1935, Tarde, 1903). Both the steam engine and the development of the Bessemer furnace are examples of a wave of technological innovation that flowed through an economy and, in doing so, heralded another successive phase of industrial revolution, economic expansion and social upheaval (Gordon, 1952, Schumpeter, 1935). Since the beginning of the Industrial Revolution, invention and innovation have fundamentally changed the manner in which work is performed, the nature of work itself, the rates of production, the way societies are structured, the way labour is organised and the manner in which competitive advantage is attained, maintained and lost (Gordon, 1952, Kanigel, 1997, Schumpeter, 1935). The Industrial Revolution's impact owed much to its reliance upon the refinement of scientific principles and technological innovation, which led to the creation of what was patented in 1769 by James Watt as the steam engine (Rankine, 1861). The successful development of the steam engine led to the development of railways as a principle means of land transport (Condor, 1983, Gordon, 1952, Schumpeter, 1935). However, this could not have been properly achieved without substantial technological advancement in the field of metallurgy to improve the material quality of the rails upon which the trains would run, or in the absence of entrepreneurial behaviour, endeavour or vision (Courvisanos and Verspagen, 2002, Gordon, 1952, Savage, 1959, Schumpeter, 1935).

The introduction of the steam-powered locomotive quickly superseded the horse as the preferred means of traction (Condor, 1983), and when combined with the durability of the newly developed wrought iron rails, the railways soon superseded the canal system in Great Britain as the dominant mode of transport (Savage, 1959). The pursuit of disruptive technological innovations by entrepreneurs such as Watt, Brunel and Stephenson harnessed the forces that drove a complete and permanent transformation of Western society (Condor,

1983) and heralded the start of global industrialisation (Gordon, 1952, Kanigel, 1997, Savage, 1959, Schumpeter, 1935). The dominance of the steam engine and its contribution to the global industrial revolution, the displacement of the horse by the steam-powered locomotive and the substitution of the canal system by the railways demonstrate the transformational effects of what were, at the time, disruptive innovations (Savage, 1959). These developments were furnished upon an economic system that had been stable for several centuries by entrepreneurs who were prepared to engage with risk in the expectation of reward (Schumpeter, 1935).

### 2.2.1 Circular flow within an economic system in which change is absent

As mentioned within the previous section, the starting point of Schumpeter’s work is an abstract economic system within which change, but not growth, is absent (Gordon, 1952, Hansen, 1938, Kuznets, 1940, Schumpeter, 1951, Sweezy, 1943). It must be stressed at the outset that such an environment is a construct of the mind. It is not intended to reflect a definite reality, and it is not an unrealistic construction. Rather, it is an abstracted condition in which both the factors of change and the creators of that change are removed (Sweezy, 1943). Accordingly, this conceptual social and economic construction provides a definitive starting point to which further considerations can be systematically added and, in doing so, analysed for their effect (Gordon, 1952, Schumpeter, 1951, Sweezy, 1943). Figure 2.2 depicts the structural model and highlights the element of an economic system in circular flow, which is the element of the diagram relevant to this section of the chapter.

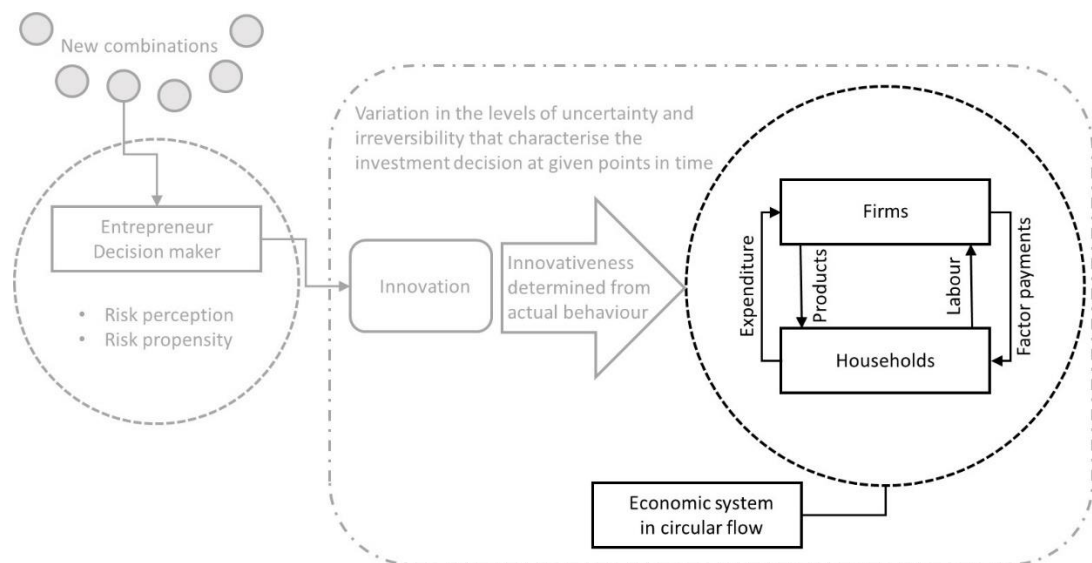


Figure 2.2: Economic system in circular flow highlighted within the structural model

At this point, it is important to clarify what is meant by an economic system within which change, but not growth, is absent. Reference to growth in the case of the theory of economic development (Schumpeter, 1951) is growth that takes place continuously across time with the rate of either incremental or decremental growth such that it can be absorbed by the existing system without perceptible shock, disturbance or displacement (Schumpeter, 1935). For example, Schumpeter (1935) provided the typical per annum population increase of a few per cent, which translates roughly into a similar level of increase in the labour pool as the classical case of what typifies growth.

The notion of circular flow within an economic system in which change, but not growth, is absent is analogous to any system in which established rules have existed for a considerable period and in which entities functioning within the system have done so without challenge to those rules. Further, while new entities have entered the system, none have demonstrated the desire to introduce something new to the system compared with what has gone before (Gordon, 1952, Sweezy, 1943). Schumpeter expressed the notion of circular flow as analogous to a system such as the blood vessels within an animal organism, whereby the circulation of blood runs within what are essentially the same tracks year on year without alteration (Schumpeter, 1951). Therefore, in essence, the starting point for Schumpeter (1951) is a circumstance where the same products, services and market offerings are produced and provided in the same form year after year within a Marshallian environment in which supply and demand conditions are in equilibrium with respect to volume, time and competition. Within this abstract steady state environment, profits, interest rates, savings, accumulation, investment and unemployment are also considered absent (Becker et al., 2012, Schumpeter, 1951, Sweezy, 1943). Other outside factors that are considered absent include chance; the effects of droughts, floods and disease; institutional changes and banking policy adjustments; natural catastrophes; and wars and revolutions (Schumpeter, 1935).

The notion of circular flow within an economic system in which change, but not growth, is absent provides a platform from which the effects of the entrepreneur as the causative factor of change and innovation can be considered (Gordon, 1952, Hansen, 1938, Schumpeter, 1951, Sweezy, 1943). While such an environment described by Schumpeter (1951) is an abstract construct of the mind, it is not an unrealistic construct (Sweezy, 1943). In terms of this thesis, the stable state of period-on-period attainment of similar outcomes, inputs and processes described and represented by this environment justifies the inclusion of the theory of economic development within this literature review. It provides a valid and

robust background context against which the following three points can be properly considered from a systems perspective:

- innovation in its place as the causative effect in change
- the causative effects of the entrepreneur upon change
- the behavioural influences of the entrepreneur acting as the innovator.

These three points will each be considered within the following sections.

### 2.2.2 Innovation as the causative factor in change

Against the backdrop of an abstract economic system within which change, but not growth, is absent, the injection of innovation into such an environment brings about the processes of change, development and the eternal displacement of the economic equilibrium compared with that which existed previously (Gordon, 1952, Hansen, 1938, Schumpeter, 1951). As such, according to Schumpeter, it is innovation that is the causative factor in change (Gordon, 1952, Schumpeter, 1951, Sweezy, 1943). Figure 2.3 shows the structural model with the element of innovation highlighted, which is the element of the diagram relevant to this section of the chapter.

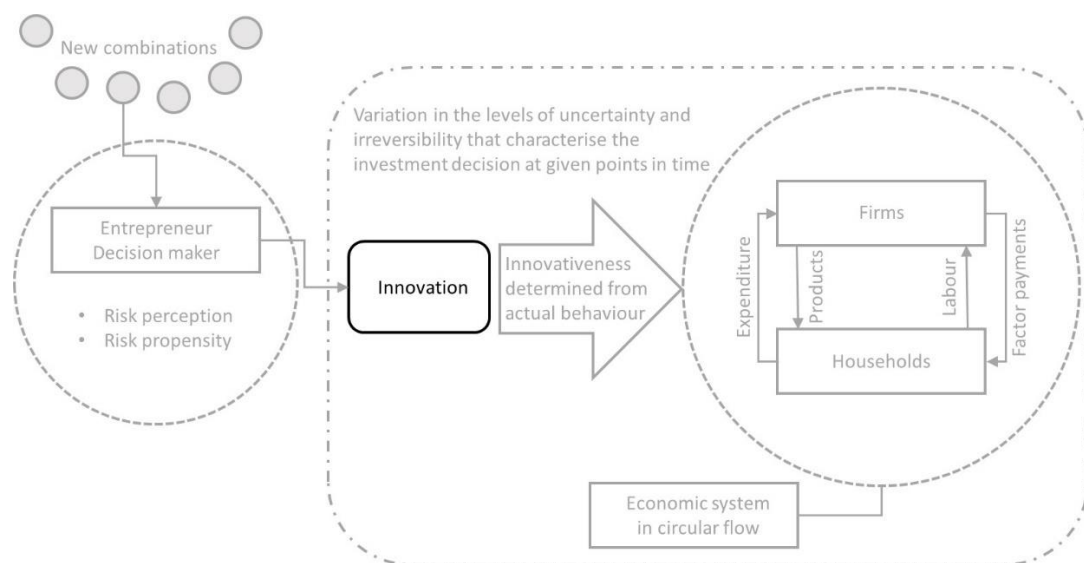


Figure 2.3: Innovation highlighted within the structural model



Over time, there has been considerable variation in both the manner in which innovation is defined and the limitations within which the phenomenon is said to occur (Godin, 2017, Rogers, 2003, Sundbo, 1998). Indeed, there is no single unidimensional definition applicable to the notion of innovation, nor is there a definition that describes it in a neat homogenous and orderly form (Kline and Rosenberg, 1986, Rogers, 2003, Sundbo, 1998).

The literature of the last 50 years has presented a range of definitions that reflect the somewhat nebulous nature of the subject, but two essential elements are generally common across various definitions. First, the innovation represents something that is new, different or an improvement on what has gone before. Second, the newness, difference or improvement arises from a comparison with what has gone before with respect to a relevant unit of analysis rather than its originality being necessarily new in and of itself (Godin, 2017, Rogers, 2003, Sundbo, 1998). Accordingly, it is the second element that places an important qualification upon the first. The combination of these two elements allows a series of transformative novel improvements within a given social context—each of which is described as innovation—to flow from that which is considered the original. Each successive innovative step builds upon both the change and benefit caused by the previous step (Rogers, 2003, Rothwell, 1986, Sundbo, 1998).

According to Schumpeter, innovation is ‘doing things differently in the realm of economic life’ (Schumpeter, 1939, p. 84). As described by Sundbo (1998), Schumpeter (1951) defined innovation as the satisfaction of at least one of the following conditions:

- the introduction of a new product into a market or a new product quality into an existing market
- the introduction of a new method of production
- accessing a new market
- accessing new sources of raw materials or new sources of inputs into a production process regardless of whether the source had existed previously
- the creation of new organisational structures within industry such as the breakdown of monopolies, oligopolies and cartels.

A key criticism of the definitions applied to the description of and conditions for innovation provided by Schumpeter (1951) is that they are particularly diffuse in nature and it is difficult

to place clear and unambiguous boundaries upon the phenomenon in question (Sundbo, 1998). Unlike Rogers (2003), Schumpeter (1951) provided scant analysis of the processes of innovation or the conditions, factors and associated elements that lead to innovation (Godin, 2008a, Sundbo, 1998). Schumpeter was instead focused upon innovation as a consequence of what it did rather than how it came about (Sweezy, 1943).

It is beyond the scope of this literature review to provide a comprehensive etymological analysis of the phenomenon broadly referred to today as innovation. However, it is important for this study to elaborate upon the descent of this term through the passage of time to the modern day. In reference to the act of providing such an analysis, Foucault (1972) stated that the necessary contextual background can enable both an understanding of how such a term has come to represent what it does, as well as how it has come to be defined. Hence, it is important to summarise the origins of the term 'innovation' because the presence of an innovation within the case study in this thesis creates the characteristics of uncertainty and irreversibility that are central to the main research problem addressed in this thesis.

The emergence and usage of different words, when combined with a developing preference for certain words to describe a particular phenomenon, indicate periods in time during which the values of society change. The change in terminology represents the point at which the social change becomes sufficiently obvious to require a new term to describe it (Godin, 2008a, Skinner, 1988, Smith, 1925). It is through such a developmental lens, calibrated in accordance with societal change over the passage of time, that innovation and innovative behaviour, as they are generally thought of today, must be viewed (Godin, 2015b). From before the Reformation to the seventeenth and eighteenth centuries, the term 'innovation' was judged within the realms of philosophy, social reform, religion, science and politics as strictly pejorative because it pointed towards the purposeful introduction of change within the established order (Godin, 2015a). Instead, the terms 'change' and 'reform' or 'reformation' were used to discuss innovation, provided that the context of such references did not have the effect or potential effect of destabilising the established order of things. Doing so was considered subversive, and in some cases revolutionary, and polemical action was often taken against those deemed to be in pursuit of what was known and understood at the time as innovation (Godin, 2015b). Fundamentally, it was considered of utmost importance that such change must be gradual and not cause too much disturbance to the status quo (Godin, 2017). Indeed, while writers such as Niccolò Machiavelli and Francis Bacon

made conceptual attempts at theories of innovation, few if any theories, writings or a philosophy of innovation existed prior to the twentieth century (Godin, 2015b).

The term 'innovation' has been associated with novelty, change and the introduction of novelty and change (Godin, 2015b, Rogers, 2003, Sundbo, 1998). Change was at the heart of that which caused the term to be considered so subversive (Godin, 2015b). The accepted conventions of the time expected and demanded that change, while it may be continuous in nature in some instances, it must be, and be seen to be, gradual in effect (Godin, 2015b, Nisbet, 1970). Change was accepted by degree, and only where no leaps forward were being promoted or suggested. It was not until the late seventeenth century that substantive definitions of innovation began to appear in English dictionaries (Godin, 2015b).

Rogers (2003) said that the roots of innovation theory, from a theoretical perspective, emerged in the late nineteenth century in the work of Tarde (1903). Given the little conceptual study undertaken prior to then, a wide divergence of approaches to the subject emerged thereafter (Godin, 2015b). Similar to innovation, the origins of the term 'imitation' can be traced to Greece, as it occupied a conceptually central place within the philosophy of Plato, and particularly with respect to Plato's Forms (Abrams, 1953, McKeon, 1936, Nahm, 1956). In Western society prior to the twentieth century, creativity and ingenuity were widely regarded to be associated with the contrasting, and at times contradictory, concepts of imitation and invention (Godin, 2015b). Indeed, throughout history and across a broad spectrum of contexts ranging from the arts and literature to the betterment of society and commerce, imitation has generally been considered the act of creatively and selectively copying or borrowing from one context and applying it to another (see Abrams, 1953, Berg, 1999, Berg, 2002, Clark, 1951, Clifford, 1999, Hathaway, 1989, Kinnunen, 1996, Kushner, 1980, Levitt, 1966, McKeon, 1936, Nahm, 1947, Nahm, 1956, Nelson and Winter, 1982, Tarde, 1903, White, 1935). However, borrowing from one context and applying it to another has at times been perceived to be also representative of invention because the outcome from doing so was seen to be new or improved compared with what had gone before (Benhamou, 1991, Berg, 2002, Clifford, 1999).

As the twentieth century approached, Tarde (1903), in his seminal work, laid down the foundations from which the modern understanding of the contrast between imitation and invention became understood (Godin, 2015b). Tarde (1903) stated that the relationship between invention and imitation is analogous to a mountain from which a river flows. In this analogy, inventions are relatively infrequently encountered landmarks of human endeavour

from which more frequently encountered acts of imitation spring forth or flow from the initial inventive uprising (Kinnunen, 1996, Rogers, 2003, Sundbo, 1998, Tarde, 1903). In doing so, they cause the characteristics of the invention to diffuse (Godin, 2017, Rogers, 2003, Rothwell, 1986, Sundbo, 1998). Following the work of Tarde (1903), the distinction between innovation and imitation began to crystallise through the works of Maclaurin (1949), Levitt (1966) and Schmookler (1966). Innovation was shown to occur in cases where a firm within a given industry introduced a technical change that originated elsewhere but was new to the industry, and competitors within the same industry subsequently copied the innovation, thereby demonstrating the act of imitation (Levitt, 1966, Schmookler, 1966). Levitt (1966) claimed that imitation rather than innovation was responsible for the greatest flow of newness across industry, because it was through imitation that companies could capture new ideas from their competitors. Thus, according to Levitt (1966), regardless of how it is defined, imitation is primarily responsible for the diffusion of ideas within a given context. Therefore, it is how the given context is defined and how the boundary conditions of that given context are formed that distinguishes innovation from imitation (Rogers, 2003, Sundbo, 1998).

However, Levitt (1966) and Schmookler (1966) argued that the distinction between innovation and imitation is not clear cut because imitation often requires the imitator to adapt and innovate or invent during implementation to successfully incorporate that which is being imitated into their own setting, place, systems and organisation (Godin, 2015b). The process of adaptation during implementation was described by Rice and Rogers (1980) as reinvention, with the level of reinvention determined by the degree to which change is necessary. Similarly, Rothwell (1986) spoke of innovation as an iterative and dynamic process in which the adopter actively adapts that which is new to them during the implementation phase to suit their circumstances, as opposed to a passive user of that which is created elsewhere. Levitt (1966) and Schmookler (1966) described that the process of imitation is in fact a process of diffusion, and the act of imitation is also an act of adoption (Godin, 2008b). Both diffusion and adoption were central to the seminal work of Rogers (2003) in the field of innovation.

As is the case with imitation, the ideas known to be representative of invention, as well as its definition, have developed over the centuries. Other than with reference to novelty, and to some degree cultural change that is indicative of progress in some form, a consistent definition for the notion of invention has been absent (Godin, 2008b, Godin, 2015b). The themes of novelty, change and progress have been most apparent in the realms of science,

and the act of invention is said to have been central to this advancement, particularly since the Middle Ages (see Bury, 1932, Crombie, 1975, Marx, 1987, Sarton, 1962, Spadafora, 1990, Zilsel, 1945). An important distinction arose as a result of this concerning the notions of discovery and invention, with the former becoming relevant to what is found but that already existed, whereas the latter increasingly came to refer to what is genuinely new and ingenious (Godin, 2017, Kneale, 1955).

Over time, the tension and dichotomy that was thought to exist between the two seemingly opposite constructs of invention and imitation eased (Godin, 2008b). This was largely due to the emergence of theories that focused upon the notion of novelty as the cause of cultural change within social or anthropological contexts (Barnett, 1953, Godin, 2015b). Indeed, it was not until the mid-eighteenth century that genuine and unrestricted originality became the primary criterion for invention and the differentiating factor between it and imitation (Godin, 2008b).

Since the early eighteenth century, when the first modern patent laws came into being, three essential criteria have characterised technological invention (Godin, 2008b). Broadly, these three criteria can be described as follows:

- the originality or novelty of the work
- the originality of the intellectual origin
- the utility of the technological invention.

Combined with the modern patent system, the advent of research laboratories within industrial organisations for the purpose of technological innovation and development for commercial gain led to the systematisation of the methods of invention on an increasingly larger scale (Godin, 2008b, Whitehead, 1926). Scholars prior to Schumpeter, commencing with Tarde (1903) in the case of imitation and including Ogburn (1936) and Linton (1936), have distinguished between invention and innovation by claiming that invention is the act of creating and developing new ideas, while innovation is the act of adopting an idea that already exists (Rogers, 2003). Schumpeter (1939) stated that the act of innovation can be achieved in the absence of invention, whereas the act of invention does not, by default, induce or cause innovation. However, scholars such as Cole (1949), Nelson et al. (1967) and Schön (1967) stated that the distinction between invention and innovation is not necessarily

obvious, and the two concepts should be considered as boundary conditions of a continuum spanning between generation and application and across which the boundary conditions merge. Nonetheless, unlike innovation, the act of invention is now understood to be representative of genuine ingenuity that is not limited or restricted in any contextual way (Godin, 2017, Kinnunen, 1996, Rogers, 2003, Sundbo, 1998).

While it is said that the terms ‘imitation’ and ‘invention’ have been contrasted, confused and in tension for a large part of Western history (Godin, 2008b), it can also be claimed that both are representative of novelty in some form, and both are considered a precursor of change (Godin, 2017, Schumpeter, 1951, Sweezy, 1943, Tarde, 1903). It was not until the early twentieth century, when these two concepts were combined within a unified process that incorporated a series of sequential steps over time, that the modern-day notion of innovation began to emerge (Godin, 2017, Wittkower, 1965).

Notwithstanding this gradual process of clarification, many contemporary definitions of innovation exist, some of which do not explicitly separate invention from innovation, as discussed by Taylor (2017). There is a wide range of variation in the meaning of the term across the fields of government, academia and industry. Further, there is considerable variation in the extent to which definitions may be broad and widely encompassing or narrowly defined and specific in nature (Taylor, 2017), in part driven by the level of abstraction considered (Cropley, 2015). The contemporary examples provided in Table 2.1 illustrate these points.

From the selection of examples contained in Table 2.1, it is clear that they each encompass, to varying extents, the degree to which something is:

- thought to be novel, creative or of immediate and apparent value
- considered in the abstract or applied form
- a product, a process or a combination thereof
- limited by context or circumstance
- considered to have an effect that is either incremental or more radical in nature.

<b>Source</b>	<b>Means through which innovation is defined</b>
Australian National Audit Office (2009)	Provides a simple explanation that refers to the creation and use of good ideas to produce better outcomes.
Bledow et al. (2009)	Stresses the importance of intentional development and the introduction of new ideas.
Cropley (2015)	Innovation implies the exploitation of an effective novelty.
Damanpour and Schneider (2008)	Focuses attention upon both the generation of new ideas and behaviours as well as the use of new ideas and behaviours.
De Vries et al. (2014)	Discusses the introduction of new elements into service, including new skills as necessary conditions for innovation.
Evers and Ewert (2015)	Sets as the criterion for social innovation the raising of hope and expectation for processes to move towards something better than prevailing conditions through acts that are considered, in some instances, disruptive in nature.
Luecke and Katz (2003)	Describes innovation as the embodiment and synthesis of knowledge for the purpose of creating and exploiting new forms that are both valuable and relevant.
Mulgary and Albury (2003)	Summarises innovation as new ideas that work and focus attention within a more detailed explanation upon outcomes from innovation associated with significant improvements in efficiency, effectiveness and quality.
National Audit Office (2009)	Highlights the exploitation of new ideas or ideas adopted from elsewhere as vital to the act of innovation.
NESTA (2012)	Describes a process focused upon the transformation of new ideas into practical value.
OECD/Eurostat (2005)	Emphasises the extent to which the creation and implementation of a product or service is considered new to potential users.

Table 2.1: Contemporary examples of the means through which innovation is defined

For the purposes of this thesis, Rogers' (2003, p. 12) definition of 'innovation as an idea, practice or object that is perceived as new by an individual or other unit of adoption' is an appropriate operational definition. This definition emphasises newness but does not limit its effect to incremental or radical cases, it considers a broad range of applicable circumstances, it is sufficiently abstract in nature to enable generalisation but can be readily employed in an applied form, and it is contextualised so as to adequately distinguish it from invention. Rogers (2003) definition is aligned with that of the Organisation for Economic Co-operation

and Development (OECD), which defined business innovation as ‘a new or improved product or process (or combination thereof) that differs significantly from the firm’s previous products or business processes and that has been introduced to the market or brought into use by the firm’ (OECD/Eurostat, 2018, p. 20). Accordingly, the use of Rogers (2003) definition of innovation is justified.

### **2.2.3 The entrepreneur as the causative factor of change**

The purpose of this section is not to undertake an exhaustive examination of Schumpeter’s analysis of the entrepreneur and entrepreneurship over a period of several decades. Nor is its purpose to trace the development of what Schumpeter believed to characterise the entrepreneur and the act of entrepreneurship as it changed from what was originally conceived in the early twentieth century to what emerged decades later. Rather, its purpose is to define what the entrepreneur provides to the processes of economic development. While Schumpeter’s personification of an entrepreneur evolved over time from one of an individual possessing uncommon capabilities to one of an impersonal individual who capitalises upon interdependent linkages, the essence of his rationale for the entrepreneur was sustained (Becker and Knudsen, 2003). That is, leadership and the will to win, succeed and dominate through the bringing together of new combinations of things is essential and integral to the act of entrepreneurship (Hansen, 1938, Schumpeter, 1935, Schumpeter, 1951). The early emphasis upon leadership transitioned towards the establishment of new combinations as Schumpeter’s own conceptualisation of entrepreneurship developed over time (Becker and Knudsen, 2003). Schumpeter’s (1951) development of the concept may be considered an extension of that described by Say (1855), whereby entrepreneurial skill was understood to be combining the factors of production, and what Mill (1885, p. 629) described as ‘labour and skill for superintendence’.

Figure 2.4 shows the structural model with the element of the entrepreneur highlighted, which is the element of the diagram relevant to this section of the chapter. The elements of risk perception and risk propensity both reside within the overarching element of the entrepreneur.



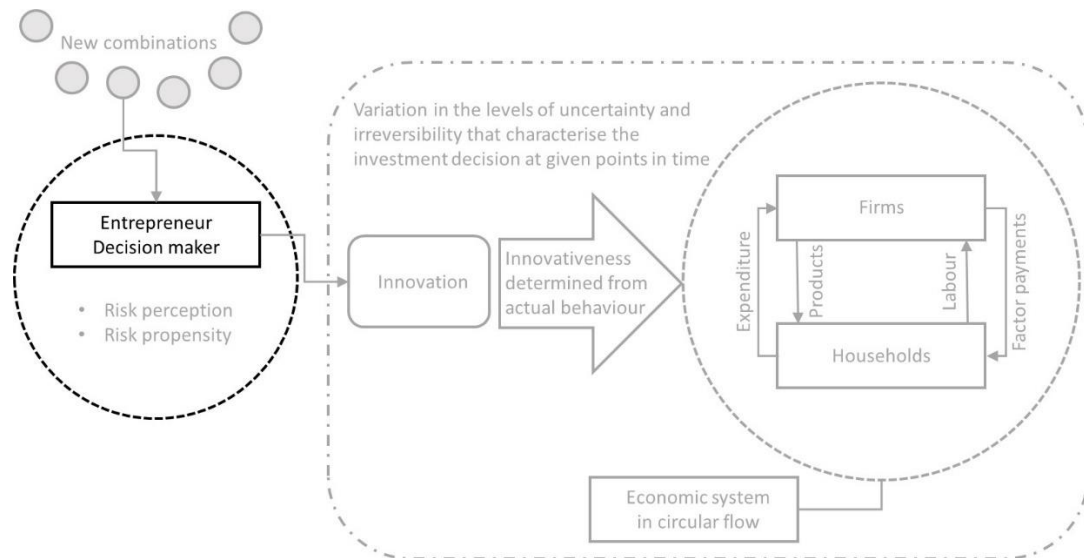


Figure 2.4: The entrepreneur highlighted within the structural model

According to Schumpeter, the set of individuals who can be characterised as entrepreneurs are accountable for bringing innovation to bear upon economic systems. Without them, the creator of the forces of change directed upon a stable economic system representing circular flow, as so defined previously, would be absent (Gordon, 1952, Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943). Indeed, the creation of the abstract notion of an economic system within which change, but not growth, is absent is brought about through the abstraction of entrepreneurs from the relevant economic system (Sweezy, 1943). Therefore, it follows that while innovation is identified as the factor in change (Schumpeter, 1951, Sweezy, 1943), the entrepreneur is characterised as the causative factor of change because it is largely they, according to Schumpeter (1951), who cause change to be inserted into the economic system (Becker and Knudsen, 2003, Gordon, 1952, Sundbo, 1998, Sweezy, 1943). Accordingly, Schumpeter claimed that the individual who acts as the entrepreneur also acts in the role of the innovator (Becker and Knudsen, 2003, Sundbo, 1998). This claim is considered pivotal to the analysis of innovation (Sundbo, 1998, Sweezy, 1943), and from it a definitive link can be drawn between the works of Schumpeter (1951), Tarde (1903) and Rogers (2003). In acting as the cause of change, the entrepreneur must also, in parallel, consider the timing and risk of their actions (Schumpeter, 1951). These considerations create linkages between Schumpeter's (1951) work regarding innovation-related decision making and decision-maker risk perception, risk propensity and the fourfold pattern of risk attitudes derived from prospect theory described by Harbaugh et al. (2010) and Kahneman (2012). Prospect theory and the fourfold pattern of risk attitudes derived from it are explained in Section 3.7.3.

Schumpeter (1951) described a process termed as 'enterprise' within which economic development is a consequence of the coupling of credit and newly formed combinations of the means through which production occurs. The task of forming these new combinations falls to those denoted as entrepreneurs, whether they are independent agents or employees of a company. According to Schumpeter's (1951) definition of an entrepreneur, they are directly responsible, through their own endeavours, for bringing together new combinations of the means by which production occurs for the first time. Entrepreneurs are therefore different to what Tarde (1903) described as imitators because they do not simply, based upon Schumpeter's definition, imitate the behaviour of others (Schumpeter, 1951, Sundbo, 1998). Similarly, they are not necessarily inventors, but through the process of bringing about new combinations of the means by which production occurs, the entrepreneur may, coincidentally through their actions, satisfy the definition of invention (Becker and Knudsen, 2003, Sundbo, 1998). According to Schumpeter (1951), entrepreneurship is neither a full-time occupation nor a profession; rather, it is a state of being for periods of time during which action-oriented conduct is seen to satisfy the requirements that define the entrepreneur. Schumpeter (1951) found three rational motivations that cause the act of entrepreneurship. They are as follows.

1. Motivation to create a personal fiefdom, dynasty or personal kingdom within either the modern industrial or commercial realm, thereby realising independence, which is described as akin to medieval lordship.
2. Motivation from the desire to win, conquer adversity or others, and the will to pursue victory not only in the context of sport or human endeavour but also within an industrial or commercial realm. According to this motivation, it is not the spoils of victory or success that provide the driving force, but the sake of victory or success itself.
3. Motivation from seeking intrinsic pleasure derived from identifying and solving problems through the exercise of one's creativity, ingenuity and energy.

Schumpeter argued that each motivation is a force that causes one to decide to take action and, through that action, bring about the creation of new combinations between the means by which production occurs as well as between producers and consumers (see Becker and Knudsen, 2003, Becker et al., 2012, Hansen, 1938, Schumpeter, 1951, Sundbo, 1998, Sweezy,

1943). As a consequence of making the decision to act, and then acting, which brings into being new combinations that in themselves represent innovation (Sweezy, 1943), the entrepreneur, as defined by Schumpeter (1951), acts similar to the adopter of innovation described by Rogers (2003). While Rogers (2003) did not explicitly refer to Schumpeter's pioneering work, strong conceptual alignment nevertheless exists between their respective theories. This alignment and the relationships between it and innovativeness will be examined within the following section.

### **2.3 Risky decision-making behaviour**

The theory of economic development has at its centre the notions of innovation and the entrepreneur (Schumpeter, 1951), which are described by Sweezy (1943) as the causative factor in change and the causative factor of change respectively. However, as stated earlier, Schumpeter was primarily a business cycle theorist and, as such, did not pursue deep insights into the processes of innovation and innovation decision making (Godin, 2008a, Sundbo, 1998). Schumpeter (1951) did not explicitly consider the detailed causes and, more importantly, the processes through which an entrepreneur decides to introduce an innovation into a given context, circumstance or social system (Godin, 2008a). It was left to scholars such as Tarde (1903) and Ryan and Gross (1943) to develop a body of empirical research to address the means by which the diffusion of innovation takes place (Gomulko, 1971, Kinnunen, 1996, Rogers, 2003, Sundbo, 1998, Wonglimpiyarat and Yuberk, 2005). Rogers' (2003) process-based approach to diffusion is considered seminal in the field, and fundamental to Rogers' innovation diffusion theory is the notion of innovativeness (see Goldsmith and Hofacker, 1991, Goldsmith and Foxall, 2003, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962, Sundbo, 1998). Similar to the definition of innovation, there are inconsistencies in the definition of innovativeness within the literature (Hurt et al., 1977).

Similar to previous sections, Figure 2.5 shows the structural model with the element of innovativeness highlighted, which is the element of the diagram relevant to this section of the chapter.

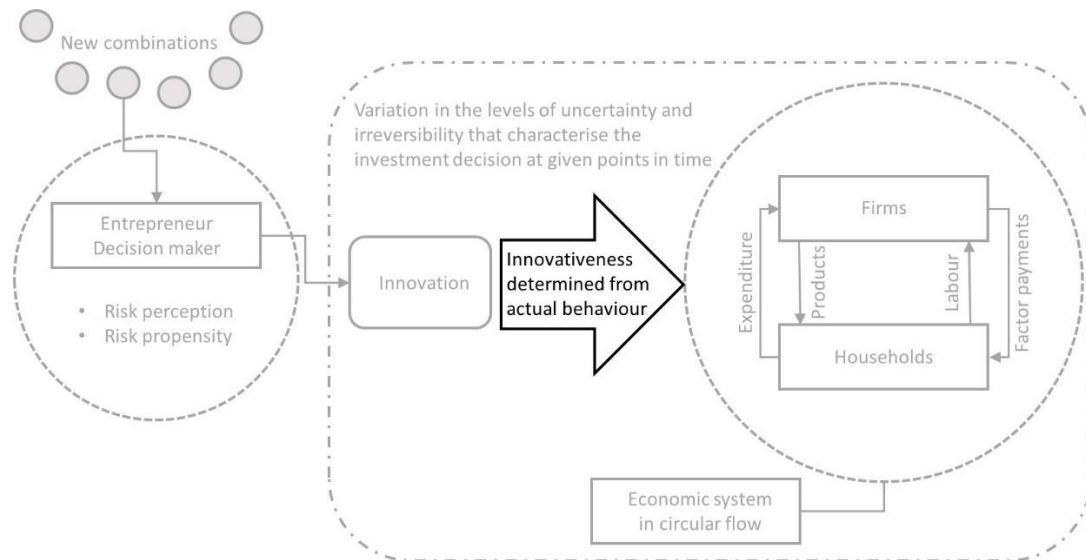


Figure 2.5: Innovativeness highlighted within the structural model

Before examining innovativeness, it is necessary to examine Rogers' (2003) theory of innovation diffusion. This theory uses a process-oriented approach to explain the acceptance and dissemination of innovation among consumers, with decision making and communication among members of a social network at the heart of the concept (Rogers, 2003, Yu and Tao, 2009). Critically, the definition of the social network or social system defines the population set of interest and, as such, also defines the boundary conditions of analysis (Sundbo, 1998). In the business context, the concept of consumers is equally as applicable as it is in the case of individuals, given that business behaviour is seen as the collective behaviour of many individuals acting in a coordinated manner (Rogers, 2003, Yu and Tao, 2009). In support of the argument that business decision behaviours closely reflect the behaviours of individual consumers, Frambach and Schillewaert (2002) and Nelson and Quick (2006) claimed that many studies have determined that organisational decision behaviours inherit both rational and irrational elements that exist in individual behaviour. As such, the behaviour demonstrated by business regarding the adoption of new technology is thought to reflect that of the individual (Rogers, 2003, Yu and Tao, 2009).

The theory is based on the premise that innovation adoption decisions are neither typically authoritative nor collective. Each member of a social system makes their own adoption or rejection decision according to a five-step process of (1) knowledge accumulation, (2) persuasion, (3) decision making, (4) implementation and (5) confirmation (Rogers, 2003). These five steps can be categorised into three decision stages. The knowledge accumulation and persuasion steps represent the precedents to the adoption of innovation, the decision-

making step is representative of the adoption or rejection choice, and the implementation and confirmation steps represent the consequences of adoption and define whether the innovation is continued or abandoned (Rogers, 2003, Yu and Tao, 2009).

The first stage concerns the factors that influence the decision to adopt an innovation based upon the development of favourable or unfavourable beliefs and perceptions, in part arising from uncertainties surrounding an innovation, that may or may not represent reality. The second stage concerns the factors surrounding the actual adoption decision and involves the determination of whether to progress with or reject an innovation (Rogers, 2003, Yu and Tao, 2009). This stage is relevant to this thesis because it is representative of the decision faced by Pat Carter in the ‘Carter Racing’ case study. The third stage represents the performance outcomes and experience following adoption. As a consequence, the nature of decision-maker behaviour within this stage determines whether to continue to support the innovation or discontinue its use (Rogers, 2003, Yu and Tao, 2009). The three stages can therefore be labelled as the pre-decision, in-decision and post-decision stages (Yu and Tao, 2009). The abovementioned five-step process that is categorised into these three stages, as described by Rogers (2003), is depicted in Figure 2.6.

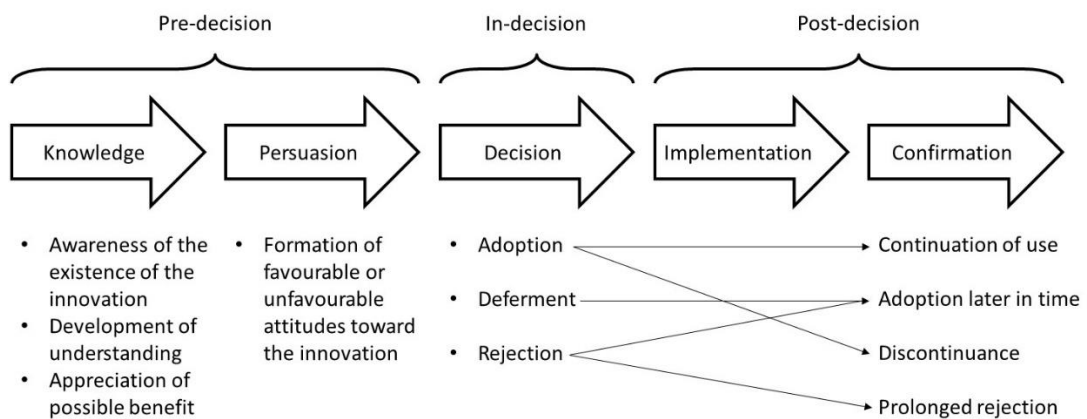


Figure 2.6: Depiction of Rogers’ innovation decision process

Given the relationships between the stages—particularly between the first and second stages—and the nature of the second stage itself and its relationship to the main research problem of this thesis, Rogers’ (2003) innovation diffusion theory has been selected as the theory upon which this study is grounded. Critically, the second stage of the process is the determinant of innovativeness, with the first stage being that which informs and, as such,

leads to the determination of innovativeness (Rogers, 2003). Rogers' innovation diffusion theory has been applied to thousands of empirical studies over several decades involving both individual consumer and business-level adoption of technological innovation, and it is widely referenced and acknowledged within the literature (Frambach and Schillewaert, 2002, Sundbo, 1998). This, coupled with the staged structure of the theory, provides a strong justification for founding this thesis upon Rogers' (1962) innovation diffusion theory.

Importantly, all stages of Rogers' theory (2003) possess and represent varying degrees of uncertainty depending upon the specific circumstances under consideration. However, the first stage is representative of decision uncertainty, which in turn influences the outcome of the second stage irrespective of whether that outcome is for the adoption of innovation or to defer that decision to a later time (Rogers, 2003). Accordingly, this relationship between stage one of Rogers' theory and uncertainty represents a critical relationship between the theories and variables pertinent to this thesis. An equally important relationship exists between stage three, which captures the consequences and implications arising from an adoption decision within stage two, and decision outcome irreversibility. Based upon the two relationships between the stages of Rogers' theory and decision uncertainty and decision outcome irreversibility, an important relationship can be said to exist between Rogers' (2003) innovation diffusion theory and the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994). This is because within the basic theory of irreversible investment under uncertainty, the constructs of uncertainty and irreversibility are combined within an intertemporal framework that explicitly recognises changes to the risk profile of an investment decision over time (Bernanke, 1983, Dixit and Pindyck, 1994, Hanemann, 1989).

As mentioned earlier within this section, inconsistencies exist concerning the definition of innovativeness (Hurt et al., 1977). Nonetheless, all accepted definitions incorporate the principle that individuals differ in their reaction to novelty and new things, with this reaction ranging from rapid engagement and acceptance to utter rejection across the balance of their lives (Goldsmith and Foxall, 2003). These differences in time to adoption underpin the diffusion of innovation within a social system. While the individual consumer or individual entity makes the adoption decision, the aggregate of these individuals or individual entities produces the rate, timing and pattern of diffusion of an innovation within a given a social system (Goldsmith and Foxall, 2003). Critically, this point-in-time relationship combines the notion of innovativeness with the processes of diffusion as described within the literature (see Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Midgley and Dowling, 1978, Rogers, 2003, Sundbo, 1998).

As such, considered from the dimension of time, a number of authors have associated innovativeness with the degree to which one member of a social system, be that member an individual or another unit of adoption such as an organisation, adopts an innovation earlier in time relative to other members of the same social system (see Goldsmith and Foxall, 2003, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers, 2003, Sundbo, 1998). Therefore, the general level of demand for an innovation at a particular point in time is governed by the innovativeness of the individual members within the relevant social system, which in aggregate combine to set both the pattern and pace of diffusion for the innovation in question (Goldsmith and Foxall, 2003, Sundbo, 1998). Accordingly, the demand from an individual or organisation for a given innovation, relative to other individuals or organisations within a particular social system and in regard to time, is representative of the construct described by Rogers (2003) as innovativeness measured in a relative sense. The notion of innovativeness as a relative measure is a fundamental and central construct of the theory of the diffusion of innovation (Midgley and Dowling, 1978, Rogers, 2003).

If the rate of adoption within a given social system for an innovation is cumulatively plotted against the passage of time, the typical result is an S-shaped curve that is approximated by a logistic function (Mansfield, 1961, Rogers, 1976, Romeo, 1975). The origins of this graphical depiction of the adoption rate arose from the seminal work of Tarde in the field of social interaction (Kinnunen, 1996, Rogers, 2003, Sundbo, 1998). Tarde (1903) described a process of imitation whereby the social spread of every new belief and social desire transitions through several distinct phases comprising a slow initial advance, a period of acceleration and then uniform advancement followed by a slackening of progress until stagnation takes place. Of these phases, the second phase was determined to be of the greatest theoretical importance because it demonstrated what was described as the energy of upheaval (Tarde, 1903). Tarde (1903) observed that seeking status was a principle reason for imitation, as innovation was denoted by him, but this would not be possible in the absence of intercommunication between members of a given social system (Rogers, 2003, Tarde, 1903). When plotted against time, these phases of dispersal typify a curve that is representative of what Tarde (1903) described as a hill-like shape that graphically depicts the process of diffusion over time (Rogers, 1976, Sundbo, 1998). A diffusion curve representative of that described within the literature is shown in Figure 2.7 (see Kinnunen, 1996, Mansfield, 1961, Rogers, 1976, Sundbo, 1998, Tarde, 1903).

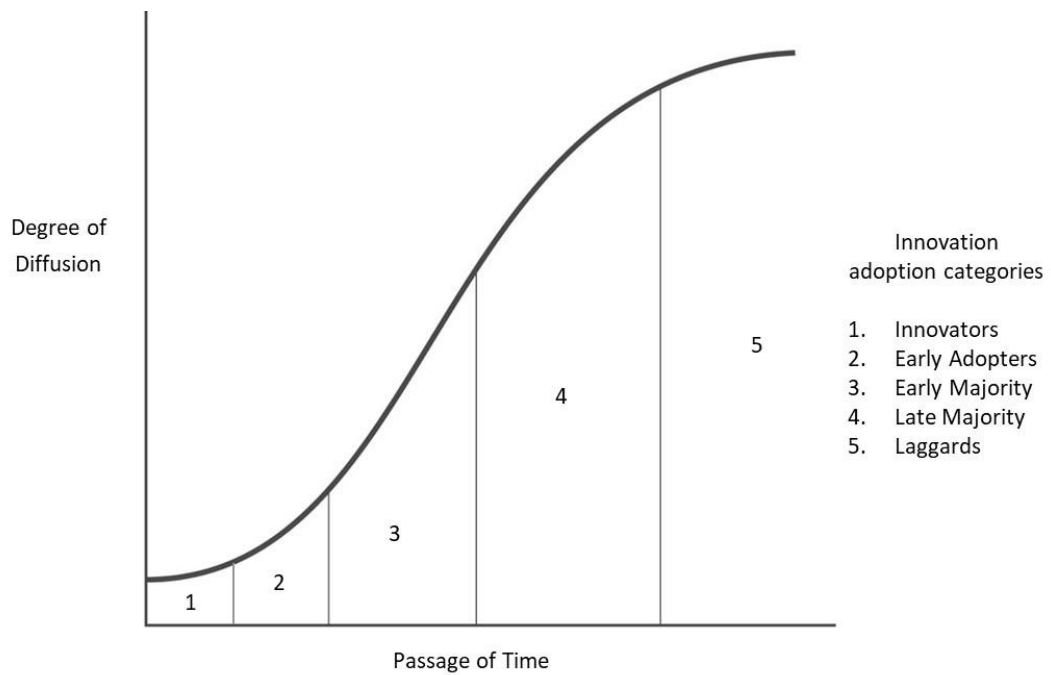


Figure 2.7: A representative diffusion curve showing relation to adopter categories

It is now widely accepted that, irrespective of the specific shape of a diffusion curve or the nature of the social system, the distribution can be divided into five stages (Rogers, 2003). These stages typically demonstrate a low initial growth rate, a transition phase of increasing rates of diffusion, a period of roughly balanced growth, a second transition phase of decreasing rates of diffusion, and growth that is approximately equal to the rate of population growth or the growth rate within the industry (Gomulko, 1971). These five stages are depicted in Figure 2.7 and are representative of and correspond with changes in the rate of diffusion measured against the passage of time.

These stages broadly translate into the five well-known innovation adopter categories of innovator, early adopter, early majority, late majority and laggard. The partitioning between each one enables the separate categories to reflect a discrete propensity for adoption, and each is representative of innovativeness measured in a relative sense (Rogers, 2003). Figure 2.8 shows these five categories depicted in the form of a conventional distribution, the shape and segregation of which has its origin within the works of Rogers (2003).



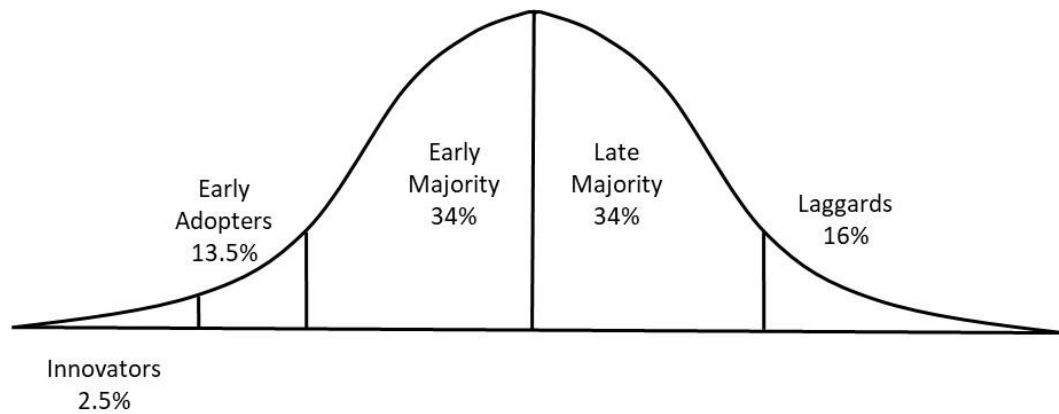


Figure 2.8: Adopter categories partitioned according to innovativeness

According to Rogers (2003), four essential dimensions define the notion of innovativeness: the existence of a specific innovation of some form; channels of communication relevant to that innovation; the passage of time; and a relevant social system that can be defined. Notwithstanding these dimensions, Midgley and Dowling (1978) made an important distinction between the many definitions of innovativeness in that the level of generality or abstraction at which the notion of innovativeness is measured is typically in terms of the relative time of adoption for a single product. Definitions based upon this approach provide a product-centric orientation towards the construct (Hurt et al., 1977, Midgley and Dowling, 1978). To enable the construct to be considered at a more abstract level, Midgley and Dowling (1978) argued that innovativeness is representative of the degree to which an individual is prepared or willing to make innovation adoption decisions independent of, or in the absence of, the communicated experience of others. This definition of innovativeness is not materially dissimilar to that put forth by Rogers (2003). However, a critical distinction is that it is not reliant upon a particular innovation for the measure of relative magnitude; rather, it is representative of a more innate individual trait—namely, a general level of decision-making independence (Midgley and Dowling, 1978). This definition is underpinned by the argument that innovativeness is a somewhat generalisable personality construct that reflects the degree to which a decision maker displays a willingness to change or to adopt change (Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Hurt et al., 1977, Sundbo, 1998).

The change in primary emphasis from a product-based construct to one that is centred upon the measurement of a willingness to change is an important distinction because it shifts the focus from the innovation itself to the individual decision maker (Goldsmith and Foxall, 2003,

Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978). Doing so enables the exploration of two important streams of investigation within the literature. The first is the opportunity to employ a predictive approach to innovativeness and risky decision-making behaviour concerning the adoption of innovations (Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Midgley and Dowling, 1978). The second is that, while each member of society is argued to possess a degree of innate innovativeness as a global personality trait that places them on a continuum of innate innovativeness for a given society (Midgley and Dowling, 1978), there is no guarantee that actual risky decision-making behaviour for a given circumstance, innovation or domain will mirror this inclination (Goldsmith and Foxall, 2003, Midgley and Dowling, 1978).

While the relationship between an individual's global level of innovativeness and domain-specific level of innovativeness may closely correspond, this need not necessarily be so, as the relationship between the two may be situational or domain-dependent (Midgley and Dowling, 1978). Further, while a higher level of a global innovativeness trait may predispose an individual to demonstrate such behaviour across a range of circumstances, this does not guarantee that this tendency will fail to overcome conservatism in some situations. For this reason and for predictive purposes, as stated by Goldsmith and Foxall (2003), it is appropriate to consider innovativeness primarily domain-specific.

Change in emphasis from a product-based construct to one that is centred upon willingness to change is of vital importance to the operational definition of the term 'innovativeness'. The emphasis on a willingness to adopt a measurement method rather than the measurement of time until the point of adoption enables a predictive element to be brought to bear upon the definition. Equally, consideration of innovativeness as a situational or domain-specific characteristic places an important limitation upon the term. Accordingly, for the purposes of this thesis, innovativeness is operationally defined as the degree to which a decision maker is more or less willing to adopt, use and rely upon an innovation, at a given point in time and within a specific context, relative to other members of a social system (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962).

## **2.4 Decision risk trade-offs**

Inherent to both the construct of innovativeness and the processes of diffusion is uncertainty resulting from the lack of predictability, structure and information typically associated with something new (Rogers, 2003). This, in combination with a flow of information becoming available concerning a given innovation over time as it is used and applied within different contexts, serves to progressively reduce the level of uncertainty surrounding it as time passes (Midgley and Dowling, 1978, Rogers, 2003, Sundbo, 1998). The flow of information is central to both the theory of innovation diffusion (Rogers, 2003) and the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994). Accordingly, the flow of information over time relevant to the subject of interest forms a conceptual linkage between the theory of innovation diffusion (Rogers, 2003) and the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994). The flow of information over time relevant to the subject of interest also forms a conceptual linkage between the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994) and the theory of economic development (Schumpeter, 1951, Sweezy, 1943). This is because the accumulated information aggregates as knowledge, which the entrepreneur relies upon when contemplating the introduction of an innovation into an economic system, as well as the timing of that introduction (Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943).

### **2.4.1 The basic theory of irreversible investment under uncertainty**

Uncertainty surrounding an investment decision coupled with the flow and receipt of new information over time has the effect of reducing the level of uncertainty surrounding the decision, which is fundamental to the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994). Also fundamental to the basic theory of irreversible investment under uncertainty is that investment decisions can demonstrate option-like characteristics, as they can represent an opportunity rather than an obligation to incur an expense or liability in the present, with the expectation that future rewards will be forthcoming as a consequence of that decision (Bernanke, 1983, Dixit and Pindyck, 1994, Hanemann, 1989, Smit and Trigeorgis, 2004, Sunstein, 2010). It is the combination of future uncertainties surrounding a decision, some decisions being more difficult to reverse than others and decision-making as a sequential process dependent upon information gathered over time that causes the option-like characteristic of an investment decision to arise and an associated option value to be created (Bernanke, 1983, Dixit and Pindyck, 1994).

Considering decisions, including investment decisions, similar to financial options, wherein the decision is conceptualised as an opportunity to act either now or in the future rather than as an obligation, substantially alters both the theory and the practice of decision making. It also marks out a far richer framework for consideration by managers and decision makers (Dixit and Pindyck, 1995). Conceptualising investment decisions as opportunities rather than obligations not only enables the decision maker to consider, assess and decide upon the most appropriate way to address an opportunity or situation, but also enables consideration of the best means of exploitation (Smit and Trigeorgis, 2004).

Critically, if the decision outcome is irreversible or substantially irreversible, making such a decision exercises the option and effectively sterilises the opportunity to gather additional information that may influence decision choices or the timing of the investment decision (Dixit and Pindyck, 1994). The loss of this opportunity represents the loss of option value, which can be highly sensitive to perceptions of risk and uncertainty surrounding the future (Dixit and Pindyck, 1995), and this loss needs to be explicitly considered during the decision-making process (see Arrow and Fisher, 1974, Dixit and Pindyck, 1994, Dixit and Pindyck, 1995, Henry, 1974a, Henry, 1974b, Marschak, 1949, Smit and Trigeorgis, 2004, Sunstein, 2010, Weisbrod, 1964). Among others, Dixit and Pindyck (1995) and Smit and Trigeorgis (2004) implicitly argued that considering investment decisions as options places far greater importance upon risk and perceptions of risk than do other means of conceptualising the decision-making process, such as calculated return rates. Figure 2.9 depicts the sequential decision-making process described by the basic theory of irreversible investment under uncertainty (Bernanke, 1983, Dixit and Pindyck, 1994). Figure 2.9 demonstrates linkages between the point at which an opportunity is known to exist and the following:

- the level of uncertainty surrounding the opportunity at a point in time
- the level of decision outcome irreversibility at a given point in time
- perceptions of risk within the mind of the decision maker
- the passage of time
- the flow of new information across time relevant to the decision in question
- recognition of the decision choice as an opportunity rather than an obligation.

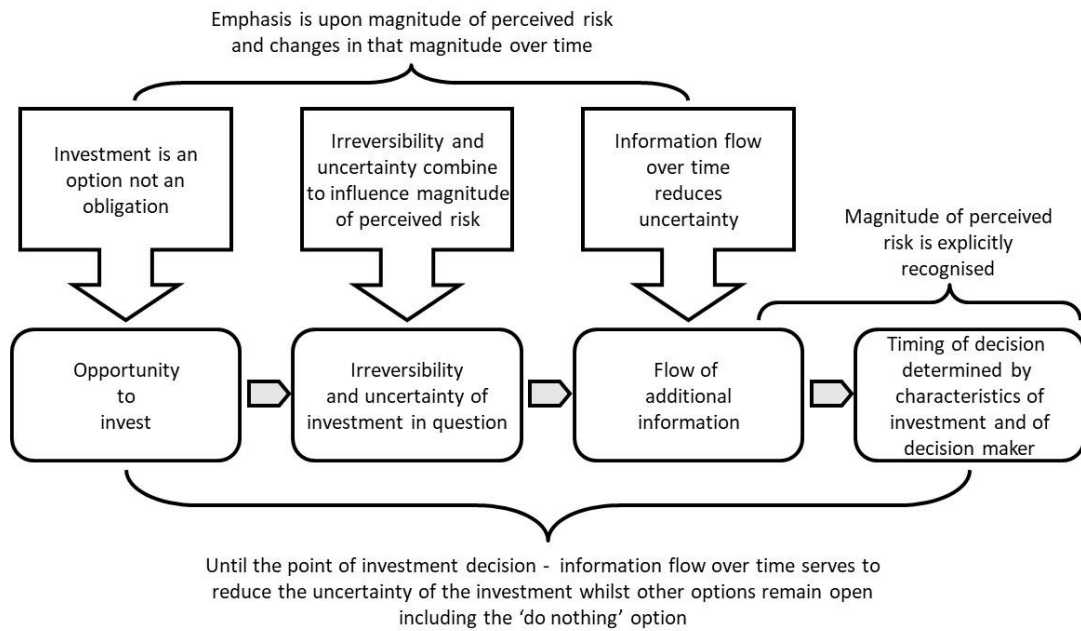


Figure 2.9: Depiction of the basic theory of irreversible investment under uncertainty

Based on the composition of Figure 2.9, the following sections examine uncertainty, irreversibility and option value.

### 2.4.2 Uncertainty

Consistent with prior sections, Figure 2.10 shows the structural model with the elements of uncertainty and irreversibility highlighted, which are relevant to this and the following section of this chapter.

As with the term 'innovation', the term 'uncertainty' has also undergone change over time and has been defined in a range of ways within the relevant literature. The seminal work of Knight (1921), a decision theorist, provided an early and definitive definition for both risk and uncertainty. Knight (1921) claimed that the notion of risk relied upon the ability to prescribe well-defined and objectively known probabilities to instances or outcomes under consideration, whereas the absence of this ability was fundamental to the notion of uncertainty. A proper analysis of the relationship between risk and uncertainty, commencing from the perspective of Knight (1921), is contained in Chapter 3.

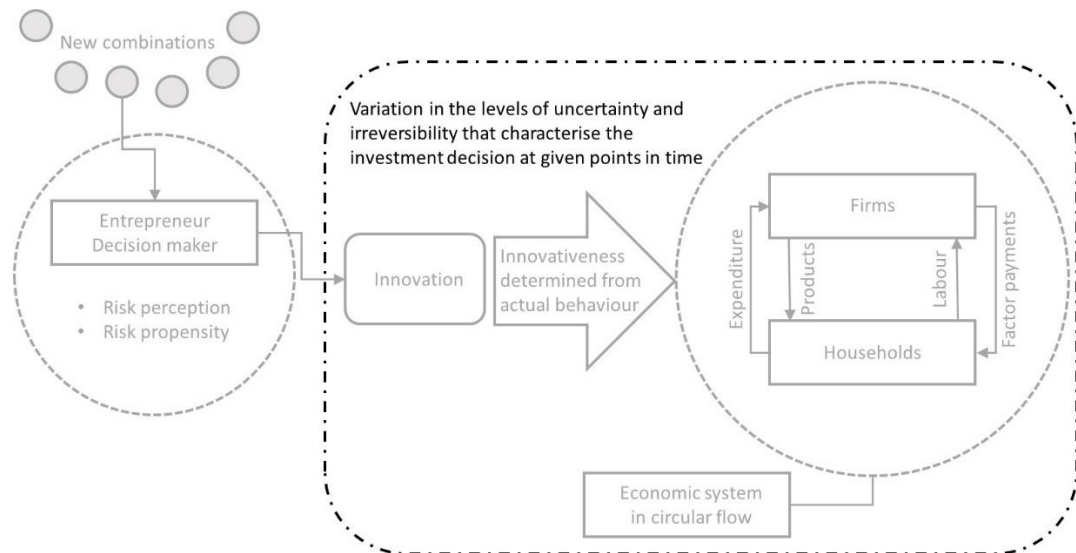


Figure 2.10: Uncertainty and irreversibility highlighted within the structural model

For the purposes of this section, it is considered sufficient if an appropriate operational definition for uncertainty relevant to this thesis is justified. Lawrence and Lorsch (1967) described uncertainty as comprising three separate dimensions associated with (a) the absence of information clarity; (b) the length of time between the point of decision and the point the definitive feedback starts to be received; and (c) a general level of uncertainty concerning the causal relationships in question. This definition is considered both vague and tautological. While it breaks down the notion into components, the lack of clarity within the definition prohibits the development of sufficiently specific operational definitions that are useful (Duncan, 1972). Duncan (1972), in an exploratory study within a manufacturing environment and using a semi-structured interview methodology to understand decision-making processes, identified three similar components of uncertainty. However, in doing so, a far greater degree of specificity was found within each of them. The three components of uncertainty identified by Duncan (1972) were:

- (a) a lack of clarity of information regarding environmental factors associated with a particular decision-making circumstance
- (b) not knowing how much might be lost if the decision choice proved to be incorrect
- (c) an inability to confidently allocate probabilities with respect to how environmental factors may affect outcomes.

Duncan (1972) concluded that the central issue concerning uncertainty was the level of confidence that an individual was prepared to assign to their estimates regarding the subject of interest. In contrast to Duncan (1972), Knight (1921) stated that uncertainty is best demonstrated when a decision maker must rely upon judgement, intuition and common sense to form opinions and guide their conduct in the absence of scientific knowledge or fact. It is argued that the majority of human conduct and most decisions are based on judgement and opinion because in the majority of instances, decisions are made without a definitive understanding of the situation or the decision consequence (Bratvold and Begg, 2010, Knight, 1921, Tversky and Fox, 1995).

For the purposes of this thesis, the term 'uncertainty' describes doubt over the validity of specific measured values or assessed criteria, its magnitude representative of deviation from exact or complete estimation, evaluation or measurement, with the result being incomplete knowledge or understanding (Bratvold and Begg, 2010, Standards Australia, 2009, Standards Australia, 2018, Thompson, 2011). Accordingly, uncertainty is operationally defined within this thesis as the degree of confidence that can be assigned to estimates of values or criteria subject to evaluation, assessment or measurement (Duncan, 1972, Thompson, 2011). As such, this definition of uncertainty is in alignment with Australian and New Zealand Standards AS/NZS ISO 31000:2009 and AS/NZS ISO 31000:2018 (Standards Australia, 2009, Standards Australia, 2018). This operational definition enables uncertainty to be contextualised in terms of the probability of future outcomes, the consequences of future outcomes and the severity of those consequences. Salient examples of uncertainty provided by Milliken (1987) include:

- the ability to predict the future behaviour of a competitor within a marketplace
- whether a national union will call for national strike action to be taken
- the likelihood of deregulation within an industry during the current government term
- the behaviour of competitors within an industry if deregulation should occur
- the effects of competitor behaviour within a deregulated industry
- how effective an option may be in response to industry competitor behaviour.

### 2.4.3 Irreversibility

The notion of irreversibility within the investment decision-making context is of fundamental importance because it refers to the degree to which an investment decision is irreversible. This creates value from the ability to wait and defer the point in time at which the investment decision is made, and it gives rise to option value (Bishop, 1982, Dixit and Pindyck, 1994, Dixit and Pindyck, 1995, Sunstein, 2010). For the purposes of this thesis, irreversibility is operationally defined as the degree to which the consequences of an investment decision can be reversed or substantially reversed after an investment decision is made (see Baldwin and Meyer, 1979, Bernanke, 1983, Bronfenbrenner, 1945, Dixit and Pindyck, 1994, Hanemann, 1989, Henry, 1974a, Marschak, 1949, Pindyck, 1991). A high degree of irreversibility is representative of a circumstance where little, if any, reversal of consequence is possible post–investment decision, whereas a low degree of irreversibility is representative of a circumstance where the opposite is possible. The combination of uncertainty, irreversibility and the opportunity to vary the timing of decision choices has important implications for investment decisions (Dixit and Pindyck, 1995). This combination, in recognition of the fact that investment decisions are opportunities to act and not absolute obligations to do so, creates an environment within which the decision maker must evaluate the possibility of benefits arising from early commitment against the opportunity to learn from information gained by waiting (Bernanke, 1983, Dixit and Pindyck, 1995, Smit and Trigeorgis, 2004). In the absence of irreversibility, such as in the case of a fully reversible investment decision, the value of waiting may be largely irrelevant because the cost incurred by early commitment is negligible if the ability to reverse an investment decision once made is cost free or almost cost free (Marschak, 1949, Dixit and Pindyck, 1994, Smit and Trigeorgis, 2004).

Irreversibility that is defined as the degree to which the consequences of an investment decision can be reversed or substantially reversed after an investment decision is made is analogous to the definition of liquidity provided by Marschak (1949). According to this definition, liquidity is the marketability of an asset across time, with perfect liquidity equal to unity representing a costless exchange and illiquidity being equivalent to zero. As such, perfect liquidity equates to absolute certainty that the total initial cost of an investment decision can be recovered, less depreciation and value in use, immediately at the point in time of a decision to dispose of it (Bronfenbrenner, 1945, Marschak, 1949). Marschak (1949) undertook what is considered one of the earliest insightful studies of how the demand for assets or contracts varies according to the liquidity of those investments under differing



levels of knowledge (Bernanke, 1983). From this, scholars such as Arrow and Fisher (1974), Henry (1974a), Henry (1974b) and Weisbrod (1964) developed a body of literature concerning uncertainty and the value associated with the conscious recognition of outcomes arising from irreversible acts.

This body of literature argues that some irreversible decisions lead to significant consequences, and when this is combined with uncertainty surrounding the case in question, the value of waiting to resolve these uncertainties may become very high, as does the value of pursuing more reversible options (Arrow and Fisher, 1974, Henry, 1974a, Henry, 1974b, Weisbrod, 1964). While recognition of this may give rise to decision inaction and paralysis, the underlying principle of carefully evaluating and balancing the costs and risks of action against the benefits of doing so in the face of uncertainty and irreversibility, especially when profoundly important decisions are at hand, assists to form a more principled approach to decision making (Sunstein, 2005). Nevertheless, such decisions, as referred to by Marschak (1949) in the study of relationships between demand, liquidity and availability of information, are dependent upon the rationality of those who are accountable for these decisions. Similarly, as found by Sitkin and Weingart (1995), how decision makers perceive risk and their propensity for risk can have important implications for decision outcomes involving factors such as and related to uncertainty and irreversibility.

To conclude this section, it is important to examine the notion of irreversibility more deeply because it can be argued that in some sense all losses are irreversible. For example, if Jane decided to play tennis instead of reading, the relevant period of time consumed playing tennis would be lost to Jane forever (Sunstein, 2010). While this explanation of the irreversible loss of time is correct in this circumstance, for the purposes of this thesis this is not the context in which the term 'irreversibility' will be employed. Rather, the influential work of Arrow and Fisher (1974) demonstrates the appropriate usage of the term within decision-making contexts where information is absent, ambiguous and uncertain in terms of both a decision and the irreversible consequences of the decision. However, through the act of waiting, valuable information may be obtained to increase knowledge, improve future decision-making flexibility and reduce the ambiguity and uncertainty surrounding a decision. This will ensure that full consideration is given to all relevant aspects of the circumstance, the irreversible nature of the decision outcomes and the future needs of those whom the decision may effect (Sunstein, 2010). Inherently important in the arguments of Arrow and Fisher (1974) is the magnitude of loss arising from an irreversible decision outcome because the magnitude of loss and the degree of harm generated as a result is central to how the

term 'irreversibility' is employed within decision-making contexts across a broad spectrum of decision-making domains (Arrow and Fisher, 1974, Henry, 1974a, Henry, 1974b, Sunstein, 2010). The magnitude of loss can be evaluated in terms of both the magnitude of loss arising from the sterilisation of an alternative and the degree to which the variety of viable choices is reduced for a long period in the future (Henry, 1974a).

Examples of irreversible decision outcomes relevant to that which is described above are discussed by Pindyck (1991) and include:

- marketing and advertising investment choices
- the purchase of minor assets where the resale value is well below the purchase price
- capital investment decisions, especially those that are industry-specific
- investment choices to which government limitations apply that prevent the relocation of funds post-decision
- industrial plant shutdown and restart decisions in response to market conditions.

It must be stressed that a dichotomy does not exist between decision outcomes that are reversible and those that are irreversible, nor is it argued that a neat continuum exists across a range of irreversible outcomes (Henry, 1974a, Sunstein, 2010). Rather, and beyond the simple notion of a sunk cost, the purpose of irreversibility in a decision-making sense is to illuminate the possible seriousness of irreversible decision consequences. This process of illumination seeks to encourage an informed evaluation of those consequences irrespective of whether they are able to be recovered at great expense and time or, in some cases, not at all (Arrow and Fisher, 1974, Henry, 1974a, Henry, 1974b, Sunstein, 2010). For completeness, it is important to note that in some cases, the losses arising from the irreversible consequences of decision outcomes may be incommensurable because what is lost is qualitatively distinctive and unique, with no means of recovery whatsoever (Sunstein, 2010). This type of loss within the context of the environment forms the basis of the argument presented by Arrow and Fisher (1974), and the evaluation of lost opportunities arising as a consequence of irreversible decision outcomes, as well as the value derived from their preservation, will be examined in the next section.

## **2.5 Option value**

In its simplest form, option value stems from and is representative of the value arising from the ability to wait and defer a decision to a point in the future (Dixit, 1992). Fundamental to option value in regard to investment decisions is the consideration of investment decisions as opportunities to act rather than strict obligations to do so. This brings into play the consideration of the timing of the investment decision as opposed to the binary 'now or never' proposition that is typically inherent within neoclassical investment models (see Bernanke, 1983, Dixit, 1992, Dixit and Pindyck, 1994, Hanemann, 1989, Pindyck, 1991, Smit and Trigeorgis, 2004, Sunstein, 2010). The perspective that investment decisions are opportunities similar to financial options in the form of rights to take action but not obligations to do so dramatically changes both the theory and practice of investment decision making. This is especially so when the decision context is uncertain and the investment decision outcomes are, at least to some extent, irreversible (Dixit and Pindyck, 1994, Dixit and Pindyck, 1995).

Following Weisbrod's (1964) seminal work concerning a decision that would result in the irreversible destruction of a national park and whether potential visitors to the park would be prepared to pay to retain the option of visiting the park in the future, considerable interest has developed surrounding the concept of option value and how it is defined and measured (Hanemann, 1989). Subsequent to the work of Weisbrod (1964), two broad channels of thought have emerged concerning the subject of option value (Hanemann, 1989). The first channel involves the interpretation of option value as similar to a risk premium that, using the example of Weisbrod (1964), is representative of uncertainty surrounding the potential value of the national park if it was to be preserved (Cicchetti and Freeman, 1971, Hanemann, 1989). Importantly, this channel is not reliant upon the passage of time for the formulation of option value (Hanemann, 1989). The second channel is representative of that described by Arrow and Fisher (1974), Dixit and Pindyck (1994), Dixit and Pindyck (1995) and Henry (1974b). It focuses upon the preservation of option alternatives that are considered to be of value and that can cease to exist when an irreversible decision is made. The second channel involves decision outcomes that are, to some extent, irreversible in nature. Uncertainty surrounding the decision and the opportunity for new information to be received as time passes reduces the level of uncertainty surrounding the decision choice up until the point in time that an irreversible decision of some form is made (Hanemann, 1989).

Aligned with the analysis of Hanemann (1989), it is the second channel that is most relevant to this thesis because only this channel explicitly focuses upon the temporal nature of an investment decision opportunity. When irreversibility, uncertainty and the opportunity to wait and gain additional knowledge over time are combined, a later decision in time may be a better one. However, the benefit gained by waiting must be offset against any strategic value stemming from an earlier decision or the value of additional profits from an earlier decision (Dixit and Pindyck, 1994). While optimisation of decision choices involving option values can be quantitatively determined—for example, as shown by Dixit (1992)—the argument of whether waiting is more valuable than the alternative is often qualitative (Dixit and Pindyck, 1995). As such, these types of decisions rely upon the decision-maker's interpretation and depend upon their perceptions of risk concerning the decision and their propensity for risk, as demonstrated by Brittain and Sitkin (1990) and Sitkin and Weingart (1995) in the case of risky decision-making behaviour.

There are inconsistencies in the definitions and methodologies used to calculate option values within the relevant literature. This has led to considerable debate and various methods for the determination of comparative equivalence (see Aslaksen and Synnøstvedt, 2004, Fisher, 2005, Fujii and Ishikawa, 2013, Mensink and Requate, 2005, Requate, 2003, Smith, 1983, Traeger, 2014). While it is beyond the scope of this literature review to consider issues such as option equivalence using differing means of calculation, it is nonetheless important to recognise the existence of inconsistencies and comparative equivalence issues as mentioned by Aslaksen and Synnøstvedt (2004), Fisher (2005), Fujii and Ishikawa (2013), Mensink and Requate (2005), Requate (2003), Smith (1983) and Traeger (2014). Notwithstanding these differences, a valid and useful definition of option value for the purposes of this thesis can be drawn from the literature.

As stated earlier within this section, option value can be conceptualised as a risk premium that is representative of the value in order to preserve that which would otherwise cease to exist as a consequence of an irreversible decision (see Bishop, 1982, Cicchetti and Freeman, 1971, Fujii and Ishikawa, 2013, Hanemann, 1989, Smith, 1983, Traeger, 2014, Weisbrod, 1964). Similarly, and as mentioned previously, option value is also representative of the creation and preservation of valuable opportunities and option alternatives that cease to exist once an irreversible decision is made (see Arrow and Fisher, 1974, Dixit and Pindyck, 1995, Fujii and Ishikawa, 2013, Henry, 1974a, Henry, 1974b, Smith, 1983, Traeger, 2014, Weisbrod, 1964). Accordingly, and regardless of whether option value is conceived as a risk premium that is representative of value at risk as a consequence of an irreversible decision

or whether it is representative of valuable opportunities and alternatives that would cease to exist as a consequence of an irreversible decision, option value can be conceptualised as a measure of what may be lost (Dixit and Pindyck, 1995, Sunstein, 2010). The logic of an option value can be applied to a broad spectrum of circumstances, including non-monetary forms such as preserving the possibility of a couple conceiving another child in the future, or narrowly defined judicial rulings to preserve the potential for future decision flexibility (Sunstein, 2010).

Regardless of the circumstance, relative differences in option values arise from decisions that either create or preserve decision alternatives within an uncertain environment. Decision outcomes may sustain future decision flexibility or, because of irreversibility within an uncertain environment, cause valuable decision alternatives to be exhausted following an irreversible decision (Dixit and Pindyck, 1995). The combination of a specific decision context and possible decision outcome consequences relevant to that context is fundamental to the determination of option values and the optimisation of irreversible decision timing within a given context (Dixit and Pindyck, 1995, Sunstein, 2010). The level of uncertainty, as well as changes in the level of uncertainty over time, give rise to variation in the magnitude of an option value and serve to both amplify and suppress that magnitude based upon new information becoming available (Dixit and Pindyck, 1995). For the purposes of this thesis, option value is defined in alignment with that described by Arrow and Fisher (1974), Dixit and Pindyck (1994), Hanemann (1989) and Henry (1974a).

Accordingly, option value refers to the worth of what is made possible through the ability to postpone an irreversible or semi-irreversible investment decision until a later time. This is to preserve alternatives, maintain flexibility and derive benefits from the flow of new information, which has the effect of reducing the level of uncertainty surrounding an investment decision (Arrow and Fisher, 1974, Dixit and Pindyck, 1995, Hanemann, 1989, Henry, 1974a). The magnitude of an option value may be evaluated based upon the quantum of what may be lost as a consequence of an irreversible or semi-irreversible investment decision and the importance of that loss relative to the circumstance in question (see Dixit and Pindyck, 1995, Freeman, 1984, Fujii and Ishikawa, 2013, Henry, 1974a, Henry, 1974b, Smit and Trigeorgis, 2004, Sunstein, 2010, Weisbrod, 1964). Change in the magnitude of an option value associated with an irreversible or semi-irreversible investment decision can be determined by the degree to which valuable alternatives and flexibility are maintained between two sequential points in time—one being prior to an irreversible or semi-

irreversible investment decision and the other being post that decision (Dixit and Pindyck, 1995, Smit and Trigeorgis, 2004, Sunstein, 2010).

## **2.6 Research gaps**

Each of the three previous sections of this chapter examined one of the three parent discipline fields that support this thesis. While each field is represented by a significant body of literature, and while apparent associations exist among these parent discipline fields, gaps within the literature have been discovered that represent domains where important and interesting knowledge gaps, worthy of exploration, are believed to exist. The main research problem of this thesis seeks to address these gaps, which are considered important because they represent opportunities to develop valuable empirically based capabilities that may enable both the prediction and explanation of risky decision-making behaviour.

Specifically, and despite a plethora of research surrounding the topics of innovation and innovativeness, no studies could be found that have modelled how and in what way uncertainty and irreversibility, in combination, effect risky decision behaviour measured in the form of innovativeness either directly or indirectly, with risk perception acting as a psychometric mediator. Further, no studies could be found that have examined the moderating effect of decision-maker risk propensity on the relationships between uncertainty, irreversibility and innovativeness. These findings justify the claim that important gaps exist within the literature that are worthy of exploration. As a verification step to support these claims, a series of literature review searches were undertaken using Scopus<sup>1</sup>. The searches verified that the modelling of such relationships, and importantly the modelling of such relationships using multiple regression techniques, has not yet been documented. Appendix A contains the results that support this claim. In all cases mentioned in Appendix A, word searches were based upon a combination of title, abstract and keywords.

The first gap verified to exist within the literature is a modelled relationship between variation in the levels of uncertainty and irreversibility and how this variation translates into innovativeness measured in terms of behavioural preferences. The section titled 'Research Gap 1' in Appendix A summarises the results of the relevant literature review search using appropriate search logic combinations.

<sup>1</sup> <https://www-scopus-com.libproxy.ucl.ac.uk>

While 174 items were identified using the terms 'innovativeness' AND 'uncertainty', no items were identified using the terms, 'innovativeness' AND 'irreversibility'. Correspondingly, no items were identified using the terms 'innovativeness', 'uncertainty' AND 'irreversibility'. Given this, the terms 'uncertain' AND 'irreversible' were substituted for 'uncertainty' AND 'irreversibility'. No material improvement was noted in the search results as a consequence of this change.

Following this, the terms 'innovation' AND 'adoption' were substituted for 'innovativeness' to test whether the terms 'innovation' AND 'adoption' would yield an increase in the number of items discovered. This approach resulted in a significant increase in items for the combined terms 'innovation', 'adoption' AND 'uncertainty', and for the combined terms 'innovation', 'adoption' AND 'irreversibility'. However, for the combination of 'innovation', 'adoption', 'uncertainty' AND 'irreversibility', only eight items were discovered, with none demonstrating relevance to the main research problem of this thesis. For example, while Weaver and Wessler (2004) examined the timing of innovation adoption decisions within the biotechnology industry and the relevance of decision uncertainty and decision outcome irreversibility to this, their work does not reflect the main research problem of this thesis. Similarly, in a study of investment decision making involving innovative information technology platforms and the manner in which uncertainty and irreversibility influence such decisions, especially in relation to when firms should pursue a lead role regarding emerging technologies, Fichman (2004) did not address the main research problem of this thesis.

Whereas Fichman (2004) examined the question of when a firm should employ an industry-leading position for information technology-based investments, Farzin, Huisman and Kort (1998) investigated the optimisation of decision rules in environments where competitive firms must consider uncertainties and irreversible outcomes surrounding technology-based investments. They examined quantitatively relative differences in decision timing based upon optimal decision rule outcomes and net present value criteria (Doraszelski, 2001, Farzin et al., 1998). Finally, when the terms 'conjoint' OR 'regression' were added to the search—that is, terms that represent the methodology employed within this thesis—no items were discovered. Thus, this analysis verified that a gap exists within the literature regarding the relationships between innovativeness, uncertainty and irreversibility, as well as the examination of such relationships using conjoint and multiple regression methods.

The second gap verified to exist within the literature is the manner in which measures of risk perception may mediate actual behaviour measured in the form of innovativeness. The

section titled 'Research Gap 2' in Appendix A summarises the results of the relevant literature review search verifications using appropriate search logic combinations. Using the terms 'innovativeness', 'risk perception' AND 'mediate', no items were discovered to exist within the literature. When the term 'mediate' was substituted by the term 'mediation', one item was discovered that concerned an investigation of intentions to use online payments systems within Kuwait (Rouibah et al., 2016). Based upon this outcome, and in a similar manner to the approach taken in the case of the first gap, the terms 'innovation' AND 'adoption' were substituted for the term 'innovativeness'. This change yielded one item for the combination including the term 'mediate', and one item for the combination including the term 'mediation'. For both combinations, the same item was discovered concerning an investigation into how privacy concerns influence consumers' intentions to adopt information technology innovations (Miltgen et al., 2016). Neither Rouibah, Lowry and Hwang (2016) nor Miltgen, Henseler, Gelhard and Popovic (2016) addressed the main research problem of this thesis in any material sense. Accordingly, it is concluded that a gap exists within the literature regarding the mediation effect of risk perception upon innovativeness.

The third gap verified to exist within the literature is the manner in which measures of risk propensity may moderate the relationships between both uncertainty and irreversibility and actual behaviour measured in the form of innovativeness. The section titled 'Research Gap 3' in Appendix A summarises the results of the relevant literature review search using appropriate search logic combinations. Using the terms 'innovativeness', 'risk propensity' AND 'moderate', no items were discovered to exist within the literature. When the term 'moderate' was substituted by the term 'moderation', again, no items were discovered. Following the processes employed for the first and second gap analyses, the terms 'innovation' AND 'adoption' were substituted for the term 'innovativeness'. No items were discovered using either the search logic combination of 'innovation', 'adoption', 'risk propensity' AND 'moderate' or the search logic combination of 'innovation', 'adoption', 'risk propensity' AND 'moderation'. Therefore, it is concluded that a gap exists within the literature in terms of the moderation effect of risk propensity upon innovativeness.

The fourth gap verified to exist within the literature relates to what extent and under what conditions irreversibility may act to moderate actual behaviour in the form of innovativeness and, in doing so, demonstrate the characteristic of an option value. The section titled 'Research Gap 4' in Appendix A summarises the results of the relevant literature review search using appropriate search logic combinations. Given that the combination of the terms



innovativeness and irreversibility yielded no results, as demonstrated above, in regard to the first identified gap within the literature, the terms 'innovation' AND 'adoption' were employed instead of 'innovativeness' in the first instance. Accordingly, using search logic combinations for the four terms of 'innovation', 'adoption', 'irreversibility', AND 'option', eight items were discovered within the literature. While each of the eight identified items examined relationships involving innovation adoption decisions and decision outcome irreversibility, only four of the eight items addressed the subject of option value in some form. Wree and Sauer (2016) undertook an ex-ante assessment of the economic impact of genetically modified wheat, while Zivin and Neidell (2010) studied the effect of technology adoption decisions upon possible future inventions. Fichman (2004) investigated decisions involving the question of when firms should pursue a lead role regarding emerging technologies, while Doraszelski (2001) critically reviewed and commented upon the work of Farzin, Huisman and Kort (1998), as mentioned previously, in regard to the first gap mentioned previously. Other than for word associations involving the terms 'innovation', 'adoption', 'irreversibility' AND 'option', none of the eight items discovered demonstrated material relevance to the main research problem of this thesis.

In combination, the existence of these four gaps within the relevant literature justify the main research problem of this thesis.

## **2.7 Chapter summary**

This chapter has provided a review of the literature drawn from the major parent discipline field relevant to this thesis. In doing so, it has explained the nature of the conceptual framework against which this thesis is framed. The chapter commenced with the background in the form of Schumpeter's (1951) theory of economic development, which comprises the dimensions of an economic system in circular flow, innovation and the entrepreneur. It then introduced the subject of innovativeness drawn from Rogers' (2003) theory of innovation diffusion. In doing so, the relation between the separate theories of Schumpeter (1951) and Rogers (2003) was demonstrated, as was the relevance of innovativeness to the purposes of this thesis. Following this, the subjects of uncertainty and irreversibility, drawn from Dixit and Pindyck's (1994) basic theory of irreversible investment under uncertainty, were brought into the developing conceptual framework of literature. In parallel, the relevance of uncertainty and irreversibility to both the conceptual framework and the work of

Schumpeter (1951) and Rogers (2003) was highlighted. Option value was then introduced, and its relation to the other parent discipline themes and essential relevance was provided. Importantly, within this chapter, four significant and important gaps within the literature were identified that give rise to the main research problem addressed by this thesis. Two of these gaps rely upon risk perception and risk propensity, which were mentioned within this chapter. Both of these risk-based psychographic variables will figure prominently within the analysis of the literature review undertaken within the next chapter. The parent discipline themes, in combination with the overarching background provided by the three dimensions that frame Schumpeter's (1951) theory of economic development, form a comprehensive analysis of the literature of the parent discipline field. It both underpins this thesis and serves to introduce the literature within the immediate discipline field discussed in Chapter 3. In combination, the literature review of the parent and immediate discipline fields enables the development of both the analytic model, which will be employed to address the main research problem of this thesis, and the necessary hypotheses in Chapter 4.

### **3. LITERATURE REVIEW: IMMEDIATE DISCIPLINE FIELD**

#### **3.1 Introduction**

Chapter 2 reviewed Schumpeter's theory of economic development (Schumpeter, 1951) as a background together with other relevant literature that, in combination, forms the parent discipline themes of this thesis. Three major parent discipline theme categories related to the study were examined: risky decision-making behaviour, decision risk trade-offs and option value. Through this analysis, four significant and materially important gaps were identified within the literature from which the main research problem flows. While Chapter 2 examined the background and parent discipline themes relevant to this thesis and the main research problem addressed by it, this chapter builds upon the content of Chapter 2 through a narrowing of focus upon the immediate discipline field that ultimately leads to the analytic model and the hypotheses that will be tested in Chapter 4. Accordingly, this chapter, with its focus upon the immediate discipline field, centres upon the review of the appropriate dimensions of risk to enable the development of the analytic model that guides this study and the hypotheses upon which it depends.

The chapter commences with justification for the review of literature on the subjects of risk, risk perception and risk propensity within it as part of the immediate discipline field rather than in Chapter 2 and among the material that is representative of the parent discipline field. The contradiction, controversy and low level of consensus surrounding the definition of risk in a general sense is then discussed to establish a foundation upon which a more detailed examination of the term can be constructed. The aim is to identify a clear and unambiguous definition of risk that is appropriate for this thesis and to enable this term to be distinguished from risk perception. The chapter first examines the definition of risk starting from the perspective of Knight (1921) and others who present definitions aligned with what Holton (2004) considered an objectivist interpretation, whereby risk is juxtaposed against uncertainty (see Aven, 2010c, Crowe and Horn, 1967, Fischhoff et al., 1984, Knight, 1921, Holton, 2004, Langlois and Cosgel, 1993, Luce and Raiffa, 1958, Morris, 1972). Then, what Holton (2004) described as a subjectivist interpretation of risk is introduced, which is representative of most contemporary thought concerning risk from a decision-making perspective. Rather than requiring the definition of risk to be conceptually juxtaposed with that of uncertainty, as is the case according to the objectivist point of view, the subjectivist approach removes this separation. Instead, uncertainty and subjective judgement become

central elements of, and essential to, the definition of risk itself (Aven and Renn, 2009, Bratvold and Begg, 2010, Fischhoff et al., 1984, Gough, 1990, Holton, 2004, Langlois and Cosgel, 1993, Vlek and Stallen, 1980).

Following this, the focus of the chapter turns to the framing of a contemporary definition of risk that is aligned with the needs of this thesis and justified in terms of arguments drawn from the relevant literature. From this, the basis upon which risk is distinguished from risk perception is justified before examining the means through which the term 'risk' is operationalised. Following this, the chapter concludes with an analysis of both risk perception and risk propensity, with justifications provided in both instances for the manner in which each is conceptualised in forms that are relevant to this thesis.

### **3.2 Setting the scene for the immediate discipline field**

Before developing hypotheses that link directly back to the main research problem stated in Section 1.4 via the six research questions detailed there, it is necessary to develop, state and justify the definition of risk used within this thesis, as well as the respective definitions of the two psychographic variables of risk perception and risk propensity. In doing so, it is important to first clarify why, from a structural perspective, this content is included in Chapter 3 among the immediate discipline field content prior to the analytic model and the hypotheses rather than in Chapter 2 among the content drawn from the parent discipline fields.

The purpose of Chapter 2 was to provide a thorough grounding for the thesis within the relevant literature in terms of both the background framing of Schumpeter (1951) and the three literature classification groups that form the major parent discipline themes from which the four research gaps were identified in Section 2.6. Building upon the analysis undertaken in Chapter 2 and the research gaps derived from it, this chapter examines the immediate discipline field that underpins this thesis, which leads to the development of the analytic model that guides this study and the hypotheses upon which it depends. As mentioned previously, Sitkin and Weingart (1995) are central to the genesis of this thesis, the main research problem and the analytic model as described later in this chapter. Given this, together with the centrality of risk, risk perception and risk propensity to the analysis undertaken by Sitkin and Weingart (1995), the inclusion of risk, risk perception and risk propensity within the immediate domain, rather than among the broader landscape of background and parent discipline themes, is considered justified.

Risk and the management of risk have been the ongoing subject of considerable and ever-present scrutiny within the fields of science, industry, insurance, the environment and public policy. This has resulted in the development of an entire field of literature dedicated to the subject in parallel to the creation of dedicated government agencies and departments within corporate bodies (Aven, 2010c, Bratvold and Begg, 2010, Crowe and Horn, 1967, Fischhoff et al., 1984, Vlek and Stallen, 1980). Risk and risk management are integral components of modern society and essential to its accepted functioning (Bratvold and Begg, 2010, Crowe and Horn, 1967, Fischhoff et al., 1984, Gilboa, 2009, Gilboa, 2010, Holton, 2004, Huff et al., 1997, Vlek and Stallen, 1980). From a historical perspective, the notion of risk can be traced to ancient times (Bernstein, 1998).

Against this background, it is important to note the existence of contradiction, controversy and a far lower level of consensus than might be expected concerning the ultimate definition of risk given the importance of the topic to the functioning of modern society and industry (see Althaus, 2005, Amundrud and Aven, 2015, Aven and Renn, 2009, Aven, 2012, Campbell, 2005, Crowe and Horn, 1967, Fischhoff et al., 1984, Hillson, 2002, Holton, 2004, Rosa, 1998, Schaefer, 1978, Solberg and Njå, 2012, Vlek and Stallen, 1980). While a broad range of discussion and analysis exists concerning the definition of risk, a similarly diverse spectrum of definitions has developed over time. Relative to this diverse spectrum of definitions, efforts to consolidate the many and differing definitions of risk within the literature are scarce (see Amundrud and Aven, 2015, Aven and Renn, 2009, Crowe and Horn, 1967, Holton, 2004, Libby and Fishburn, 1977, Rosa, 1998, Schaefer, 1978, Solberg and Njå, 2012). Further, there is debate within the literature regarding whether risk is purely epistemic in nature and dependent upon available knowledge, experience and perception or whether it possesses an independent ontological status (see Aven, 2012, Beck, 1992, Freudenburg, 1988, Jasanoff, 1999, Rosa, 1998, Slovic, 1992, Solberg and Njå, 2012).

It is also important to note that a similar level of inconsistency and contradiction surrounds that which is claimed to be the etymology of the term (Althaus, 2005, Aven, 2012). Aven (2010a) stated that while the individual needs of business, medicine and engineering, for example, require different sets of risks methods, models and procedures, there should be no reason why each sector should have different conceptual perspectives about how to interpret the concepts of risk and uncertainty. In each instance, the basic challenge is to conceptualise that a process, activity or system could yield future outcomes, consequences and severity of those consequences that differ from those that are planned, desired or expected as a result of the uncertainty and that do not correspond with previously stated

objectives (Aven, 2010a, Aven and Renn, 2009, Bratvold and Begg, 2010, Standards Australia, 2009, Standards Australia, 2018).

As a result of these circumstances, where clear and unambiguous definitions of risk are absent or no explicit definitions are provided, situations can arise whereby the exact nature of what is being measured, compared or communicated is not precise and distinct (Aven and Renn, 2009, Holton, 2004). Therefore, given that risk, risk perception and risk propensity are vital to this thesis, it is important to achieve clarity concerning the definition of risk and its relation to both uncertainty and risk perception within this thesis. Accordingly, the definition of risk from a Knightian perspective will be examined first.

### **3.3 Risk and uncertainty juxtaposed**

As mentioned in Section 2.4.2, the seminal work of Knight (1921) provided definitions for both risk and uncertainty, with the primary distinction between them being whether well-defined and objectively known probabilities can be ascribed to possible instances or outcomes (Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987). Knight (1921) argued that in considering risk, decision makers may rely upon scientific knowledge as well as direct and indirect experience to mechanistically define objective probabilities for sets of probable outcomes to assist with the decision-making process (Langlois and Cosgel, 1993). However, if this knowledge is not available to enable decisions to be made on an objective basis, decision makers are forced to rely upon subjective judgement and the organic development of opinion in the face of uncertainty for the purposes of advancing the decision-making process (see Crowe and Horn, 1967, Gilboa, 2009, Knight, 1921, Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987).

The approach employed by Knight (1921) for both the definition of risk and the delineation between risk and uncertainty is said to be illustrative of an objectivist approach as it is dependent upon whether subjective judgement must be employed because only partial knowledge is possessed (Holton, 2004, Langlois and Cosgel, 1993). Considering risk from the perspective of the objectivist, it is the absence of justified and objective knowledge that gives rise to uncertainty (Holton, 2004, Knight, 1921). According to Knight (1921), uncertainty must not come about through factual ignorance. Rather, gaps in information and knowledge that are necessary to give rise to uncertainty must come about through necessity (Holton, 2004, Knight, 1921, Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987). That is, for the condition

of uncertainty to be present, these gaps in knowledge must exist because the information required to address them is not yet able to be known; as such, the necessary information and required knowledge to resolve these gaps is said to be currently unknowable (Holton, 2004, Knight, 1921, Langlois and Cosgel, 1993). An important question arises in regard to the distinction employed by Knight (1921), and its reliance upon objective probability and knowledge of this, concerning how and by what means necessary ignorance is adequately distinguished from simple ignorance for any given circumstance (Langlois and Cosgel, 1993). Other than recognising this, it is beyond the scope of this thesis to examine this question further.

As an objectivist, Knight (1921) argued that if knowledge of the future is only partial, then the objective classification of possible future instances and outcomes tends towards an impossibility, as the true factual circumstances surrounding future situations cannot be adequately understood (Langlois and Cosgel, 1993). Accordingly, the delineation between risk and uncertainty based upon Knight (1921) depends not simply upon whether probabilities can be described for possible outcomes but upon whether, in the first instance, there exists a valid means for deriving and classifying future instances before any attempt to assign probabilities to them (Langlois and Cosgel, 1993). Knightian uncertainty can best be explained through example. A contemporary example is the emergence and global spread of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The lack of experience with this new virus in the human population necessitates a subjective estimation of the range of possible future instances caused by the virus, as well as the probabilities of occurrence in each instance. However, as experience is gained and more is understood about the virus and its effects, the range of possible future instances will become increasingly clarified, as will the probabilities of occurrence in each instance (Okamoto, 2020). The effect of this will be to transition the circumstance according to Knight (1921) from one of uncertainty to one of risk. This was denoted by Knight (1921) as risk categorised in the form of a statistical probability, because it would become possible to empirically classify the possible instances (Runde, 1998). This example shows that the correct interpretation of Knight (1921) with respect to both risk and uncertainty is not necessarily evident at first glance (Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987).

Regardless of any complexity in the correct interpretation of Knight (1921), those aligned with an objective interpretation of the difference between risk and uncertainty, including Crowe and Horn (1967), Luce and Raiffa (1958) and Morris (1972), showed that risk and uncertainty are distinct and mutually exclusive concepts. As a result, uncertainty is not

contained within the objectivist's definition of risk (Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987). Delineation is achieved through the definition of uncertainty being reliant upon the existence of subjective probabilities caused by necessary ignorance, and it may also entail the inability to validly derive properly classified future instances, outcomes and states (Holton, 2004, Knight, 1921, Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987). Alternatively, the definition of risk can be said to relate to objectively known and understood outcome probabilities associated with validly derived and properly classified future instances, outcomes and states (see Crowe and Horn, 1967, Gilboa, 2009, Knight, 1921, Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987, Luce and Raiffa, 1958).

Considerable discussion and analysis exist within the literature concerning whether this rigid dichotomy adequately reflects how Knight (1921) wished to articulate the difference between the terms 'risk' and 'uncertainty', or whether the substance of that distinction resided at a much more subtle and complex level (Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987). For the purposes of this thesis, it is not necessary to pursue further analysis of the literature surrounding risk and uncertainty from the position of Knight (1921). It is sufficient to recognise that an important conceptual foundation arose from Knight's (1921) seminal analysis, from which contemporary understandings of risk have developed (Langlois and Cosgel, 1993, LeRoy and Singell Jr., 1987) that usefully inform this thesis.

Most contemporary definitions of risk encompass both a measure of uncertainty and a measure of exposure or consequence of some form arising from uncertainty (see Amundrud and Aven, 2015, Aven, 2012, Bratvold and Begg, 2010, Fischhoff et al., 1984, Vlek and Stallen, 1980). However, the definition of risk employed by Knight (1921) and others who adopt a similar objectivist approach, such as Crowe and Horn (1967), Luce and Raiffa (1958) and Morris (1972), does not include these measures. Objectively interpreted descriptions of risk that employ a binary means for their definition, such as that provided by Crowe and Horn (1967), Knight (1921), Luce and Raiffa (1958) and Morris (1972), exclude consideration of exposure and consequence arising from a given circumstance. Further, in regard to this thesis, they exclude whether the possible exposures and consequences are, in fact, materially significant to the case under consideration (Holton, 2004). Accordingly, the definitions of risk described by Crowe and Horn (1967), Knight (1921), Luce and Raiffa (1958) and Morris (1972) are inappropriate for this thesis.



### **3.4 The integration of uncertainty within the definition of risk**

A contemporary alternative to the objective interpretations of Crowe and Horn (1967), Knight (1921), Luce and Raiffa (1958) and Morris (1972) is illustrated by Aven and Renn (2009), wherein risk is said to be representative of both uncertainty and severity of consequence associated with some activity, situation or circumstance, where both must be considered simultaneously. In describing risk in this manner, risk loses the objective requirement of probability prescribed by Knight and instead refers to uncertainty about the consequences and the severity of those consequences associated with an activity, situation or circumstance (see Aven and Renn, 2009, Bratvold and Begg, 2010, Fischhoff et al., 1984, Gough, 1990, Holton, 2004, Vlek and Stallen, 1980). Importantly, uncertainty of outcomes and uncertainty surrounding the severity of consequences must be associated with something of human value in some sense (Aven et al., 2011, Aven and Renn, 2009). The condition that the activity, situation or circumstance represents something considered as being of value in some sense is a vital aspect of the conceptualisation of the term because it gives weight to the consequences or outcomes. In the absence of this requirement, it would be unclear whether the consequences or outcomes in question actually mattered (Aven and Renn, 2009). The inclusion of consequence within the risk construct as opposed to the expected value approach of Knight (1921) also enables consideration of circumstances that are very low probability but very high consequence, as in the case of nuclear accidents and acts of terrorism, without which the weight of such events would not be adequately recognised (Aven, 2010c).

The second half of the twentieth century has witnessed a shift in emphasis from the objective interpretation of risk described by Crowe and Horn (1967), Knight (1921), Luce and Raiffa (1958) and Morris (1972) to a set of definitions within the decision-making context that encapsulate, to varying extents, uncertainty about potential outcomes and recognition of potential consequences (Aven and Renn, 2009, Bratvold and Begg, 2010, Fischhoff et al., 1984, Gough, 1990, Holton, 2004, Vlek and Stallen, 1980). A spectrum of such definitions has come to exist, but it is important to note that this convergence is not universal. For example, within the fields of economics and finance, risk is representative of a measure of uncertainty, not in terms of probabilities of outcomes and the consequences arising, but in regard to variance or standard deviation (Bratvold and Begg, 2010). For the purposes of this thesis, definitions of this type are excluded from consideration because they represent what can be considered a special type. Rather, the type of definition of risk relevant to this thesis is that which prevails both within the social sciences and more generally (Aven et al., 2011, Aven

and Renn, 2009). Common to the prevailing definitions of this type are two conditions as mentioned at the start of this section. First, risk arises from outcomes and severity of consequences that are each subject to uncertainty. Second, the context within which the activities, events or circumstances occur is of human value (Aven et al., 2011, Aven and Renn, 2009).

It is important to emphasise that a high level of uncertainty does not necessarily give rise to a high level of risk (Aven and Renn, 2009). Comparisons made between risk scenarios must consider the two dimensions of uncertainties and the severity of consequences relative to what is of human value simultaneously. What is thought to be at stake is a critical determinant of risk (Aven and Renn, 2009, Rosa, 1998). For example, consider a hypothetical stunt performer act in which two possible outcome states may eventuate being in the worst case either the loss of one leg or alternatively death, correspondingly labelled as outcomes A and B. The likelihood of each possible outcome state is equally uncertain, and the occurrence of the worst-case consequence for A is highly uncertain. However, should B occur, then death would be a near certainty. Relying upon an assumption that it is human life that is most highly valued, B is of the greatest risk given what is at stake and the low level of uncertainty surrounding the death of the performer should B eventuate. As such, the risk of the act would be evaluated on this basis.

Alternatively, using the same uncertainties for the likelihood of the outcome states but different consequences and uncertainty of the consequences in each instance, a very different risk outcome emerges. For example, if the nature of the consequences arising from A is highly uncertain, while for B the worst-case consequence is expected to be a minor injury, then A represents the greatest risk of the act because of the level of uncertainty surrounding the severity of the consequences that may eventuate from it.

### **3.5 Framing a contemporary definition of risk**

As mentioned previously, no widely agreed historical or contemporary definitions of risk exist within the literature (see Althaus, 2005, Aven and Renn, 2009, Campbell, 2005, Crowe and Horn, 1967, Fischhoff et al., 1984, Hillson, 2007, Holton, 2004, Rosa, 1998, Schaefer, 1978, Solberg and Njå, 2012, Vlek and Stallen, 1980). Nevertheless, it is possible to prescribe simple but important underlying premises that definitions of risk must satisfy at the most basic level to be considered adequate contemporary representations of the concept (Aven, 2012). In an

analysis of the concept of risk and trends in the development of the term, Aven (2012) provided two such premises that usefully inform the manner through which the term can be interpreted for the purposes of this thesis. These two premises are as follows.

1. The definition of risk should be such that it enables risk, of itself, to be differentiated from the way risk is managed.
2. The definition of risk should be such that it enables risk, of itself, to be differentiated from the way risk is perceived.

These premises provide a useful starting point for both the framing of definitions of risk in a general sense and for the selection and development of a justified definition that is both appropriate and appropriately justified for this thesis. To summarise the nature of each premise, the purpose of the first is to distinguish between what risk is said to be from the means by which it may be dealt with (Aven, 2012). Similarly, the purpose of the second premise is to distinguish between and separate what risk is said to be and personal feelings, judgements and affections associated with and arising from circumstances that are said to characterise risk (Aven, 2012, Aven and Renn, 2009). Aven (2012) claimed that little argument should be expected to arise in regard to the first premise, although it must be recognised that definitions of risk do exist that do not satisfy this premise. For example, the definition provided by Beck (1992) does not satisfy the first premise as it claims that risk represents a systematic method for the management of hazards arising from the modernisation of society (Aven, 2012, Beck, 1992, Campbell and Currie, 2006). Definitions of risk that describe the term as a method that is employed to manage effects within a constrained period of history are considered inadequate representations of the concept (Aven, 2012, Campbell and Currie, 2006); thus, they are excluded from further analysis within this thesis. The first premise is considered to usefully contribute to the development of a definition of risk that is appropriate for this thesis.

However, acceptance of the second premise is not so straightforward. By adopting a position drawn from constructivism, it can be argued that risk and risk perception are not individually distinct but are instead one and the same (Aven and Renn, 2009, Rosa, 1998, Slovic, 1992). This claim arises from a position that argues that the notion of risk is reliant upon perceptions of it and that, consequently, risk as an entity has no independent existence from perceptions

of it (Aven, 2010a, Beck, 1992, Freudenburg, 1988, Jasanoff, 1999, Rosa, 1998, Slovic, 1992). Analysis of the distinction specified within the second premise above, as relevant to this thesis, as well as a critical review of and justification for that distinction, is undertaken within this and the subsequent section. However, it is sufficient to state that the question of whether risk, of itself, is believed to exist separate from perceptions of it largely depends upon how risk is first conceived in a metaphysical sense and thereafter defined (see Aven, 2010a, Aven, 2012, Campbell and Currie, 2006, Rosa, 1998, Solberg and Njå, 2012).

At the next level of detail beyond the two basic premises described above, Aven et al. (2011) specified three primary categories across which it is possible to allocate the majority of contemporary risk definitions. Building upon the two premises mentioned above, these categories of risk provide three different interpretations of the term, with each enabling the nature of the term to be conceptualised within a different form. Importantly, consideration and analysis of these categories, as well as the type of definitions of risk applicable to each category, clarifies questions surrounding the second premise mentioned above.

The three primary categories of risk specified by Aven et al. (2011) are distinguished based upon the following interpretations:

- (a) Risk defined as a concept founded upon uncertainties, events and consequences: This interpretation of risk may be illustrated by considering a boulder precariously perched high above a pathway frequented periodically by a given person. It cannot be known when the boulder will dislodge, whether the given person would be struck by it and what the severity of their injury would be (Aven et al., 2011, Rosa, 2010).
- (b) Risk in the form of a modelled quantitative concept that reflects aleatory uncertainties: This interpretation of risk relies upon the probabilistic determination of an event based upon a sufficiently large number of trials and tests for the purpose of determining the limit of the event frequency (Aven et al., 2011). An example of this interpretation is risk represented through the derivation of endurance-based performance characteristics associated with manufactured components used within aircraft and aircraft engines (Singpurwalla, 2006).
- (c) Definitions of risk based upon subjective knowledge-based measurements and probabilities: This interpretation of risk relies upon the assignment of subjective probabilities that reflect the background experience and knowledge possessed by an

assessor. Examples that are relevant to this interpretation include participation in games of betting and chance (Aven et al., 2011, Singpurwalla, 2006).

Definitions of risk allocated within category (a) include those that rely upon events and consequences that may or may not occur because of uncertainty. That is, the events themselves, along with the associated consequences and the severity of those consequences, may be subject to uncertainties, with the consequences arising relevant to something of human value (Aven and Renn, 2009). Definitions to which category (a) also apply include those in which risk is described as, for example, the effect of uncertainty upon objectives (Aven, 2011, Bratvold and Begg, 2010, Hillson, 2002, Hillson, 2007, Standards Australia, 2009, Standards Australia, 2018). Risk defined as the effect of uncertainty upon objectives is the definition of risk contained within the AS/NZS ISO31000 standard for risk management (Aven, 2011, Standards Australia, 2009, Standards Australia, 2018). However, according to Aven (2011), definitions of risk that permit the characterisation of an event to become merged within the consequence of it, or similar simplifications within a definition's structure, result in a lack of sufficient precision in terms of both descriptive power and applicability.

Aven (2011) illustrated that if risk is associated with uncertainty and uncertainty is only mentioned in regard to objectives, what does this mean and what is the actual effect of uncertainty within the circumstance in question? How is uncertainty to be understood to take effect? Further, if risk, by definition, relates to objectives of some form, what if these objectives are ill-defined or poorly conceived? Does this mean that there is no risk even if the consequences are materially significant? Notwithstanding these deficiencies within the definitions as highlighted by Aven (2011), category (a) is purposefully defined in such a way to accommodate a range of definitions. However, and as it is with categories (b) and (c), only a subset of the total population of definitions applicable to category (a) present with sufficient descriptive precision and clarity (see Aven, 2010a, Aven, 2011, Aven et al., 2011).

For category (a) definitions of risk that provide the necessary precision and clarity as described by Aven (2010a), Aven (2011) and Aven et al. (2011), risk may be formalised as:

$$Risk = f(A, C, U)$$

where *A* represents initiating events, subsequent events and scenarios, *C* represents the outcome consequences and *U* represents uncertainty surrounding the underlying factors that influence and effect both *A* and *C*. The interpretation of the category (a) description should not limit uncertainty so it is considered only in general terms or in regard to events and not consequences, or vice versa. Instead, uncertainty must be considered in terms of both the events themselves and in regard to consequences and the severity of the consequences that arise from those events (Aven, 2010a, Aven, 2010b, Aven, 2011, Aven and Renn, 2009, Aven et al., 2011). Such precision is necessary to ensure that the requisite attributes from which risk is conceived and that are referred to within category (a) can be brought into full view and effect. The same requirement for precision is also necessary in regard to the terms 'uncertainty' and 'severity'. For completeness, uncertainty concerning events and consequences can be described in the form that for a specific event we do not know if it will occur or not, and for that event we do not know what the consequences of it will be, including the severity of those consequences if the event occurs (Aven, 2011).

In terms of definitions of risk represented by category (a), uncertainty is typically measured by degree dependent upon the level of knowledge available (Aven, 2011, Aven et al., 2011, Duncan, 1972). In this regard, the definition of uncertainty described by Aven (2011) corresponds with the definition of uncertainty employed by this thesis, as well as the analysis of relevant literature concerning uncertainty in Sections 2.4.1 and 2.4.2. In regard to the term 'severity', in the form of severity of consequences, this should be interpreted as a measure of consequential magnitude in regard to something of human value, measured in terms of, for example, financial impact, number of lives lost, environmental loss, expansion of scope or intensity of impact (Aven, 2011, Rosa, 1998, Solberg and Njå, 2012). As with uncertainty, an appropriate scale is necessary for the interpretation of severity to enable interpretation or measurement by degree (Aven, 2011).

While the emphasis within category (a) definitions of risk is upon uncertainties, events and consequences, the emphasis of category (b) and category (c) definitions is upon probabilities

and expected values (Aven et al., 2011). However, although categories (b) and (c) represent definitions based upon probabilities and expected values, they each address the probability of events in different ways (Aven et al., 2011). Specifically, category (b) definitions represent frequentist probabilities—that is, probabilities that represent the number of times a specific event occurs when an infinite population is considered that comprises similar scenarios or circumstances to that which is analysed. Conversely, category (c) definitions are based upon subjective probabilities derived from an assessor’s judgement and knowledge through which the assessor expresses the probability—that is, their degree of belief—that a specific event will occur (Aven, 2010a, Aven et al., 2011). To generate the necessary estimates for the determination of frequentist probabilities associated with category (b), risk measurement processes allocated as being within category (c) must first be relied upon (Aven et al., 2011).

It is important to note that neither the main research problem that this thesis seeks to address nor the case study upon which it relies provides information that is probabilistic in nature. Rather, the case study expresses a circumstance where the problem is ambiguous in nature, its causes are unclear and essential pieces of information required to solve the problem appear to be contradictory and to some extent incomplete. Therefore, the two types of risk definitions represented by category (b) and category (c) are far less appropriate for the purposes of this thesis than those represented by category (a). Given the main research problem that this thesis seeks to address and the nature of the case study upon which this problem relies, and given that uncertainties within the case concern outcomes and consequences that are relevant to something of human value, a preference for category (a) definitions of risk within this thesis is justified.

### **3.6 Distinguishing between risk and risk perception**

Following the determination of a preferred categorical type for the definition of risk applicable to this thesis, it is important to establish and justify whether arguments concerning an ontological status for risk are valid and relevant to the purposes of this thesis. By examining this, the relationship between the variables of risk and risk perception within this thesis will be made clear. It is beyond the scope of this thesis to undertake a detailed analysis of the literature concerning the ontological status of risk. However, given that both risk and risk perception are central concepts within this thesis, it is necessary to clarify what difference, if any, exists between the two concepts in regard to this study and how any difference between them is justified.

Among the literature concerning the subject of risk, a considerable proportion is devoted to debating the merits of competing metatheoretical positions and paradigms that represent the dichotomy between positivistic science and social constructivism (Rosa, 1998, Solberg and Njå, 2012). The purpose of this section is not to contribute to this debate but to undertake a concise analysis that summarises the arguments appropriate to this thesis. Following this, a reasonable, appropriate and justified position that contributes to addressing the main research problem will be determined and, vitally, a distinction will be made between risk and risk perception based upon this analysis.

The dichotomy mentioned above can be distinguished by considering two opposing branches of philosophy. The first is ontological in nature and denotes the field within metaphysics associated with the ultimate reality of things, what exists in the world, what the states of the world are believed to be and what is considered the true nature of existence. The second is the field of epistemology, which concerns the acquisition and accumulation of knowledge, the completeness of knowledge and the means through which knowledge can be justified (Aven et al., 2011, Rosa, 1998, Solberg and Njå, 2012). Objectivism is the field within ontological theory that represents the metaphysical position that independent of the perception of human observation, a world exists, and this metaphysical position anchors the foundations of science, as does the presupposition that this world can be understood and known, albeit not completely (Kline, 1985, Rosa, 1998, Solberg and Njå, 2012). This position has dominated the fields of risk and risk analysis since their inception; however, this dominance has not prevented an alternative position from coming into being. This position, which has phenomenological origins, denies much of what is argued from a positivistic position (Solberg and Njå, 2012). The tension between these opposing philosophical positions is relevant to this thesis because this dichotomy regarding risk gives rise to the question of whether risk and risk perception are two distinct and different things or whether they are one and the same (Rosa, 1998). For the purposes of this thesis, justification of the ontological status of risk to properly distinguish it from perceptions of risk is considered unnecessary if risk is examined at a more abstracted level, through which it can be shown that risk and risk perception are two separate things.

A starting point for a more abstract examination of risk is to presuppose that future states of the world are possible and are not predetermined (Solberg and Njå, 2012). If these possible future states are not predetermined, the occurrence of any one of them is probabilistic and consequently is associated with some degree of uncertainty both in terms of the nature of the future state and the severity of the consequences that arise from it. Across all three



categories described by Aven et al. (2011), risk is conceived as being related to events in the future, such as possibilities associated with those future events, the outcomes arising from those future events, the consequences of those future events, the severity of those consequences, and the forthcoming earnings and rewards (Aven et al., 2011, Solberg and Njå, 2012).

The time-based relationship between the present and possible future states that will become known and understood over time forms the foundation of an abstracted notion of risk and exists independent of any definition of the term (Rosa, 1998, Solberg and Njå, 2012). Accordingly, risk can be said to exist at the point where there is a conjunction between possible future states, uncertainties associated with these possible future states, the consequences arising from these outcomes, uncertainties surrounding the severity of these consequences and human concerns regarding this in its entirety (Rosa, 1998). Coupled with this conjunction of future states, uncertainties, outcomes, consequences and human interest is the action of change itself, which is represented by the point in time where one state transitions to the next. In doing so, a possible future state becomes the present and, at the same instant, other possible future states become excluded from the present moment and collapse away (Solberg and Njå, 2012). However, among these considerations, risk does not in itself appear as something explicitly present within the mechanism. Rather, risk can be conceptualised as a label that is projected upon a set of specific conceivable characteristics possessed by a future state that in some manner relates to an event or activity that has occurred or may occur at an earlier point in time (Solberg and Njå, 2012). These conceivable characteristics represent both the level of uncertainty surrounding the realisation of that future state and the level of uncertainty surrounding the severity of consequences arising from the realisation of that future state relative to something of human value (Aven and Renn, 2009, Rosa, 1998, Solberg and Njå, 2012).

Based upon knowledge and the ability to logically conceive possible future states and the consequences that stem from them, decision choices may be interpreted and evaluated within a context of uncertainty. However, the means through which this interpretation is made and the nature of the interpretation itself is not part of risk per se (Aven, 2010b, Fischhoff et al., 1984, Holton, 2004, Rosa, 1998, Solberg and Njå, 2012). These aspects instead belong to the process associated with first deciding how to frame risk once a circumstance has been labelled as such and, second, evaluating the magnitude of the risk based upon that framing (Fischhoff et al., 1984, Solberg and Njå, 2012). This process is widely characterised within the relevant risk-related literature as being representative of the

essential foundations that support the psychometric paradigm (Renn, 1985, Slovic, 1987, Slovic, 1992). The act of framing is representative of the means through which risk is operationalised as a feature within the world. In contrast, the evaluation of the magnitude of risk subsequent to the act of framing may be accomplished, for example, subjectively, from perceptions of risk developed by an individual based upon their own considerations of the circumstance relative to the framing employed (see Aven, 2010b, Fischhoff et al., 1984, Holton, 2004, Renn, 1985, Rosa, 1998, Slovic, 1987, Slovic, 1992, Solberg and Njå, 2012). Both the operationalisation of risk through the process of framing and risk perception are addressed within the following two sections of this chapter.

Based upon the logic of this argument, a distinction between risk and risk perception is justified; consequently, premise two, as discussed in Section 3.5, is also justified. While the question of the ontological status of risk remains open, this is a secondary consideration. The primary concern of this section has been addressed—that is, proper justification of a clear distinction between risk and risk perception. The definition of risk that is applicable to this thesis is addressed in the next section.

### **3.7 A definition of risk**

Within this thesis, risk is defined in alignment with the definition provided by Aven and Renn (2009). Risk refers to the combination of uncertainty about future outcomes concerning events or possible future states of the world, uncertainty surrounding the consequences arising from those uncertain outcomes, and the severity of those consequences, in regard to something that is of human value or of value to humanity (Aven and Renn, 2009). This definition provides the necessary precision within its structure to enable the explicit recognition of the sources from which the characteristics of risk are derived. These are: (1) future outcomes that are uncertain, (2) the consequences and the severity of the consequences arising from the uncertain future outcomes that are themselves uncertain, and (3) the future outcomes, consequences and severity of consequences, in combination, relate to something that is of importance and is of human value or is valued by humanity (Aven, 2010c, Aven and Renn, 2009, Rosa, 1998, Solberg and Njå, 2012).

This definition does not refer to any specific objectives, as does the definition provided by AS/NZS ISO 31000:2009 and AS/NZS ISO 31000:2018 (Standards Australia, 2009, Standards Australia, 2018). However, this is not a concern because relative comparisons between

future states and objectives can be considered through the operationalisation of the term rather than within its definition (Hillson, 2002, Holton, 2004). The definition of risk employed within this thesis does not explicitly refer to the extent to which there is potential for significantly opportunistic or disappointing outcomes to arise from the decisions, as is the case with the definitions provided by Sitkin and Pablo (1992) and Sitkin and Weingart (1995). However, again, such considerations relate to the manner through which the term 'risk' is operationalised and consequently perceived rather than to the definition of risk itself (Fischhoff et al., 1984, Holton, 2004). The means through which risk is operationalised and the manner in which it is perceived are dealt with in Sections 3.7.1 and 3.7.2 respectively.

Notwithstanding the abovementioned differences, similar to the definitions employed by Sitkin and Pablo (1992) and Sitkin and Weingart (1995), the definition of risk employed within this thesis provides for three separate yet vital dimensions. These are considered essential to the understanding and application of risk in an applied sense and must, necessarily, be enabled through an adequate definition. These three future outcome-based dimensions represent uncertainty of possible future outcomes, possible future outcomes relative to expectations and objectives, and the potential of possible future outcomes (Aven, 2010b, Aven and Renn, 2009, Rosa, 1998, Solberg and Njå, 2012). These dimensions are described below.

1. Uncertainty of possible future outcomes: This enables the recognition of events that cause variability and uncertainty in future outcomes (Aven and Renn, 2009, Bratvold and Begg, 2010, Hillson, 2002, Holton, 2004, Libby and Fishburn, 1977, Sitkin and Weingart, 1995), the degree to which the distribution of possible future outcomes and the probability of each possible outcome is understood (Aven and Renn, 2009, Bratvold and Begg, 2010, Hillson, 2002, Holton, 2004, March, 1978, Sitkin and Weingart, 1995) and the extent to which the attainment of future outcomes may be controlled (Aven and Renn, 2009, Bratvold and Begg, 2010, Sitkin and Pablo, 1992, Vlek and Stallen, 1980).
2. Possible future outcomes relative to expectations and objectives: It is not the expected outcome itself that constitutes the magnitude of risk in an operationalised form. Rather, it is to what extent and in what respect possible future outcomes may differ from the decision-maker's expectations and objectives relevant to the case in question. While the differential may be constrained through choice to only those

outcomes that are negative and deleterious in nature (Baird and Thomas, 1985, Levitt and March, 1988), this need not be the case. That is, it may also be characterised as encapsulating both positive and negative relative differences between possible future outcomes and objectives or expectations (Aven and Renn, 2009, Bratvold and Begg, 2010, Gough, 1990, Sitkin and Pablo, 1992). These differentials may be either negative or positive in sign dependent upon the interplay between the range and distribution of possible future outcomes relative to the expectations held in the form of the objectives by the relevant decision maker. Differentials of a positive sign represent potential upside opportunities, whereas differentials of a negative sign represent potential downside exposures (Amundrud and Aven, 2015, Aven and Renn, 2009, Bratvold and Begg, 2010, Sitkin and Pablo, 1992).

3. The potential of possible future outcomes: Possible future outcomes are examined to understand the nature, consequences and severity of consequences associated with the more extreme ends of the possible future outcome range. The purpose of this examination is to determine whether, as the extremities are approached, the possible outcomes, outcome consequences and the possible severity of these consequences are considered to demonstrate a stepped categorical function rather than one that is more or less continuous in nature (Bratvold and Begg, 2010, Dutton and Jackson, 1987, Jackson and Dutton, 1988, Sitkin and Pablo, 1992). This third dimension asks: 'How bad or good could a possible future outcome potentially be relative to expectations or objectives?' As such, it is an extension of that which is considered within the second dimension.

Attention will now turn to the means through which risk is operationalised.

### **3.7.1 The operationalisation of risk**

When defined in a form comprising uncertainties surrounding outcomes, the consequences of these outcomes and the severity of these consequences (Aven and Renn, 2009), risk must be appropriately contextualised to suit the circumstance in question to provide relevance, because the term cannot be operationalised without this (Aven, 2010b, Holton, 2004, Kahneman, 2012, Rosa, 1998, Solberg and Njå, 2012). However, as discussed in Section 3.6,

it is not risk, of itself, that is operationalised. Instead, operationalisation is achieved through the contextual descriptors and measurement scales employed, the qualitative and quantitative means by which comparisons are made, the boundaries with which the relevant circumstances are considered, the types of concern that are applicable to each instance and the level of tolerance for each of those concerns.

The inherent nature of this process dictates that to a greater or lesser extent in each case, through evaluation processes and the determination of the descriptors and measurement scales against which the evaluation takes place, it is perceptions of uncertainty, possible outcomes, potential consequences and severity levels that are operationalised through appropriate scales, rather than risk itself (Aven, 2010b, Fischhoff et al., 1984, Holton, 2004, Rosa, 1998, Renn, 1985, Slovic, 1987, Slovic, 1992, Solberg and Njå, 2012). This is because, as described in Sections 3.6 and 3.7, risk can be said to be a human construct, its purpose being to help cope with, understand and manage the uncertainties of life. As such, it does not exist, in and of itself within the world separate from circumstances, our minds and our culture waiting to be assessed, evaluated and measured (Kahneman, 2012, Solberg and Njå, 2012). Instead, the notion of risk is operationalised through the contextualisation of uncertainty, outcomes and consequences as mentioned above, and through what is measured, judged or perceived to be so based upon the process of contextualisation and through the evaluation of these dimensions (Aven, 2010b, Bratvold and Begg, 2010, Crowe and Horn, 1967, Fischhoff et al., 1984, Holton, 2004, Rosa, 1998, Renn, 1985, Slovic, 1987, Slovic, 1992, Solberg and Njå, 2012).

Risk preferences have been observed to influence decision-making behaviour when an individual is faced with a decision choice involving a number of possible solutions to a problem that are distinguished among themselves to the extent that they are more or less risky in nature (Brockhaus, 1980, Gough, 1990, Kahneman and Tversky, 1979, McClelland, 1961, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995). The two dimensions of risk preference that are relevant to this thesis are risk perception and risk propensity. Before advancing to the subjects of risk perception and risk propensity in the next two sections, it is important to return to the structural model shown in Figure 3.1. It is important to properly place these two psychographic variables within the overall structural model that has been employed to conceptualise all of the components of the literature review contained in Chapters 2 and 3. As shown in Figure 3.1, risk perception and risk propensity are functions of the entrepreneur decision maker, as each has been found to represent dimensions of individual risk preference (see Brockhaus, 1980, Gough, 1990, Hatfield and Fernandes, 2009,

Sitkin and Pablo, 1992, Sitkin and Weingart, 1995). The justification for this claim, its relevance to this thesis, and the operational definitions for both terms are provided in Sections 3.7.2 and 3.7.3.

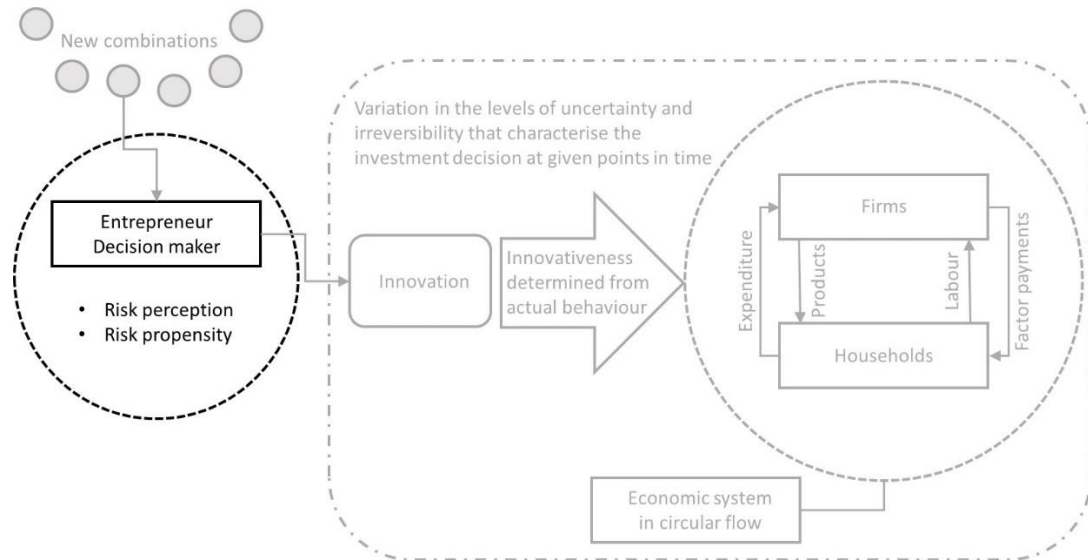


Figure 3.1: Risk perception and risk propensity highlighted within the structural model

Risk perception and risk propensity, together with the determination of their respective operational definitions, are examined below.

### 3.7.2 Risk perception

Within this thesis, risk perception is considered from the perspective of the psychometric paradigm as described by Slovic (1992) and Renn (1985). This approach is appropriate for the purposes of this thesis because it is the psychometric paradigm that conceptualises the notion of risk, the means by which this is operationalised through an appropriate set of parameters, and from which perceptions of risk subjectively arise within an integrated whole (Renn, 1985, Slovic, 1987, Slovic, 1992). Accordingly, the psychometric paradigm is dependent upon the existence of an appropriate definition of risk, because without this, a discussion concerning risk perception is impossible (Aven, 2010b). It is also dependent upon operational parameters that appropriately contextualise circumstances that enable an evaluation based upon that definition, as well as properly designed survey instruments that allow these parameters to be quantified (Aven, 2010b, Slovic, 1992). Risk perceptions are

framed using appropriate operational parameters for a circumstance under consideration, against which perceptions of risk are contextualised and evaluated, and through which risk perceptions can be measured and comparisons between differing perceptions of risk can be made (Slovic, 1987, Slovic et al., 1982a).

Fundamental to the psychometric paradigm is recognition that perceptions of risk are inherently subjective in nature and are reliant upon individual judgement. As such, they are the product of factors that include knowledge, memory, context, and social and cultural constructs such as values, symbols and ideologies, irrespective of their validity (see Aven and Renn, 2009, Aven, 2010b, Freudenburg, 1988, Gough, 1990, Mythen, 2004, Renn, 1985, Simon, 2000, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995, Slovic et al., 1982b, Slovic, 1987, Slovic, 1992, Vlek and Stallen, 1980). More specifically, individual judgement is influenced by inferential decision-making rules that come into play during the processes of exercising judgement under conditions of uncertainty. These inferential rules are known as heuristics and develop over time. The effect of these heuristics is relevant because they are employed by individual decision makers to simplify difficult mental tasks and account for some of the differences in perceptions of risk between individuals (Slovic et al., 1982b). Examples include the representativeness of a circumstance relative to those with which one is familiar, the availability or ease with which similar circumstances can be brought to mind and psychological anchoring relative to initial impressions formed concerning the circumstance in question (Slovic et al., 1982b, Slovic, 1992).

Perceptions of risk are also framed by individuals' information processing capabilities, which limit the ability to fully comprehend and conceptualise the necessary facets and dimensions associated with a decision-making circumstance, therein bounding rationality to varying extents for each individual (Kahneman, 2003, Simon, 2000). Accordingly, the evaluation process associated with the development of individual beliefs such as risk perception is a deeply personal one (Renn, 1985, Rosa, 1998, Slovic, 1992, Slovic et al., 1982a). As a consequence, the perception of risk concerning a given circumstance held by one individual may be materially different to the perception of risk held by another individual concerning the same circumstance. Both believe that their own evaluation is aligned with their own personal belief systems and, as such, is entirely rational based upon this (Gilboa, 2009, Gilboa, 2010). Given the focus upon the individual and the beliefs they may subjectively form regarding the characteristics of particular circumstances, the use of the psychometric paradigm in regard to risk perception within this thesis is justified.

A sizeable body of literature surrounds the subject of risk perception in terms of how it may be conceived, framed and evaluated (Freudenburg, 1988, Renn, 1985). It is beyond the scope of this thesis to undertake a detailed examination of this literature or an analysis of the debate contained within it. Questions surrounding the influence of subjective perceptions of risk and the influence of these perceptions upon decision-making behaviour have attracted the attention of scholars for a range of reasons, as described by Sitkin and Pablo (1992) and Sitkin and Weingart (1995). This is because perceptions of risk have, in part, been found to be associated with the denial of uncertainty, the overestimation and underestimation of risk, the tendency to demonstrate unjustified confidence in the merit of their personal judgement (Bazerman, 2013, Roll, 1986, Slovic, 1972), the accumulation of knowledge (Monroe, 1976, Rao and Monroe, 1988) and the capability to manage or perform in risky circumstances (March and Shapira, 1987, Slovic et al., 1982b). However, across a range of studies into relationships between situational characteristics and risk behaviour, outcomes have demonstrated variation and inconsistency that is, in some cases, considerable (Sitkin and Pablo, 1992, Sitkin and Weingart, 1995).

For example, the results from the seminal work of Kahneman and Tversky (1979), who developed prospect theory, demonstrated that the manner in which a situation is framed is a determinant of individual risk behaviour. They found that individuals are risk-averse in terms of protecting prior gains (Kahneman and Lovallo, 1993, Kahneman and Tversky, 1979). In separate but related studies, Osborn and Jackson (1988) and Thaler and Johnson (1990) discovered an opposite relationship to the one found by Kahneman and Tversky (1979) when examining how the results of a decision-maker's past behaviour predict their future risky decision-making behaviour. Unlike Kahneman and Tversky (1979), Osborn and Jackson (1988) and Thaler and Johnson (1990) found that past gains led to risk-seeking behaviour, thereby contradicting prospect theory and raising questions regarding the cause of this contradiction. Sitkin and Pablo (1992) argued that such inconsistencies are either the result of other variables upon which the relationships in question are contingent, or that perceptions of risk are in fact correlated in some way with another variable, proposed to be the risk propensity of the decision maker in each case, that is influencing each relationship. Through the earlier examination of these relationships by Sitkin and Pablo (1992) and Sitkin and Weingart (1995), a direct linkage is created between the purpose of this thesis and, for example, Kahneman and Tversky (1979) and Tversky and Kahneman (1974) in regard to relationships between decision-makers' behavioural responses and varying forms of situational circumstance.



The operational definition of risk perception that satisfies the purposes of this thesis is aligned with the definition stated by Sitkin and Pablo (1992) and Sitkin and Weingart (1995). Given the centrality of both Sitkin and Pablo (1992) and Sitkin and Weingart (1995) to the genesis of this thesis and the main research problem that this thesis seeks to address, this approach is considered appropriate and justified. Accordingly, risk perception is operationally defined as an individual's intuitive evaluation of the risk associated with a circumstance based upon predefined parameters and measurement scales. It takes into consideration probabilistic estimations of the uncertainties surrounding the circumstance (Sitkin and Pablo, 1992), the level of confidence in those estimates and the degree to which uncertainties are believed to be controllable (see Baird and Thomas, 1985, Bettman, 1973, Duncan, 1972, Gough, 1990, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995, Vlek and Stallen, 1980). The four-item measurement scale employed in this thesis to evaluate risk perception also reflects the one employed by Sitkin and Weingart (1995). An explanation of this is provided in Section 5.4.5.2. The items on the scale provide the means to evaluate four aspects of risk associated with each conjoint task in terms of the separate ranges: opportunity/threat; gain/loss; positive situation/negative situation; and likelihood of success/likelihood of failure. The four-item scale employed by Sitkin and Weingart (1995) was adapted from McCrimmon and Wehrung (1985, 1986a, 1986b) and Wehrung et al. (1989).

### **3.7.3 Risk propensity**

Similar to the definition of risk perception and the items employed within this thesis that serve as measurement scales for the individual evaluation of risk perception for each of the ten conjoint tasks completed, the definition of risk propensity employed within this thesis, as well as the set of measurement scales through which this is calculated, reflects that employed by Sitkin and Weingart (1995). However, unlike the four-item measurement scale employed by Sitkin and Weingart (1995), the five-item measurement scale employed by Sitkin and Weingart (1995) to assess risk propensity was original (Sitkin and Weingart, 1995). The balance of this section is dedicated to the justification of the decision to employ the approach used by Sitkin and Weingart (1995) within this thesis.

Sitkin and Weingart (1995) described risk propensity as an attitudinal measure of the current tendency of an individual to take or avoid risks. This definition is in conceptual alignment with the definitions described by Baird and Thomas (1985), Brockhaus (1980), Hatfield and

Fernandes (2009) Hurt et al. (1977), MacCrimmon and Wehrung (1985), MacCrimmon and Wehrung (1990), Nicholson et al. (2001) Pablo (1997), Pablo and Javidan (2002) and Sitkin and Pablo (1992). While the definition of risk propensity is broadly consistent at a conceptual level among a sample of the relevant literature, debate exists across three dimensions regarding:

1. the extent to which risk propensity, or a like measure, is a general or innate trait rather than domain-specific, and the extent to which it is stable and enduring over time rather than changeable (see Corsini and Osaki, 1984, Fagley and Miller, 1987, Gerrans et al., 2015, Goldenson, 1984, Huff et al., 1997, MacCrimmon and Wehrung, 1985, MacCrimmon and Wehrung, 1986b, MacCrimmon and Wehrung, 1990, Nicholson et al., 2001, Richards et al., 1996, Rowe, 1997, Salminen and Heiskanen, 1997, Sitkin and Weingart, 1995, Sutherland, 1989, Weinstein and Martin, 1969, Wolman, 1989)
2. the means through which risk propensity is appropriately and reliability measured (Huff et al., 1997, Sitkin and Weingart, 1995)
3. how and to what extent risk propensity conforms with or contradicts that described by prospect theory (Garvey, 2010, Levy, 1992, Wehrung, 1989).

The traditional approach for the conceptualisation of risk propensity is that the term is representative of a behavioural disposition that is constant and stable across time and is manifest in the form of an innate trait (see Goldenson, 1984, Huff et al., 1997, MacCrimmon and Wehrung, 1985, MacCrimmon and Wehrung, 1990, Rowe, 1997, Sitkin and Weingart, 1995, Sutherland, 1989, Wolman, 1989). The definition of risk propensity employed by Sitkin and Weingart (1995) differs from the traditional approach in that it denotes the trait as a current tendency. Therefore, as described by Richards et al. (1996), it enables a stable trait to be persistent but also to change over time as a consequence of the accumulation of knowledge and experience. Accordingly, the conceptualisation of risk propensity applicable to this thesis is aligned with that of Sitkin and Weingart (1995). It is representative of a stable and persistent trait, but one that may also change and adapt over time in recognition that it is learned behaviour (Corsini and Osaki, 1984, Goldenson, 1984, Sutherland, 1989, Sitkin and Weingart, 1995).

Beyond questions concerning whether risk propensity is a constant trait or one that may change and develop through exposure and life experience, the literature provides

contrasting evidence regarding whether risk propensity is a general behavioural trait that is stable across domains or whether it is a domain-specific trait limited by context (Huff et al., 1997, Nicholson et al., 2001). For example, in some cases, risk propensity, or measures of a similar nature, validly and consistently characterise an individual's risk aversion or risk-seeking behaviour across a range of decision-making domains (Gerrans et al., 2015, Huff et al., 1997, MacCrimmon and Wehrung, 1986b, Weinstein and Martin, 1969, Wolman, 1989). However, in other cases, an individual's risk propensity is variable and inconsistent across domains depending upon the circumstance or decision-making context (see Fagley and Miller, 1987, Huff et al., 1997, MacCrimmon and Wehrung, 1985, MacCrimmon and Wehrung, 1986b, Nicholson et al., 2001, Salminen and Heiskanen, 1997).

It is beyond the scope of this thesis to undertake an in-depth review of the merits of the respective arguments and the literature that supports them concerning the extent to which individuals demonstrate differing levels of risk aversion or risk-seeking behaviour in different situations. Instead, the conceptualisation of risk propensity within this thesis will proceed on the premise that it encapsulates a domain-specific trait that is aligned with the approach described by Huff et al. (1997), MacCrimmon and Wehrung (1985) and Nicholson et al. (2001). Neither Sitkin and Pablo (1992) nor Sitkin and Weingart (1995) explicitly stated the premise upon which their definition of risk propensity was made in regard to either a general or specific domain (Huff et al., 1997). However, the five-item measurement scale employed by Sitkin and Weingart (1995) appeared to focus upon a business-based domain; thus, on this basis, and in the absence of information confirming otherwise, it is believed that they purposefully employed a business-related domain approach (Huff et al., 1997). To avoid doubt, the context of the 'Carter Racing' case study used in this thesis is a business-related domain. The definition of risk propensity and the associated measurement scales used within this thesis reflect those employed by Sitkin and Weingart (1995). Thus, it is apparent that the applicable domain is specific to that associated with a business context, and the definition of risk propensity should be limited to a business-specific domain. Accordingly, for the purposes of this thesis, the definition for risk propensity is justified based upon the premise that the term can be conceptualised as being both domain-specific and a stable yet changeable characteristic as a consequence of experience and the acquisition of knowledge.

As mentioned at the start of this section, the five-item measurement scale employed by Sitkin and Weingart (1995) to measure business risk propensity was original in nature. They provided no validation of the instrument other than to state the corresponding Cronbach alpha as .86 (Huff et al., 1997, Sitkin and Weingart, 1995). A validation test of the Sitkin–

Weingart business risk propensity scale was undertaken by Huff et al. (1997). They found that the measurement scale was a valid means for measuring business risk propensity based upon the results of comprehensive testing and analysis conducted in accordance with a prescribed methodology for validating such measurement instruments (Huff et al., 1997). The experiment undertaken by Huff et al. (1997) to validate the risk propensity measurement scale of Sitkin and Weingart (1995) followed the multi-step validation process described by Churchill Jr (1979) and Zaichkowsky (1985).

The methodology employed by Huff et al. (1997) involved a two-part questionnaire. One part contained a single self-rating of general risk propensity adapted from MacCrimmon and Wehrung (1985), and the other part contained the five-item business risk propensity scale of Sitkin and Weingart (1995). The questionnaire was administered to two groups, each comprising public university students, on two different occasions separated by four weeks (Huff et al., 1997). Using the single self-rating of general risk propensity adapted from MacCrimmon and Wehrung (1985) to perform manipulation and convergent validity checks (Huff et al., 1997), the six measures were found to be highly reliable (Cronbach alpha of .76). All of the scale questions addressed the same underlying construct, they were sufficiently stable over time, and the measurement scale of Sitkin and Weingart (1995) demonstrated convergent validity with another measure for the same construct (Huff et al., 1997). Accordingly, the original risk propensity measurement scale of Sitkin and Weingart (1995) is considered a valid and reliable means of measuring business risk propensity; therefore, its use within this thesis is justified from this perspective.

Nicholson et al. (2001) and Sitkin and Weingart (1995) considered risk propensity either a persistent and generalisable cross-domain trait or one that may be domain-specific and that may change over time. In contrast, prospect theory argues that an individual's risk-taking behaviour is asymmetric about a reference point dividing domains of perceived gains and losses. This reference point is unique to each individual (Schneider and Lopes, 1986, Kahneman and Tversky, 1979). Critically, perceptions that arise from the framing of circumstances as representative of either gains or losses have important implications for decision-making behaviour (Kahneman and Tversky, 1979, Sitkin and Weingart, 1995). According to prospect theory, decision makers typically exhibit risk-averse behaviour, but when faced with a circumstance that is perceived as having a high probability of loss, risk-seeking behaviour may instead be observed (Harbaugh et al., 2010, Kahneman, 2012, Kahneman and Tversky, 1979).

The asymmetry of behaviour regarding the reflection point is a primary differentiator of prospect theory, as defined by Kahneman and Tversky (1979) and Tversky and Kahneman (1992), from behavioural theories that rely upon traditional approaches such as expected utility theory (see Erickson, 2013, Garvey, 2010, Gilboa, 2009, Gilboa, 2010, Kahneman, 2012, Levy, 1992, Lewandowski, 2017, Schneider and Lopes, 1986). Investigations by Sitkin and Pablo (1992) and Sitkin and Weingart (1995) were stimulated by contradictions arising from comparisons between the works of Kahneman and Tversky (1979), Tversky and Kahneman (1992) and others concerning actual risk-taking behavioural responses in circumstances framed as loss or gain prospects. These investigations subsequently led to the genesis of this thesis as mentioned in Chapter 1.

Further work by Tversky and Kahneman (1992) gave rise to the development of cumulative prospect theory (Tversky and Kahneman, 1992), which enabled methodological improvements such as a greater level of nuance to be applied to decision-weighting processes. In addition, it confirmed both the two-domain nature of prospect theory and the fourfold pattern of risk attitude arising from the interaction of prospect framing with the level of probability associated with each decision choice frame (Harbaugh et al., 2010, Tversky and Kahneman, 1992). Figure 3.2 depicts the nature of the relationships and associated behavioural attitudes adapted from Harbaugh et al. (2010) and Kahneman (2012). Regardless of the additional complexities that arise from the consideration of those shown in Figure 3.2, numerous investigations have shown that most individuals typically exhibit risk-averse behaviour (see Gilboa, 2010, Kahneman and Lovallo, 1993, Kahneman and Tversky, 1979, Schneider and Lopes, 1986, Tversky and Kahneman, 1992). That is, they exhibit a preference for certainty rather than a gamble of equal expected value or a gamble of low variance in comparison with what they consider a riskier prospect (Kahneman, 2012, Kahneman and Lovallo, 1993, Schneider and Lopes, 1986). Kahneman and Lovallo (1993) claimed that there are three important exceptions to this generalisation:

1. The first concerns risk-seeking behaviour displayed by those who are willing to pay a premium to participate in a lottery where the ticket price can be shown to be greater than the corresponding expected value. This exception is illustrated in the top left quadrant of Figure 3.2.

2. The second applies to moderate to high probability cases that are, because of their nature, representative of the domain of losses. This exception is illustrated in the bottom right quadrant of Figure 3.2.
3. The third applies to addicted gamblers who, through their gambling behaviour, may demonstrate a general prevalence for risk-seeking behaviour across the two framing domains shown in Figure 3.2.

Framing Domain	Gains	<b>RISK SEEKING</b> 5% chance to win \$100,000 Hope of large gain Buying lottery tickets	<b>RISK AVERSE</b> 95% chance to win \$100,000 Fear of disappointment Locking in a position to be sure of a gain
	Losses	<b>RISK AVERSE</b> 5% chance to lose \$100,000 Fear of large loss Purchase of insurance	<b>RISK SEEKING</b> 95% chance to lose \$100,000 Hope to avoid loss Desperate acts in hope of reducing loss
		Low Probability (Possibility effect)	High Probability (Certainty effect)

Within each quadrant the following applies:

The top row indicates how most people react when offered the choice between a gamble and a certain gain or a loss equivalent to its expected value. For example, the choice between a 5% chance to win \$100,000 and \$5,000 with certainty. Choices are risk-seeking if the gamble is preferred, and risk-averse if otherwise. The second row states a prospect relevant to the quadrant. The third row describes a typical emotion evoked by the prospect in question. The fourth row provides an example relevant to the quadrant.

Figure 3.2: The fourfold pattern of risk attitudes

These results, together with a prevailing bias towards risk aversion in cases that involve favourably perceived prospects and probabilities that are known, have been confirmed across a broad cross-section of studies, including groups that comprise executive-level business leaders (Kahneman and Lovallo, 1993). Nonetheless, as mentioned by Sitkin and Pablo (1992) and Sitkin and Weingart (1995), a body of evidence within the literature contradicts that predicted by prospect theory and serves to reflect the complex multifaceted nature of the subject under consideration (Doszyń, 2018, Garvey, 2010).

Studies dedicated to examining the nature of the relationships between risk propensity and the asymmetric behavioural domains described by prospect theory are scarce. Notably, Levy (1992) provided an analysis of the relationships between risk propensity and the evaluation of prospects measured in terms of their respective value and probability weighting functions. Empirical analysis undertaken by Garvey (2010) highlighted an important behavioural distinction in regard to self-attributed risk propensity across the domains of perceived gains (positive framing) and losses (negative framing). The investigation by Garvey (2010) provided useful insights that help address the question of how and to what extent risk propensity conforms with or contradicts that described by prospect theory. In a study involving self-attribution of risk propensity and probability-based decisions framed as both negative and positive prospects, Garvey (2010) found that risk-taking and risk-avoiding preferences and propensities were dominant factors in the decision-making process within the positively framed domain. However, this effect was found to be muted and less likely to be a factor within the decision-making process when the circumstance in question was representative of that described as the negatively framed domain (Garvey, 2010). A similar finding was made by Wehrung (1989).

Therefore, it is clear that a gap exists within the literature concerning knowledge of the relationships between risk propensity, however it is measured, and that described by prospect theory. Notwithstanding this, based upon the analysis contained within this section, which is framed in accordance with the three dimensions stated earlier, the operational definition of risk propensity appropriate to this thesis can be justifiably based upon that provided by Sitkin and Weingart (1995). The operational definition of risk propensity applicable to this thesis is that it is an attitudinal measure of the current tendency of an individual to take or avoid risks within a predefined domain (Hatfield and Fernandes, 2009, Hurt et al., 1977, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995).

### **3.8 Conclusion**

While Chapter 2 provided a review of the relevant literature that forms the major parent discipline themes of this thesis, this chapter built upon the content of Chapter 2 by reviewing the relevant literature that forms the immediate discipline field that informs this thesis and leads to the development of the analytic model and hypotheses that guide the study.

The chapter commenced by establishing the structure through which the immediate discipline field would be examined, together with an explanation and justification for the delineation of the relevant literature between that detailed in Chapter 2 and that contained within this chapter. The centrality of Sitkin and Weingart (1995) to the genesis of this thesis and the development of the main research problem that this thesis seeks to address was then discussed to justify the inclusion of risk, risk perception and risk propensity within this chapter rather than elsewhere.

Following the justification of the inclusion of these terms within this chapter, the notion of risk was examined from a range of perspectives, including its relationship to uncertainty and how the notion of risk is justifiably distinguished from the notion of risk perception. Then followed an analysis of the definition of risk applicable to this thesis, as well as the justification for this. As an extension of that analysis, the means through which the term is operationalised was discussed based upon the relevant literature. Finally, literature surrounding the psychographic variables of risk perception and risk propensity were examined, and valid and adequately justified definitions were provided in both instances. The completion of this chapter marks the conclusion of the literature review relevant to this thesis and signals a shift in focus from the parent and immediate discipline fields to the development of the analytic model and hypotheses in Chapter 4.



## **4. ANALYTIC MODEL DEVELOPMENT AND HYPOTHESES**

### **4.1 Introduction**

Following the review of literature relevant to this thesis, this chapter focuses upon the development of the critically important analytic model employed within this thesis. This is followed by consideration of the means through which the variables of uncertainty and irreversibility will be operationalised, and then the development of the necessary hypotheses. This chapter comprises three primary sections. The first section examines the origin of the analytic model employed and the justifications for its use in regard to the purpose of this thesis and the gaps that exist within the literature as identified in Section 2.6. The second section is dedicated to the development of how the variables of uncertainty and irreversibility are operationalised within this thesis. In the third and final section, attention is focused upon the development of hypotheses that link directly back to the main research problem stated in Section 1.4 via the six research questions detailed within that section. The structure of the section is ordered to reflect the sequence of the six research questions.

### **4.2 The analytic model**

As mentioned in Chapter 1, the genesis of this thesis in regard to risk perception and risk propensity acting as psychographic determinants of risky decision behaviour can be found in Sitkin and Weingart (1995). Sitkin and Weingart (1995) employed a simple mediation model in two studies to examine the influence of decision-maker risk perception and risk propensity upon indirect relationships using a revised version of the 'Carter Racing' case study previously employed by Brittain and Sitkin (1990). The relationships examined in the two studies concerned relations between the predictor variables of outcome history and problem framing, both of which were dichotomous in nature, and risky decision-making behaviour. The latter was measured using an 11-point Likert scale covering a range of 0–100% likelihood of engaging in risky decision-making behaviour advancing in 10% increments (Sitkin and Weingart, 1995). To test mediation effects, Sitkin and Weingart (1995) employed the causal steps approach of Baron and Kenny (1986), which is a form of hierarchical regression analysis (Sitkin and Weingart, 1995). The classic example of a simple mediation model is one in which a given variable is said to act as a mediator between two other variables, and its effect is gauged by the extent to which it can be shown to account for a relationship between those

variables (Baron and Kenny, 1986, Hayes, 2018). Figure 4.1, adapted from Hayes (2018), shows this in an abstracted conceptual form. The predictor variable of interest is denoted as  $X$ , the mediating variable is represented by  $M$  and the outcome variable is shown as  $Y$ .

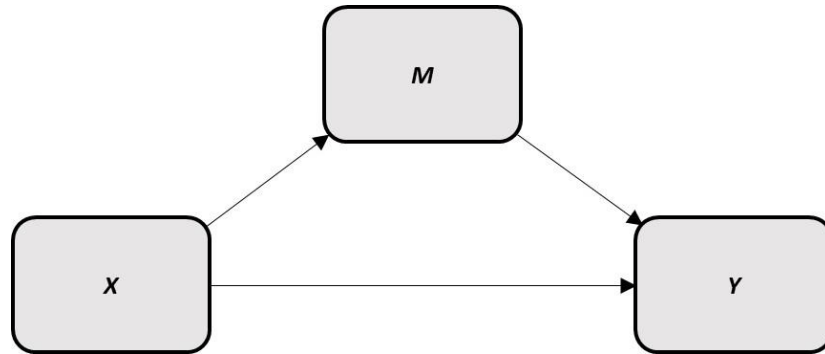
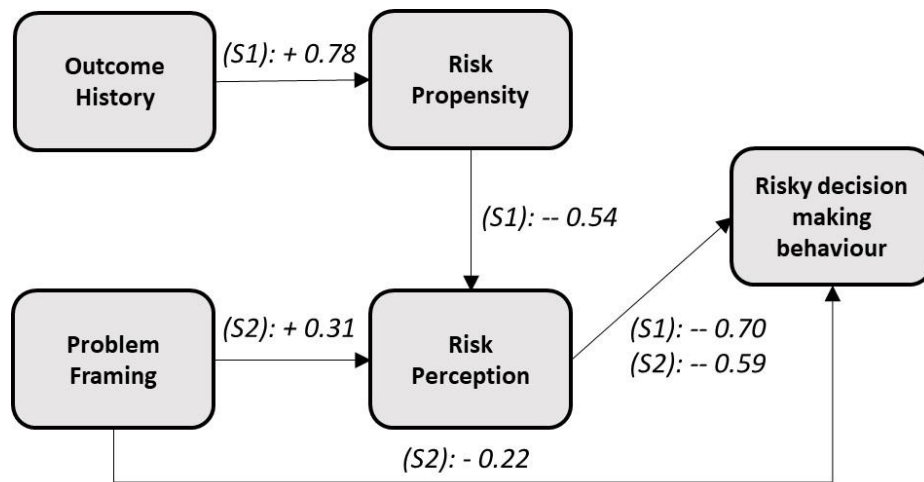


Figure 4.1: Simple mediation model in conceptual form

Mediation models may be employed, for example, to explain how and to what extent physical events gain psychological significance with consequential behavioural effects given that the principal intention of mediation analysis is not simply to establish whether a particular treatment produces a given effect, but rather how this comes about (Baron and Kenny, 1986, Judd and Kenny, 1981). The results of the two studies of Sitkin and Weingart (1995) are summarised in Figure 4.2.



Only significant results are shown, with the sign of each relationship included for each significant path. The study from which each result was derived is indicated within parentheses, this being (S1) for study one and (S2) for study two. Single plus and minus signs indicate significance of  $p < 0.05$  or greater, whereas double minus signs indicate significance of  $p < 0.01$  or greater (Sitkin and Weingart, 1995).

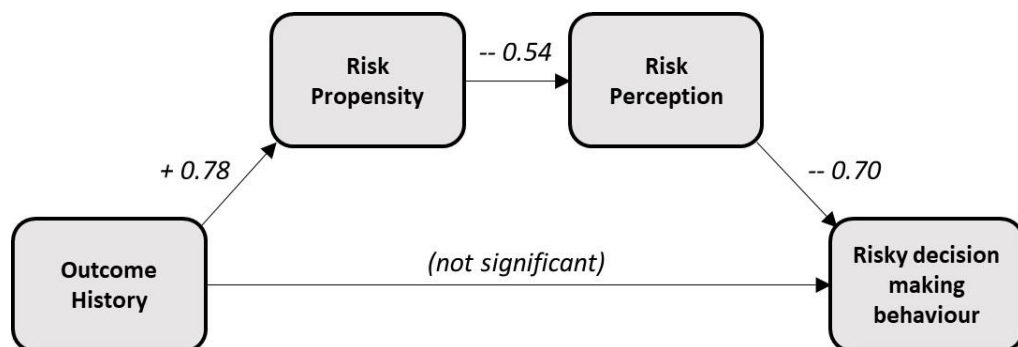
Figure 4.2: Sitkin and Weingart's model of risky decision-making behaviour

The arguments presented by Sitkin and Weingart (1995) build upon and advance the earlier analysis of Sitkin and Pablo (1992), which was the first empirical work to examine the indirect effect of outcome history upon decision-making behaviour (Sitkin and Pablo, 1992, Sitkin and Weingart, 1995). The principal argument made by both Sitkin and Pablo (1992) and Sitkin and Weingart (1995) is that the causal mechanisms through which a range of exogenous variables affect decision-making behaviour occur via the psychographic functions of risk perception and risk propensity (Sitkin and Pablo, 1992, Sitkin and Weingart, 1995). This argument, made by both Sitkin and Pablo (1992) and Sitkin and Weingart (1995), was fundamental to how the main research problem of this thesis was both conceived and then structured.

The revised model of determinants of risky decision-making behaviour of Sitkin and Weingart (1995), based upon the combined results of the two studies, can be shown as two separate diagrams derived from Figure 4.2. The simple mediation models for study one and study two are shown as Figure 4.3 and Figure 4.4 respectively. Study one examined the relationships between outcome history and risky decision-making behaviour together with the mediating effects of both risk propensity and risk perception (Sitkin and Weingart, 1995). Within that study, outcome history was defined as the degree to which an individual believes that previous risk-related decisions that they made in similar situations resulted in successful or unsuccessful outcomes (Sitkin and Weingart, 1995). Outcome history was operationalised by each respondent being given one of two possible outcome history condition statements to

read together with the case study prior to completing a simple survey. One outcome history condition statement emphasised that the respondent's (fictitious) prior decision making in similar circumstances had led to disappointing results. The alternate outcome history statement emphasised that the respondent's (fictitious) prior decision making in similar circumstances had yielded very pleasing results, thereby creating a sense of confidence and self-assurance (Sitkin and Weingart, 1995). The outcome variable of study one and study two—risky decision-making behaviour—was a probability-based measure scale, and its purpose was to gauge the degree to which a decision maker was willing to demonstrate risk-seeking behaviour in a given circumstance (Sitkin and Pablo, 1992, Sitkin and Weingart, 1995).

The results of study one found that the relationship between outcome history and risky decision-making behaviour was mediated by both risk propensity and risk perception. Further, the results showed that the effect of risk propensity upon risky decision-making behaviour was mediated by risk perception (Sitkin and Weingart, 1995). Employing Baron and Kenny's (1986) causal steps approach to mediation analysis, Sitkin and Weingart (1995) found that while outcome history and risky decision-making behaviour demonstrated a statistically significant positive direct relationship, when risk propensity was included within the model as a mediator, the indirect pathway via risk propensity demonstrated statistical significance, while the direct pathway ceased to do so (Sitkin and Weingart, 1995). This effect was described by Baron and Kenny (1986) as full mediation. The mediation effect of risk perception upon the relationship between risk propensity and risky decision-making behaviour was also found to exhibit what Baron and Kenny (1986) described as a full mediation effect (Sitkin and Weingart, 1995). This is shown in Figure 4.3.

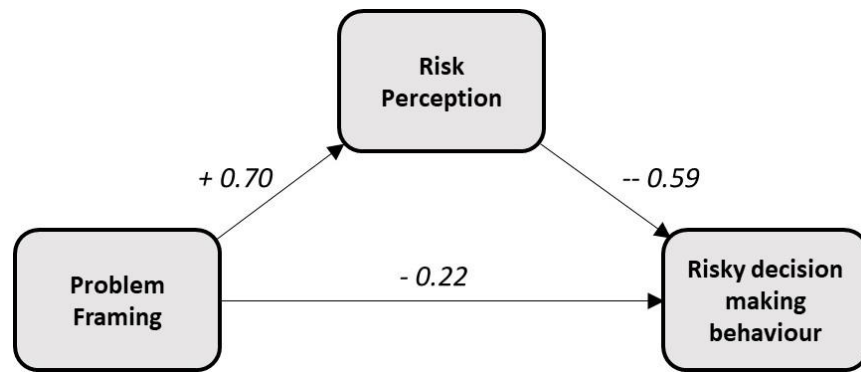


Single plus and minus signs indicate significance of  $p < 0.05$  or greater, whereas double minus signs indicate significance of  $p < 0.01$  or greater (Sitkin and Weingart, 1995).

Figure 4.3: Simple mediation model of study one from Sitkin and Weingart (1995)

Study two examined relationships between problem framing and risky decision-making behaviour together with the mediating effect of risk perception (Sitkin and Weingart, 1995). For study two, problem framing was defined as whether a circumstance is portrayed to a decision maker in the form of either an opportunity or a threat or is characterised in terms of gains or losses (Jackson and Dutton, 1988, Kahneman and Tversky, 1979, Sitkin and Weingart, 1995). Similar to study one, each respondent in study two was given one of two problem-framing statements to read together with the case study prior to completing a simple survey. One problem-framing statement emphasised the domain of losses, whereby the statement described the downside exposures inherent in the circumstance and what was at stake as a consequence. The alternate problem-framing statement emphasised the domain of gains, with an emphasis upon the upside potential of the circumstance and the gains that might arise. The outcome variable for study two was identical to that employed within study one (Sitkin and Weingart, 1995).

The results of study two found that the relationship between problem history and risky decision-making behaviour was mediated by risk perception. Again employing Baron and Kenny's (1986) causal steps approach to mediation analysis, Sitkin and Weingart (1995) found that problem framing and risky decision-making behaviour demonstrated a statistically significant negative direct relationship. However, when risk perception was included within the model as a mediator, the indirect pathway via risk perception demonstrated statistical significance in parallel with the direct pathway, which continued to demonstrate a negative relationship, albeit at reduced strength (Sitkin and Weingart, 1995). This effect was described by Baron and Kenny (1986) as partial mediation and is depicted in Figure 4.4. The results of study two supported the position of Kahneman and Tversky's (1979) prospect theory in regard to individual behaviour subject to conditions of different problem frames, with positive frames leading to risk-averse decision outcomes and negative frames leading to risk-seeking decision outcomes (Sitkin and Weingart, 1995, Kahneman and Tversky, 1979).



Single plus and minus signs indicate significance of  $p < 0.05$  or greater, whereas double minus signs indicate significance of  $p < 0.01$  or greater (Sitkin and Weingart, 1995).

Figure 4.4: Simple mediation model of study two from Sitkin and Weingart (1995)

While the genesis of this thesis can in part be found in Sitkin and Weingart (1995) and the simple mediation model employed as shown above, this does not justify the use of a similarly structured analytic model to address the main research problem of this thesis. Instead, it illustrates the means by which the main research problem and the corresponding research questions were in part conceived. Rather, the analytic model must be valid and satisfy the requirements of this thesis to be justified (Perry, 1998). Nevertheless, this thesis represents both an adaptation and an advancement of Sitkin and Weingart (1995) in regard to indirect causal relationships involving actual decision-making behaviour and the risk perception and risk propensity-based psychographic characteristics of the decision maker. Therefore, alignment of the model structures is, from the perspective of theory building, advantageous if justified.

The main research problem of this thesis seeks to examine the relationships between innovativeness, measured in terms of actual decision-making behaviour, and uncertainty and irreversibility using risk perception and risk propensity as the respective mediator and moderator of the relationships in question. Therefore, the analytic model must enable this. Further, the following points gathered from the stated purpose of this thesis, the main research problem and the research questions represent the premises that the analytic model must satisfy to justify it as appropriate and fit for purpose in this case:

1. In terms of examining the relationships between the salient variables, the analytic model must enable predictions of investment decision-making behaviour to be made based upon variation in the levels of uncertainty and irreversibility surrounding the

decision circumstance in question, as the main research problem addressed by this thesis requires that predictive capability be evaluated.

2. The requirement to examine how and to what extent decision-maker risk perceptions concerning the decision circumstance may affect actual decision-maker behaviour also demands that the model enables the testing of mediation processes. It is through the testing of mediation processes that causal chain effects can be evaluated to provide insights into how the effects come to be (Baron and Kenny, 1986, Judd and Kenny, 1981).
3. Given that each respondent to the online survey that forms part of the methodology is required to complete ten decision-making-based tasks, as mentioned in Section 1.6, the analytic model must not preclude quantitative methods that have the capability to accommodate multi-level data. For multi-level datasets, this capability is necessary so that important assumptions underlying the validity of the analytical methods are not violated (see Bickel, 2007, Field, 2009, Hair et al., 2006, Hayes, 2006, Hayes and Rockwood, 2019, Kreft and de Leeuw, 2007, Robson and Pevalin, 2016, Snijders and Bosker, 2004).
4. As the main research problem calls for an examination of the extent to which decision-maker risk propensity may, acting in the form of a moderator, affect relationships between the salient variables, the analytic model must possess the capability to accommodate this requirement.
5. Given that analysis of both uncertainty and irreversibility acting as predictor variables must be accommodated by the analytic model, and given that uncertainty and irreversibility are both represented by two dichotomous attributes, the research model must not preclude the use of quantitative techniques within which the effect of the covariates can be controlled as described by Hayes (2018).

The simple mediation model structure employed within study two by Sitkin and Weingart (1995), shown above as Figure 4.4, provides a platform from which each of the five capabilities may be satisfied. Figure 4.5 repeats the basic structure of both Figure 4.1 and Figure 4.4 and includes one moderator variable  $W_{(M \rightarrow Y)}$ . The moderator variable  $W$  has been applied to the  $M \rightarrow Y$  indirect pathway within the model to enable testing of the moderating effect of the psychographic variable of risk propensity, as well as the moderating effect of the irreversibility attribute of irreversible consequence postponement as discussed in Sections 4.4.5 and 4.4.6.

Also shown in Figure 4.5 is the addition of variables  $C_i$  and  $K_j$ , with each conceptually representing the respective sets of  $i$  level one and  $j$  level two variables. Acting as covariates, these may threaten claims of causality within the model through confounding and epiphenomenal associations based upon the selection of a particular predictor variable as described by Hayes (2018). For clarity and in alignment with convention, lower-level datasets, denoted as level one datasets, are those datasets associated with a particular circumstance or event (see Bauer et al., 2006, Bickel, 2007, Kreft and de Leeuw, 2007, Luke, 2004, Robson and Pevalin, 2016, Snijders and Bosker, 2004). In the case of this thesis, level one data is associated with a unique conjoint task that is completed by a given survey respondent. Upper-level datasets commence with level two datasets and represent groupings of data that exist within an overall dataset and can be categorised and identified as having a common source; as such, they can lead to the violation of statistical assumptions of independence (see Bauer et al., 2006, Bickel, 2007, Kreft and de Leeuw, 2007, Luke, 2004, Robson and Pevalin, 2016, Snijders and Bosker, 2004). For the purposes of this thesis, data associated with each survey respondent are classified as level two data, as each survey respondent is required to complete ten conjoint tasks. The research model of this thesis is limited to level one and level two datasets, with level one representing data derived from a given conjoint task and level two data representing data that describe each survey respondent.

Referring to Figure 4.5, the predictor variable of interest is again denoted as  $X$ , the mediating variable is represented by  $M$  and the outcome variable is shown as  $Y$ . The moderator variable is denoted as  $W$ . The set of level one covariates  $C$  comprises the three predictor variables that are not the predictor variable of interest for a given analysis. The set of level two covariates  $K$  comprises the three respondent-related variables of age, gender and working career duration measured in years, which are constant across the conjoint tasks.



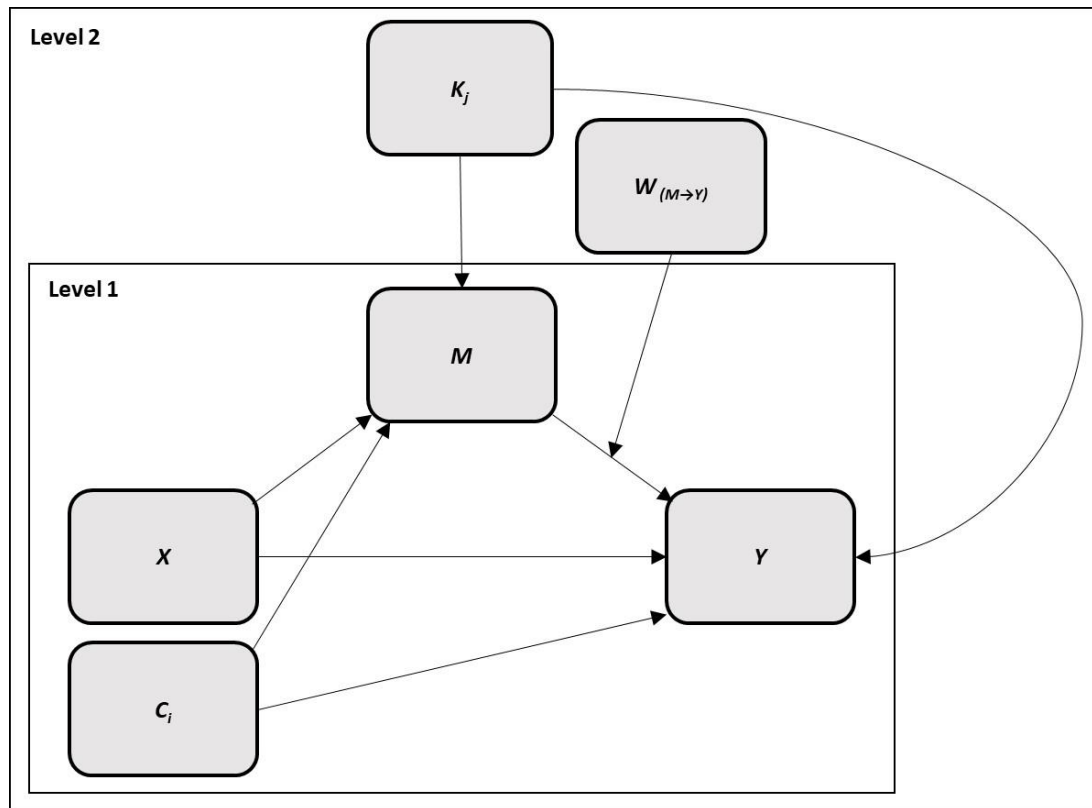


Figure 4.5: The analytic model of this thesis

Building upon the revised model of Sitkin and Weingart (1995) shown in Figure 4.2 previously, and incorporating the necessary capabilities required to address the purpose, the main research problem and research questions of this thesis, Figure 4.5 is justified and represents the analytic model that will henceforth be employed within this thesis. Advancing the work of Sitkin and Weingart (1995) in this manner addresses a research opportunity referred to by Sitkin and Weingart (1995), namely examination of the effect of other variables upon risky decision-making behaviour using a similar general approach. This opportunity has hitherto not been explored in regard to uncertainty, irreversibility and innovativeness.

### **4.3 Contextualisation of uncertainty and irreversibility**

To enable the construction of valid hypotheses concerning uncertainty and irreversibility within this chapter, these terms, which are drawn from the parent discipline theme literature as described in Sections 2.4.2 and 2.4.3 respectively, must be operationalised so they are contextually relevant and operationally useful to this thesis.

Both uncertainty and irreversibility are contextualised within this thesis through the content of the 'Carter Racing' case study, which is provided in Appendix B, and through the design of the full-profile CVA online survey upon which this thesis relies. As described in detail in Chapter 5, the research method relies upon the 'Carter Racing' case study and the associated online survey, with each survey respondent being placed in the role of Pat Carter, one of the owners of Carter Racing. The case study centres upon a critical time-bound investment decision, the consequences of which range from the creation of a serious threat to the ongoing viability of the business or an opportunity to realise a major commercial breakthrough for the racing team depending upon the race team's performance in the next race at Ponono Raceway. A number of uncertainties surround this critical decision, including the degree to which a new innovative engine gasket sealing arrangement has prevented engine failure in recent races. This is combined with a range of possible responses from essential sponsors, should engine failure occur, that determine the degree to which the consequences of the investment decision in question are irreversible. The original 'Carter Racing' case study, which has undergone minor adaptation to suit the purpose and objectives of this thesis, was written with the intent of illustrating, within both university classroom and corporate education contexts, the challenges of managerial decision making wherein the nature of problems is ambiguous, their causes unclear and vital pieces of information required to solve them are unavailable, contradictory or suppressed (Brittain and Sitkin, 1990). The original 'Carter Racing' case study was based upon facts and circumstances drawn from the Challenger Space Shuttle disaster (Brittain and Sitkin, 1990, Sitkin and Weingart, 1995).

Within this thesis, uncertainty is operationalised in the variable of decision uncertainty, whereas irreversibility is operationalised in the variable of decision outcome irreversibility. Decision uncertainty reflects uncertainty that surrounds the critical investment decision of whether the Carter Racing team should race at the Ponoco Raceway based upon the content of the case study and the additional information provided within the online survey. Decision uncertainty is contextualised in this way through two attributes within this thesis. One attribute of decision uncertainty is the degree to which a new innovative engine gasket sealing arrangement has successfully prevented engine failure in recent races. This attribute is named 'solution uncertainty'. The second attribute of decision uncertainty concerns the degree to which the race car engine reliability problems faced within the case study are related to ambient temperature. This attribute is named 'problem uncertainty'. Both solution uncertainty and problem uncertainty are dichotomous variables, and each is

represented by two levels. One level is categorised as a higher degree of uncertainty, while the other is categorised as a lower degree of uncertainty.

Decision outcome irreversibility reflects outcomes that arise from decision choices made in regard to competing at Ponoco Raceway. Like decision uncertainty, decision outcome irreversibility is contextualised within this thesis through two attributes. The first attribute concerns the sponsorship consequences that arise from a decision choice to race in the Ponoco event, with the outcome being failure to finish due to an engine failure. This attribute is dichotomous and representative of two levels: one is irreversible and the other is semi-irreversible. This attribute is representative of the irreversible consequences of failure and is denoted as 'irreversible consequence failure'. The second attribute of decision outcome irreversibility concerns the sponsorship consequences that arise from a decision not to race in the Ponoco event. This attribute is also dichotomous and has two levels: one is fully reversible and the other is semi-irreversible. Accordingly, this attribute is representative of the irreversible consequences of postponement and is denoted as 'irreversible consequences postponement'. Table 4.1 demonstrates how the variables of uncertainty and irreversibility, drawn from the parent discipline field literature examined in Chapter 2, are first operationalised within this thesis as decision uncertainty and decision outcome irreversibility. Each is then contextualised in the form of two dichotomous attributes with levels reflective of either uncertainty or irreversibility as appropriate. Table 4.1 repeats the information contained in Table 1.1.

Variable	Uncertainty		Irreversibility	
<b>Variable name in operation</b>	Decision uncertainty		Decision outcome irreversibility	
<b>Attribute of the variable</b>	Solution uncertainty	Problem uncertainty	Irreversible consequence failure	Irreversible consequence postponement
<b>Attribute description</b>	# of races completed using new gasket arrangement since last failure using old gasket	% of finished races in season with air temp in 18–24° C range	Sponsor funding outcomes if decision is to race and then blow up racing car engine	Sponsor funding outcomes if decision is not to race
<b>Levels of higher uncertainty or greater irreversibility</b>	2 races completed so little positive experience with solution	60% of races completed in doubtful temperature range	Lose both oil and tyre sponsorships	Retain option to negotiate oil sponsorship next season but lose tyre sponsorship
<b>Levels of lower uncertainty or lesser irreversibility</b>	5 races completed so more positive experience with solution	73% of races completed in doubtful temperature range	Lose oil sponsorship but retain option to negotiate tyre sponsorship	Retain options to negotiate both oil and tyre sponsorships next season

Table 4.1: The attributes and levels for uncertainty and irreversibility

The selection of two levels for each attribute was made because it enables the effect of variation in the state of each attribute to be measured while ensuring that the total number of conjoint tasks presented to each respondent is restricted to a manageable level. The relationship between the number of levels, the number of attributes and the required number of conjoint tasks is discussed in Section 5.4.4. The origins of the levels for each of the four attributes shown in Table 4.1, together with justification for the chosen levels in each case, are outlined below:

- Solution uncertainty: Both levels were selected to illustrate within each of the conjoint tasks a low level of racing experience with the new innovative gasket arrangement. The difference between the two levels is sufficient to properly distinguish one level from the other and thus enable the testing of two distinct levels of solution uncertainty.

- Problem uncertainty: The attribute levels were calculated based upon content contained within the 'Carter Racing' case study. The lower level (73%) represents 11 of the 15 races completed being within the 18–24° C ambient temperature range. The higher level (60%) represents 9 of the 15 races completed being within the 18–24° C range. The higher level was set at 60% to distinguish it from the lower level (73%) to enable the testing of two distinct levels of problem uncertainty.
- Irreversible consequence failure: The higher level reflects the worst sponsorship loss outcome (\$800,000) described as conceivable within the 'Carter Racing' case study. Similarly, the lower level reflects what is said to be the sponsorship loss outcome that will be incurred, at a minimum, if a decision to race is made and an engine failure is the consequence (\$500,000). Together, they provide a distinctly different pair of levels for this attribute.
- Irreversible consequence postponement: The higher level reflects that which is contained with the case, being the loss of a \$300,000 tyre sponsorship if a decision is made not to race. The lower level was selected to provide a risk-free decision outcome, thus creating a distinctly different pair of levels for this attribute.

#### **4.4 Categorisation and development of the hypotheses**

In Chapters 2 and 3, the necessary parent and immediate discipline fields have been considered in terms of both the breadth and depth of the relevant literature to adequately inform this thesis. Based upon this, the balance of this chapter is dedicated to developing a set of hypotheses that will be tested via the methodologies described in Chapter 5. These hypotheses have been categorised as follows:

- respondent preferences for conditions of uncertainty and irreversibility
- predictors of risk perception
- predictors of innovativeness
- mediation effects
- moderation effects
- option value effects.

Each category is considered separately below. Within each section, reference is made to the relevant relationship contained within the analytic model used in this study, as shown in Figure 4.5.

#### **4.4.1 Preferences for conditions of uncertainty and irreversibility**

The first research question addressed by this thesis concerns to what extent innovativeness may be predicted based upon respondent decision choice preferences demonstrated through the conjoint analysis. The conjoint analysis relies upon uncertainty operationalised as both solution uncertainty and problem uncertainty, and irreversibility operationalised as both irreversible consequence failure and irreversible consequence postponement. Therefore, the first question seeks to examine the ability to predict future decision-making behaviour based upon variations in these four variables. As each variable is dichotomous in nature, the underlying purpose of the first research question is therefore to examine whether predictions of innovativeness can be made based upon actual respondent decision-making choice preferences associated with the dichotomous states that represent each variable. As described in Section 4.3 and as shown in Table 4.1, for problem uncertainty and solution uncertainty, the corresponding dichotomous states can be categorised as being either a higher or lower level of uncertainty. Similarly, for irreversible consequence failure and irreversible consequence postponement, the corresponding dichotomous states can be categorised as being either a higher or lower level of irreversibility.

The variable of uncertainty is operationally defined within this thesis as the degree of confidence that can be assigned to estimates of values or criteria subject to evaluation, assessment or measurement (Duncan, 1972, Thompson, 2011). Uncertainty relates to doubt over the validity of specific measured values or assessed criteria. Its magnitude represents deviation from an exact or complete estimation, evaluation or measurement, with the result being incomplete knowledge or understanding (Bratvold and Begg, 2010, Standards Australia, 2009, Standards Australia, 2018, Thompson, 2011). Therefore, based upon this operational definition, the dichotomous states categorised as representative of a higher level of uncertainty characterise higher levels of doubt over the validity of specific measured values or assessed criteria, greater levels of expected deviation from an exact estimation or measurement and a lower level of knowledge and understanding. Alternatively, the dichotomous states categorised as representative of a lower level of uncertainty characterise lower levels of doubt over the validity of specific measured values or assessed criteria, lower

levels of expected deviation from an exact estimation or measurement and a higher level of knowledge and understanding.

According to the 'Carter Racing' case study content and Section 4.3, uncertainty about the actual cause of the racing engine reliability problem and uncertainty as to whether the new innovative gasket arrangement is an effective solution to that problem both result in uncertainty surrounding future racing engine reliability outcomes. The effect of a higher level of uncertainty associated with either problem uncertainty or solution uncertainty is expected to result in a correspondingly higher level of uncertainty surrounding possible future engine reliability outcomes. Conversely, the effect of a lower level of uncertainty associated with either problem uncertainty or solution uncertainty is expected to result in a correspondingly lower level of uncertainty surrounding possible future engine reliability outcomes. As a consequence, based upon the definition of risk employed within this thesis, such variation in possible future outcomes caused by variation in the level of uncertainty associated with those outcomes may also affect how risk is characterised and perceived.

Among the literature concerning uncertainty and its relation to innovativeness, as detailed in Section 2.3, consistent examples are presented that associate increased levels of uncertainty with reduced rates of innovation diffusion. Commencing with a study by Ryan and Gross (1943), which examined the non-economic factors that influence farmers' economic decision-making behaviours, studies into the adoption of innovation have shown that increased levels of uncertainty are associated with reduced willingness to adopt innovation and slower rates of diffusion (see Diamond Jr., 2003, Dixit and Pindyck, 1994, Gilboa, 2009, Griliches, 1957, Griliches, 1980, Mansfield, 1961, Midgley and Dowling, 1978, Rogers, 2003, Sundbo, 1998). For example, Ryan and Gross (1943) found that early adopters of hybrid corn were better educated and made more frequent visits to Des Moines, the largest city in Iowa, compared with corn farmers who adopted hybrid corn seed varieties later (Griliches, 1957, Griliches, 1980, Rogers, 2003, Ryan and Gross, 1943). As a consequence, the early adopters possessed the capability to resolve uncertainties relevant to the adoption decision faster than those who were less well educated and who made less frequent visits to Des Moines. The effect was a more rapid transition through the first three steps of the innovation adoption process as described by Rogers (2003) and shown in Figure 2.6. A key finding of the study was that interpersonal communication between farmers who had trialled the hybrid corn and those who had not played an important role in increasing the willingness of the latter group to trial the new innovative corn seed (Rogers, 2003, Ryan and Gross, 1943, Rogers, 2004). Therefore, it can be presupposed that, as a consequence of

interpersonal communication between farmers, the level of uncertainty possessed by farmers who had not trialled the new corn type was reduced, thereby having a positive effect upon their willingness to trial it.

While examples of studies of the intertemporal effects of uncertainty upon decision making within the relevant literature are rare (Hardisty and Pfeffer, 2017), findings from these studies show that uncertainty influences the time preference for rewards (see Ahlbrecht and Weber, 1997, Anderson and Stafford, 2009, Grusec, 1968, Hardisty and Pfeffer, 2017, Mischel and Grusec, 1967), and that in circumstances of intertemporal choice, decision makers generally act to avoid uncertainty (Hardisty and Pfeffer, 2017). While finding in favour of the avoidance of losses is consistent with that described by Ahlbrecht and Weber (1997), Anderson and Stafford (2009), Blackburn and El-Deredy (2013), Grusec (1968) and Mischel and Grusec (1967), this contradicts some premises prescribed within prospect theory (Kahneman and Tversky, 1979). As prospect theory was developed on the basis of immediate outcomes rather than within a context of intertemporal choice, this may account for the difference in findings (Hardisty and Pfeffer, 2017). Specifically, Hardisty and Pfeffer (2017) found that while maintaining the expected value of payouts as constant, losses and gains in the present were found to be preferred if the future appeared more uncertain, and future losses and gains were preferred if the present time was considered more uncertain than the future. These findings point to an intertemporal preference for the avoidance of uncertainty—whether real or perceived—together with a preference for more immediate and more certain rewards (Hardisty and Pfeffer, 2017). The findings of Hardisty and Pfeffer (2017) regarding individuals in circumstances of intertemporal choice who exhibit behaviour that seeks to avoid uncertainty in the present are not misaligned with the findings established by Ryan and Gross (1943). In all cases mentioned, the underlying motivational factor appears to be an aversion to loss arising from uncertainty.

Given that innovativeness is operationally defined in this thesis as the degree to which a decision maker is more or less willing to adopt, use and rely upon an innovation, at a given point in time and within a specific context, relative to other members of a social system (Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers and Havens, 1962), the following relationships between uncertainty, as operationalised in this thesis, and innovativeness can be hypothesised:



***H1a: Solution uncertainty is negatively associated with innovativeness.***

***H1b: Problem uncertainty is negatively associated with innovativeness.***

The term 'irreversibility' is operationally defined as the degree to which the consequences of an investment decision can be reversed or substantially reversed after an investment decision is made. A high degree of irreversibility is representative of a circumstance where little, if any, reversal of consequence is possible post-investment decision, whereas a low degree of irreversibility is representative of a circumstance where the opposite is possible (see Baldwin and Meyer, 1979, Bernanke, 1983, Bronfenbrenner, 1945, Dixit and Pindyck, 1995, Hanemann, 1989, Henry, 1974a, Marschak, 1949, Pindyck, 1991).

Although only a small body of literature surrounds decision irreversibility and its relation to decision-making preferences (Bullens, 2013, Bullens et al., 2014, Shiner, 2015), previous research indicates that individual decision makers generally prefer reversible decisions because they provide an opportunity to revise an earlier decision at a later point in time (Bullens, 2013, Bullens and Harreveld, 2016, Bullens et al., 2011, Bullens et al., 2014, Bullens et al., 2013, Gilbert and Ebert, 2002, Shiner, 2015). These findings regarding a preference for reversible decisions are in broad alignment with that which underpins the basic theory of irreversible investment under uncertainty (Dixit and Pindyck, 1994, Dixit and Pindyck, 1995), which was addressed in Chapter 2. This is particularly so given that irreversible decisions tend to elicit a greater sense of perceived risk within the mind of the decision maker (Bernanke, 1983, Dixit and Pindyck, 1994, Dixit and Pindyck, 1995) and a tendency to delay the point in time of an irreversible or largely irreversible decision to preserve valuable options that exist within the decision context (see Arrow and Fisher, 1974, Dixit and Pindyck, 1995, Henry, 1974a, Henry, 1974b, Marschak, 1949, Smit and Trigeorgis, 2004, Sunstein, 2010, Weisbrod, 1964). These issues often cause irreversible decisions to be considered more cognitively taxing than reversible decisions up until the point that a decision is made, after which this relationship has been observed to reverse (see Bullens, 2013, Bullens and Harreveld, 2016, Bullens et al., 2011, Bullens et al., 2014, Bullens et al., 2013, Gilbert and Ebert, 2002, Shiner, 2015).

While the abovementioned research findings show that individuals generally prefer reversible decisions because such decisions provide an opportunity for revision, prior

research also indicates that reversible decisions generally result in a lower level of post-choice satisfaction (see Bullens, 2013, Bullens and Harreveld, 2016, Bullens et al., 2011, Bullens et al., 2014, Bullens et al., 2013, Gilbert and Ebert, 2002, Shiner, 2015). Notwithstanding this, Shiner (2015) found that decision makers who seek to maximise the utility arising from their decisions through a process of iteration prefer reversible decisions both before and after the point at which a decision is made. The matching of the 'fit' between the decision-maker's goals and the 'safety net' provided by the reversible decision process is argued to result in a longer-term preference for reversible decisions where utility maximisation is sought (Bullens and Harreveld, 2016, Shiner, 2015). Therefore, in the case where a decision option is to take action within the context of an irreversible consequence arising from that decision, the following relationship is hypothesised:

***H1c: Irreversible consequence failure is negatively associated with innovativeness.***

Conversely, in the case where a decision option is to defer action within the context of an irreversible consequence arising from that decision, the following relationship is hypothesised:

***H1d: Irreversible consequence postponement is positively associated with innovativeness.***

In the case of hypothesis *H1d*, the sign of the relationship is reversed as compared to hypothesis *H1c*, which reflects the motivational influence of a high level of irreversible consequence associated with a decision option to defer action in the present until a time in the future. Therefore, hypothesis *H1d* illustrates risk-seeking behaviour in the domain of high-probability losses as depicted in Figure 3.2. The surety of loss associated with the high-level state of hypothesis *H1d* is expected to be highly aversive, thus giving rise to risk-seeking rather than risk-averse behaviour. Figure 4.6 diagrammatically depicts the four abovementioned hypotheses.

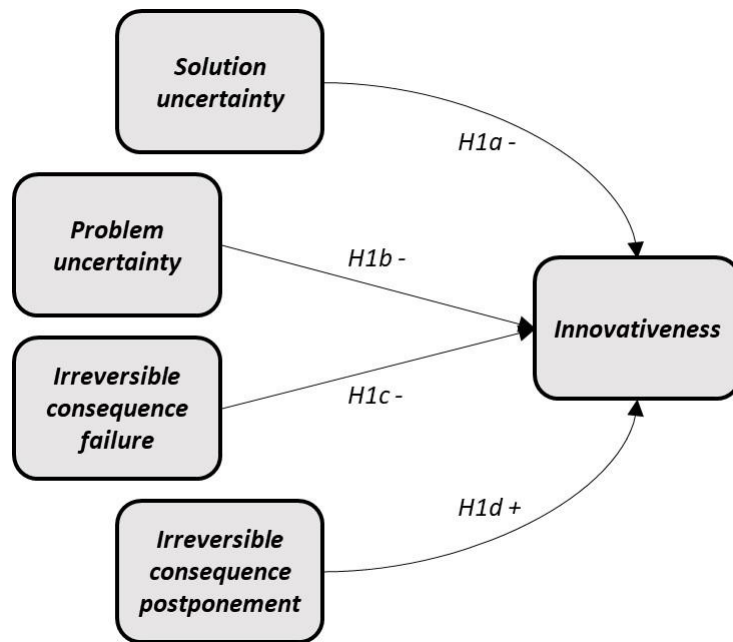


Figure 4.6: Hypothesised relationships—innovativeness, uncertainty and irreversibility

#### 4.4.2 Predictors of risk perception

The second research question addressed by the thesis concerns to what extent the variables of solution uncertainty, problem uncertainty, irreversible consequence failure and irreversible consequence postponement can be shown to be predictors of risk perception.

To examine the relationships between the variable of risk perception and the predictors of it relevant to this thesis, it is important to return to the corresponding sections of Chapters 2 and 3 and to bring forward from those sections the parts that, in combination, enable the creation of the necessary hypotheses that will be tested within this study. The subjects of interest for the development of hypotheses that concern the predictors of risk perception are the conceptualisation of risk, the definition of uncertainty, the definition of risk itself, the operationalisation of risk in the form of risk perception, the definition of irreversibility and the means through which both uncertainty and irreversibility are operationalised within this thesis. The variables are problem uncertainty, solution uncertainty, irreversible consequence of failure and irreversible consequence of postponement.

As described in Section 3.6, risk can be conceptualised as a label that is projected upon a set of specific conceivable characteristics possessed by a future state that in some manner relates to an event or activity that has occurred or may occur at an earlier point in time (Solberg and Njå, 2012). These conceivable characteristics represent both the level of uncertainty surrounding the realisation of that future state and the level of uncertainty

surrounding the severity of consequence arising from the realisation of that future state relative to something of human value (Aven and Renn, 2009, Rosa, 1998, Solberg and Njå, 2012). It is important to highlight that uncertainty is central to this projection effect, with uncertainty operationally defined as the degree of confidence that can be assigned to estimates of values or criteria subject to evaluation, assessment or measurement (Duncan, 1972, Thompson, 2011). Based upon the following two points, it is posited that an increase in the level of uncertainty relevant to a given circumstance should lead to a corresponding increase in the level of risk perception arising from evaluations of that circumstance.

- (a) Risk refers to the combination of uncertainty about future outcomes and uncertainty surrounding the consequences arising from those uncertain outcomes, together with the severity of those consequences, in regard to something of human value (Aven and Renn, 2009).
- (b) Risk perception is operationally defined as an individual's intuitive evaluation of the risk associated with a circumstance based upon predefined parameters and measurement scales, taking into consideration probabilistic estimations of the uncertainties surrounding the circumstance (Sitkin and Pablo, 1992), the level of confidence in those estimates and the degree to which uncertainties are believed to be controllable (see Baird and Thomas, 1985, Bettman, 1973, Duncan, 1972, Gough, 1990, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995, Vlek and Stallen, 1980).

Accordingly, given that the variables of problem uncertainty and solution uncertainty represent the means through which the variable of uncertainty is operationalised within this thesis, the following relationships are hypothesised:

***H2a: Solution uncertainty is positively associated with risk perception.***

***H2b: Problem uncertainty is positively associated with risk perception.***

The relationship between risk and irreversibility is dependent upon the degree to which the consequences that are associated with uncertain outcomes that are central to the notion of

risk can be reversed to minimise the severity of those consequences and their effect upon something of human value. For example, if the consequences that arise from an uncertain outcome or a set of uncertain outcomes are fully reversible, then the associated risk will be materially less than would be the case if the consequence or consequences were semi-reversible or irreversible. Therefore, employing similar logic as in the case above concerning the relationship between uncertainty and risk perception, it is hypothesised that an increase in the level of irreversibility of consequence associated with a given decision should lead to a corresponding increase in the level of risk perception associated with that decision. As the variables of irreversible consequence failure and irreversible consequence postponement represent the means through which the variable of irreversibility is operationalised within this thesis, the following is said to apply:

**H2c:** *Irreversible consequence failure is positively associated with risk perception.*

**H2d:** *Irreversible consequence postponement is positively associated with risk perception.*

Figure 4.7 depicts the four abovementioned relationships of this section.

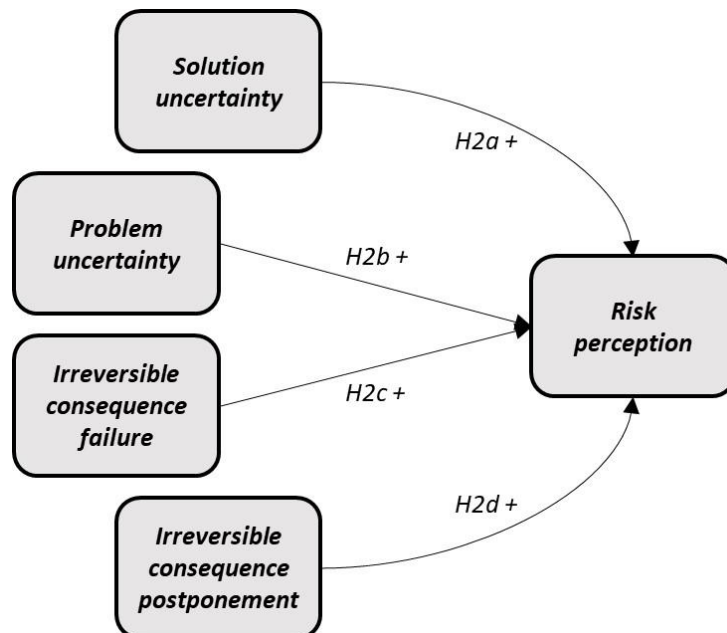


Figure 4.7: Hypothesised relationships—risk perception, uncertainty and irreversibility

Given that the operational definition of risk propensity applicable to this thesis is that risk propensity is an attitudinal measure of the current tendency of an individual to take or avoid risks within a predefined domain (Hatfield and Fernandes, 2009, Hurt et al., 1977, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995), the definition gives rise to the following two propositions:

- (a) Individual decision makers who exhibit a propensity to avoid risks are hypothesised to amplify and give greater salience to uncertainties and negative outcomes rather than possible upside potential and positive outcomes. As a consequence, they bias their attention towards risk and the probability of losses rather than opportunity and the probability of gains (Brockhaus, 1980, Schneider and Lopes, 1986, Vlek and Stallen, 1980, Sitkin and Weingart, 1995).
- (b) Individual decision makers who exhibit a propensity to take risks are hypothesised to give greater salience to the potential of opportunities, the possibilities arising from positive outcomes and the probability of gains as opposed to uncertainties, negative outcomes and the probability of losses (March and Shapira, 1987, Sitkin and Weingart, 1995).

In combination, the following two inferences can be drawn from this pair of propositions arising from biases affecting both outcomes and associated perceptions of situational risk. The first is the potential for the overestimation of gains by more risk-seeking decision makers and losses by more risk-averse decision makers. The second is the potential for the underestimation of losses by more risk-seeking decision makers and gains by more risk-averse decision makers. Therefore, it is hypothesised that individuals who exhibit greater levels of risk propensity within a given domain will evaluate perceived risk within that domain at lower levels than individuals who exhibit lower levels of risk propensity. Based upon the definition of risk perception applicable to this thesis, the following hypothesis applies:

***H2e: Risk propensity is negatively associated with risk perception.***

Figure 4.8 depicts this relationship. In alignment with this hypothesised proposition, Sitkin and Weingart (1995) found within study one that a significant negative correlation existed between risk propensity and risk perception.

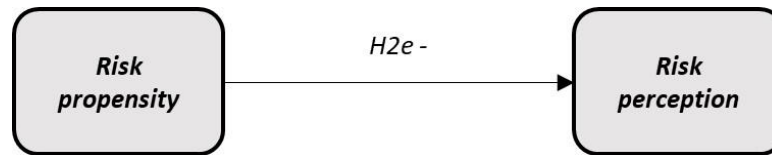


Figure 4.8: Hypothesised relationship—risk propensity and risk perception

#### 4.4.3 Predictors of innovativeness

Building upon the hypotheses developed to address research question two, the third research question addressed by the thesis concerns to what extent the question of whether risk perception and risk propensity can each be shown to be a predictor of innovativeness.

Based upon the definitions of risk and risk perception applicable to this thesis, it can be argued that the motivation for risk-averse behaviour is greater when threats against something that is of human value are perceived to be high compared with when such threats are perceived to be low. As argued by Sitkin and Pablo (1992) and Sitkin and Weingart (1995), a higher level of perceived situational risk may be associated with reduced willingness to engage in risky decision behaviour because a greater level of asymmetric focus is placed upon the possible negative outcomes and consequences that may arise. That is, a greater level of risk perception, based upon the means through which risk is to be considered and assessed for a given circumstance, reflects a greater level of risk aversion, which manifests in behaviour that exhibits a diminished level of willingness to engage in risky decision behaviour as described by Hamid et al. (2013), Huang et al. (2016) and Xia et al. (2017). While Kahneman and Tversky (1979), Tversky and Kahneman (1986) and Tversky and Kahneman (1992) did not explicitly consider risk perception within their respective analyses associated with the development and refinement of prospect theory, their findings do not contradict this proposition. Thus, it is hypothesised that a greater level of risk perception will be associated with a reduced level of willingness to engage in risky decision behaviour. This also aligns with the principles of chronic unease drawn from the literature and management theory surrounding safety leadership, wherein the conscious promotion of a heightened sense of vigilance, discomfort and concern among organisational leadership and culture causes a greater level of behavioural rigour to be introduced to risk-based decision-making

processes (see Flin and Fruhen, 2015, Fruhen and Flin, 2016, Fruhen et al., 2014). It is important to note that across the global operations of BHP, the principles of chronic unease were introduced to the organisation's leadership across all levels during 2017. Accordingly, the following is posited:

***H3a: Risk perception is negatively associated with innovativeness.***

This relationship is depicted diagrammatically in Figure 4.9.

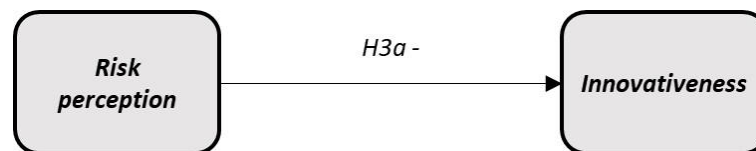


Figure 4.9: Hypothesised relationship—risk perception and innovativeness

Similar to the approach taken by Sitkin and Weingart (1995) in regard to the hypothesised relationship between risk propensity and actual risk-taking behaviour, the relationship between risk propensity and innovativeness within this study is hypothesised in accordance with the straightforward logical claim that arises from the following assertions:

- The essence of risk propensity is the willingness of an individual to take risks (MacCrimmon and Wehrung, 1990). An increasing level of risk propensity suggests that an individual will be more inclined to make increasingly riskier decisions in circumstances relevant to the domain within which the measure of risk propensity is assessed (see Fagley and Miller, 1987, Huff et al., 1997, MacCrimmon and Wehrung, 1985, MacCrimmon and Wehrung, 1986b, Nicholson et al., 2001, Salminen and Heiskanen, 1997).
- The essence of innovativeness is the willingness of an individual to embrace risk through the adoption and use of, and reliance upon, innovation. An increasing level of innovativeness is associated with a greater inclination to embrace risk and, in doing so, adopt, use and rely upon an innovation within a given point in time and



within a specific context (see Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rogers, 2003, Sundbo, 1998).

If an increasing level of risk propensity reflects an increasing willingness of an individual to take risks within a predefined domain, and if an increasing level of innovativeness demonstrates an increasing willingness to embrace risk through the adoption, use and reliance upon innovation within a context that is domain-relevant to that in which risk propensity is measured, the following is hypothesised:

**H3b:** *Risk propensity is positively associated with innovativeness.*

This relationship is depicted diagrammatically in Figure 4.10.

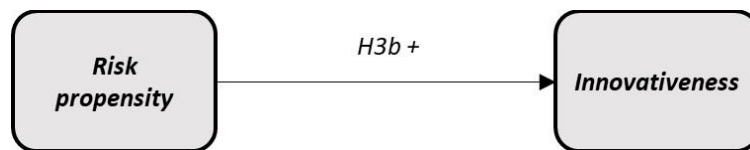


Figure 4.10: Hypothesised relationship—risk propensity and innovativeness

#### 4.4.4 Mediation effects

The fourth research question addressed by the thesis concerns whether it can be shown that risk perception mediates the effect of each predictor variable upon innovativeness. As discussed in Section 2.6, using search criteria that focused upon title, abstract and key words, no relevant literature could be found concerning the word combinations of (1) innovativeness, risk perception and mediate, (2) innovativeness, risk perception and mediation, (3) innovate, adoption, risk perception and mediate, and (4) innovate, adoption, risk perception and mediation. Therefore, it is necessary to frame the justification of the hypotheses concerning the mediation effect of risk perception upon innovativeness relevant to this thesis upon other literature that examines the mediating effect of risk perceptions within other separate risk-based contexts.

In a study that included the mediation effect of risk perception upon the relationships between risky decision-making behaviour and both outcome history and problem framing,

Sitkin and Weingart (1995) found support for a mediated model of risky decision-making behaviour based, in part, upon the mediating effect of risk perception. Employing the causal steps approach to mediation analysis described by Baron and Kenny (1986), James and Brett (1984) and Judd and Kenny (1981), Sitkin and Weingart (1995) found that risk perception fully mediated the relationship between outcome history and risky decision behaviour and partially mediated the relationship between problem framing and risky decision behaviour. The hypotheses employed by Sitkin and Weingart (1995) were largely based upon prior studies undertaken by Sitkin and Pablo (1992), which were claimed to be the earliest work undertaken that examined the indirect relationships in question (Sitkin and Weingart, 1995). In a separate but related study, employing the same causal steps approach to mediation analysis as Sitkin and Weingart (1995), Hamid et al. (2013) found that the relationship between risk propensity and risky behaviour was partially mediated by risk perception in a study involving individual investors who frequented the public galleries of eight Malaysian stockbroking firms. Similarly, Xia et al. (2017) examined relationships between risk perception and workplace safety behaviour and interviewed 120 Chinese construction workers. They employed the same approach to mediation analysis as Sitkin and Weingart (1995) and found that the relationship between the perceived severity of risk outcomes and safety compliance was fully mediated by risk perception.

Based upon the results of Sitkin and Weingart (1995), Hamid et al. (2013) and Xia et al. (2017) concerning the mediating effect of risk perception, and building upon the logic employed for the development of hypotheses *H2a* and *H2b* in regard to uncertainty in Section 4.4.2 and hypothesis *H3a* in Section 4.4.3, the following two propositions are postulated:

***H4a:*** Risk perception mediates the effect of solution uncertainty upon innovativeness.

***H4b:*** Risk perception mediates the effect of problem uncertainty upon innovativeness.

Hypotheses *H4a* and *H4b* rely upon arguments in the literature that an increase in the magnitude of solution uncertainty or problem uncertainty will result in a consequential increase in the level of risk perceived, as posited by hypotheses *H2a* and *H2b*. From this, it follows that any consequential increase in the level of risk perceived results in a hypothesised reduction in the level of innovativeness demonstrated through actual decision-maker behaviour, as stated by hypothesis *H3a*. The results obtained by Sitkin and Weingart (1995),

Hamid et al. (2013) and Xia et al. (2017) support an intuitively based argument in favour of the relationships between solution uncertainty, problem uncertainty, risk perception and innovativeness demonstrating indirect mediation effects. These two mediation relationships, hypotheses *H4a* and *H4b*, are depicted diagrammatically in Figure 4.11.

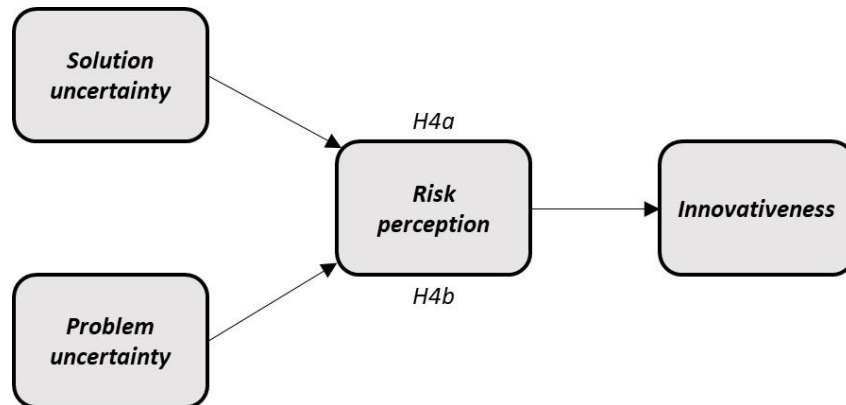


Figure 4.11: Hypothesised mediation effects—risk perception and uncertainty

In the case of the hypothesised mediation effect of risk perception upon the relationship between irreversible consequence of failure and innovativeness, an argument is postulated based upon identical logic to that used above for the mediation effect of risk perception upon solution uncertainty and problem uncertainty. Accordingly, the following applies:

***H4c:*** *Risk perception mediates the effect of irreversible consequence of failure upon innovativeness.*

As is the case for both hypotheses *H4a* and *H4b*, *H4c* relies upon arguments within the relevant literature that an increase in the magnitude of irreversible consequence failure will result in a consequential increase in the level of risk perceived, as is posited by hypothesis *H2c*. Therefore, it follows that any consequential increase in the level of risk perceived results in a hypothesised reduction in the level of innovativeness demonstrated through actual decision-maker behaviour, as stated by hypothesis *H4c*. However, it is hypothesised that such an argument cannot be made in favour of the relationship between irreversible consequence postponement and innovativeness because of the pair of relationships posited to exist between irreversible consequence postponement and risk perception, irreversible consequence of postponement and innovativeness, as stated in hypotheses *H1d* and *H2d*.

Hypothesis *H1d* is premised on the argument that risk-seeking behaviour in the domain of high probability losses will apply in its case, as described in Section 4.4.1. This causes a reversal of what is typically risk-averse behaviour, as discussed in Section 3.7.3 relating to prospect theory (Kahneman and Tversky, 1979) and as described by Harbaugh et al. (2010) and Kahneman and Lovallo (1993). Therefore, the following is postulated to apply in the case of the mediating effect of irreversible consequence postponement:

***H4d:*** Risk perception does not mediate the effect of irreversible consequence postponement upon innovativeness.

Figure 4.12 diagrammatically depicts the hypothesised mediation effect of relationships *H4c* and *H4d* in relation to the two variables of irreversible consequence failure and irreversible consequence postponement.

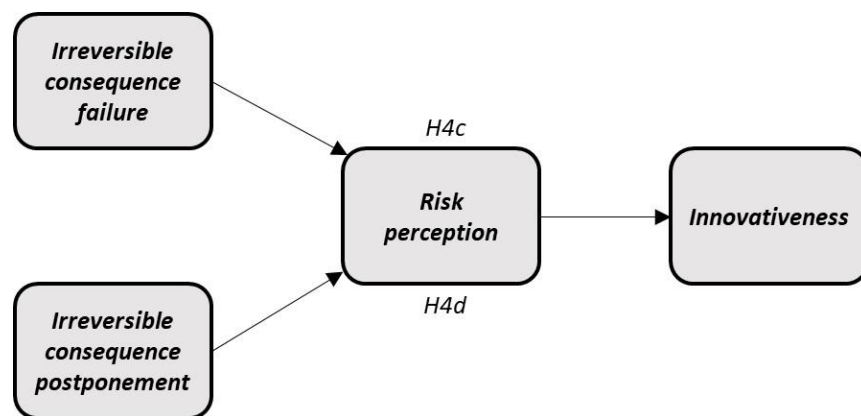


Figure 4.12: Hypothesised mediation effects—risk perception and irreversibility

#### 4.4.5 Moderated mediation effects

As an extension of the fourth research question, the fifth research question addresses whether it can be shown that risk propensity moderates the mediating effect of risk perception upon individual indirect relationships between innovativeness and solution uncertainty, problem uncertainty and irreversible consequence failure.

As noted in Section 2.6, no evidence could be found in the literature concerning the moderation effect of risk propensity upon innovativeness or, in a broader sense, upon the adoption of innovations. However, Hatfield and Fernandes (2009) conducted an insightful

study concerning the role of risk propensity in the driving behaviour of individuals aged from 16 to 25 and above 35 years of age who attended five motor registries in the Australian state of New South Wales. They considered the possibility for risk propensity to moderate the relationship between perceptions of risk and risky driving behaviour, claiming that very little had been done in this field previously (Hatfield and Fernandes, 2009). Evidence was observed demonstrating that risk propensity, defined within the study as ‘a positive attitude toward taking recognised risks’ (Hatfield and Fernandes, 2009 p. 25), had the effect of moderating relationships between risk perception and risky driving behaviour.

It is important to highlight that the indications of moderation observed by Hatfield and Fernandes (2009) affected the relationship between risk perception and the behaviourally relevant dependent variable. As a starting point in an otherwise largely barren field of directly relevant literature, the results of Hatfield and Fernandes (2009) indicated that the hypothesised moderating behavioural influence of risk propensity within this study affects the relationship between risk perception and innovativeness. Accordingly, the following three hypotheses concerning the existence of moderated mediation relationships will be tested:

***H5a:** Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

***H5b:** Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

***H5c:** Where risk perception is shown to mediate the effect of irreversible consequence failure upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

#### **4.4.6 Option value effects**

As a further extension of the fourth research question, the sixth and final research question addresses whether it can be shown that the variable of irreversible consequence postponement moderates the mediating effect of risk perception within the individual indirect relationships between innovativeness and solution uncertainty, problem uncertainty and irreversible consequence failure. The hypotheses developed within this section rely

upon the content of Chapter 2 concerning irreversibility (Section 2.4.3) and option value (Section 2.5). Each of these hypotheses are postulated according to the logic outlined in the argument below, which is itself developed from that contained in Sections 2.4.3 and 2.5.

Underpinning the sixth research question is whether the variable of irreversible consequence postponement, when it is in its low state—this being retention of the option to negotiate both oil and tyre sponsorships next season if the decision is not to race in the Ponoco event—moderates innovativeness, causing a statistically significant reduction in willingness to race. That is, the reduction in willingness to race is reflective of implicit recognition of an option value arising within the conjoint tasks of the online survey from the ability to wait and defer a decision to race until a future time without penalty or loss. This logic is similar to that described by Arrow and Fisher (1974), Dixit and Pindyck (1994) and Henry (1974b) in terms of the existence and preservation of valuable options that could cease to exist at the point in time at which an irreversible decision is made.

In doing so, the option to defer without penalty enables the possibility of reducing the level of uncertainty surrounding the cause of engine reliability problems through controlled testing prior to a future race. The value of the option in this case is avoiding the loss of sponsorship if the option to defer is not risk free. Further, a qualitative benefit is achieved from testing the race car engine within a controlled environment prior to the next race to better establish the true cause of the reliability problems as opposed to trial and error in race conditions. It is not known whether any survey respondent extended their consideration to this point. However, based on the information in this section and in Sections 2.4 and 2.5, the following is hypothesised following a similar approach to that employed in Section 4.4.5:

**H6a:** *Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

**H6b:** *Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

**H6c:** *Where risk perception is shown to mediate the effect of irreversible consequence of failure upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

Figure 4.13 contains all hypotheses developed in this chapter synthesised within the analytic model framework depicted in Figure 4.5.

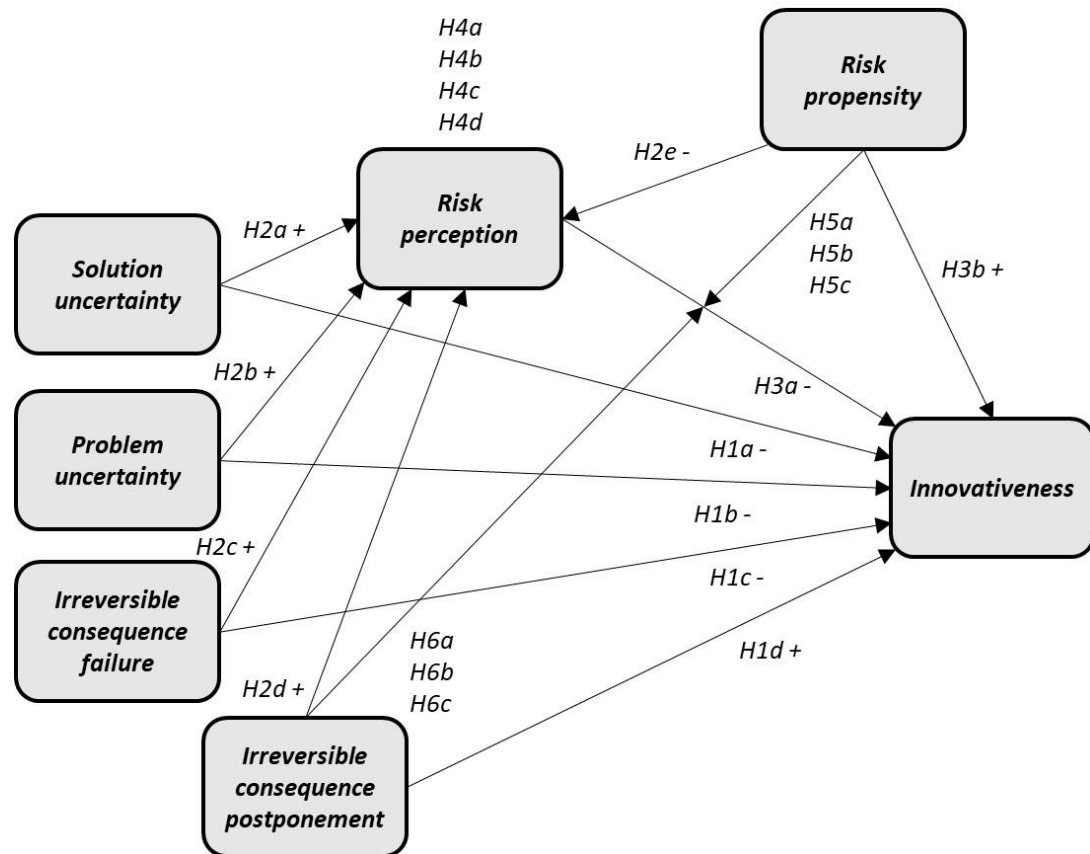


Figure 4.13: The analytic model showing all hypotheses to be tested

#### 4.5 Chapter summary

Three important elements of the thesis have been completed within this chapter. First, the analytic model to be employed by this thesis was developed. Following this, the means through which the variables of uncertainty and irreversibility are operationalised were considered. Finally, the necessary hypotheses linked to each of the six research questions listed in Section 1.4 were developed. The completion of this chapter marks the completion of the theoretical section of this thesis, which encompasses Chapters 2–4, as shown in Figure 1.3. The next chapter marks the commencement of the empirical section and focuses upon the methodologies employed within this thesis to generate the necessary dataset for analysis, as well as the analytical techniques used to test the hypotheses originating from this chapter.

## 5. RESEARCH METHODOLOGY

### 5.1 Introduction

Following the review of the salient literature in Chapter 2 and the development of the research model for the thesis and the hypotheses in Chapter 3, this chapter discusses the methods employed for the measurement of the variables, the validation of the model and the testing of the hypotheses. The chapter begins with an overview of the research design, followed by an explanation and justification of the methodology employed to address the main research problem of the thesis, as stated in Section 1.4. The chapter then identifies and justifies the population of interest and addresses the survey questionnaire design and measurement scales that are employed. As part of this, the chapter also addresses pilot testing of the survey and introduces the case study content upon which the CVA survey relies. In addition, the chapter addresses the instrument development process, the data collection plan, the primary techniques employed for data testing and analysis, potential issues concerning non-response and common method bias, and the necessary ethical considerations.

### 5.2 Research design overview

As stated in Section 1.2, the purpose of this thesis is to examine to what extent predictions of investment decision-making behaviour may be made based upon indirect effect relationships between actual risky decision-making behaviour and variables concerning decision uncertainty and decision outcome irreversibility. This is done using decision-maker risk perception and risk propensity as psychographic mediator and moderator respectively. To ensure that this objective could be achieved within the duration of the candidature, a set of research design steps have been followed. Figure 5.1 shows an overview of the process employed to complete this study, which is described in Section 5.3. Elements marked with an \* apply to both the pilot and main surveys.



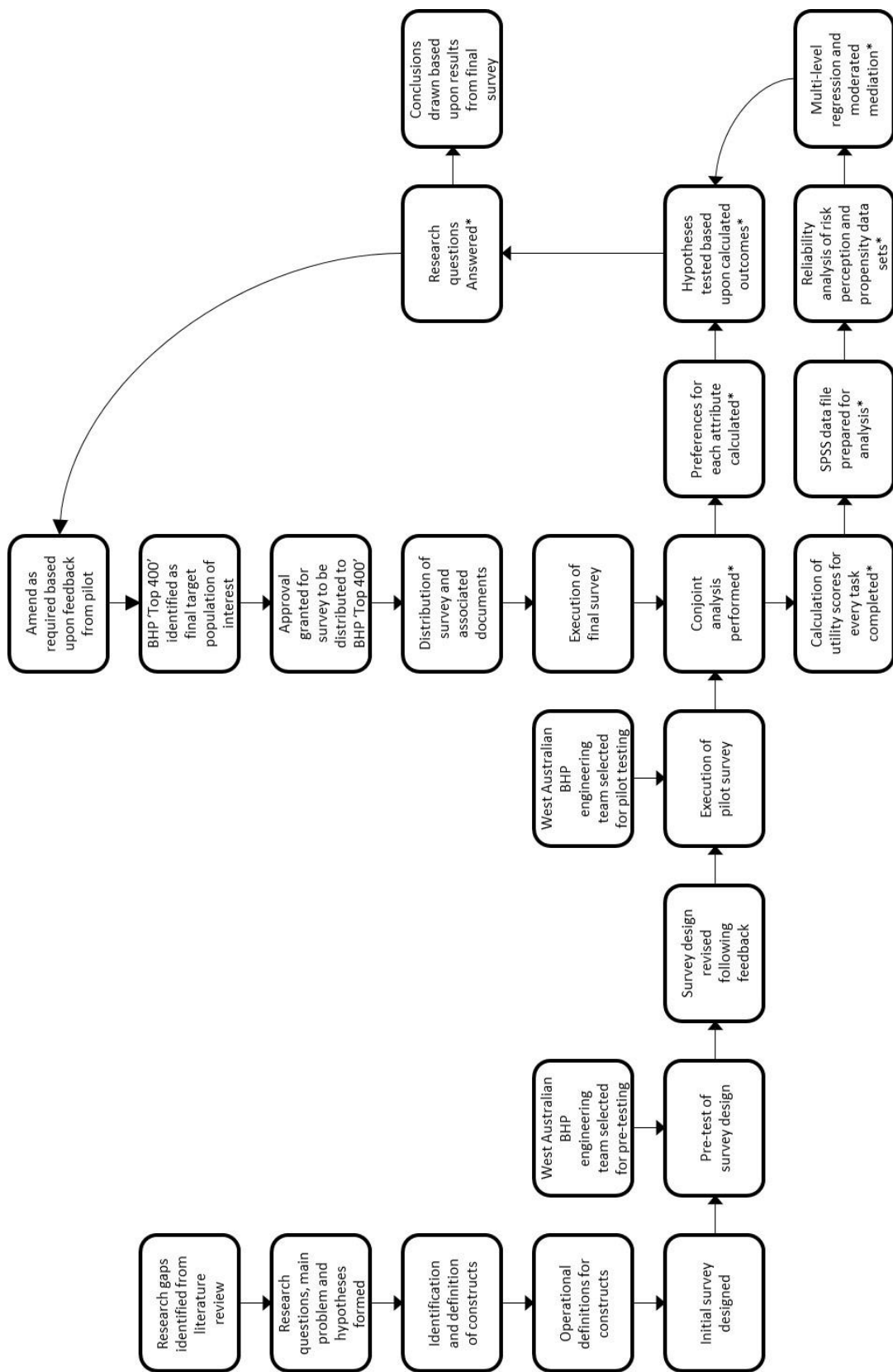


Figure 5.1: Overview of the research design

### **5.3 Research methodology employed**

Based upon the main research problem that this thesis seeks to address, as stated in Section 1.4, as well as the six research questions that arise from the research problem, the research methodology employed within this thesis has two primary aims. The first aim is to use full-profile conjoint analysis to create an online survey and, consequently, calculate respondent preferences and utilities values that represent the variable of innovativeness. This is based upon ten conjoint tasks that describe differing combinations of the two means through which both uncertainty and irreversibility are operationalised, as outlined in Table 4.1. A further objective of the first aim is to gather responses through the online survey concerning the psychographic variables of risk perception and risk propensity. These will be used as inputs to address the second aim of this thesis, which is to examine the relationships between innovativeness, the operationalised forms of uncertainty and irreversibility, and risk perception and risk propensity using multi-level moderated mediation analysis (MLmed) techniques to establish the extent to which predictions of innovativeness may be made based upon these variables.

The methodology employed in this thesis combines full-profile CVA with MLmed using data gathered through an online survey. As stated in Section 1.2, the unit of analysis is a population of 400 executive leaders employed by the global resources company BHP during the period October to December 2018. These leaders are defined by BHP as the 'Top 400' and access to the group was achieved via email. The cultural composition of the BHP global business and, by consequence, the survey population for the online survey motivated an initial need to provide the online survey and all associated documents required to complete it in both English and Spanish language versions. However, as a result of complexities associated with the translation and interpretation of the online survey content and the associated documents, in the absence of the ability to source assistance in real time to resolve any uncertainties or misunderstandings, the final survey was executed in the English language only.

A hypothetical case study titled 'Carter Racing' provided the necessary background and situational context within it to enable the survey. The case study content is contained in Appendix B. The full-profile CVA component of the methodology was enabled by the case study, with the online survey design requiring that each respondent complete ten single-concept conjoint tasks. Each task provided a unique combination of the uncertainty and irreversibility variables in their operationalised form to enrich the information provided

within the case study. For each task, respondents were required to make a subjective assessment of the probability that they would decide to engage in risky decision behaviour by racing in the Ponoco race event as described within the case study, a dichotomous 'yes or no' response to the same question, and their perceptions of risk associated with the specific conjoint task.

### **5.3.1 Carter Racing case study**

The 'Carter Racing' case study was written based upon the facts and circumstances surrounding the Challenger Space Shuttle disaster that occurred on 28 January 1986 (McDonald and Hansen, 2009). The original case study was developed by Sim Sitkin and Jack Brittain and was first presented in 1987 (Brittain and Sitkin, 1990). Since then, it has been used in numerous university classroom, corporate education and military leadership development contexts. Within these contexts, it has been used to illustrate the challenges of managerial decision making when the nature of problems are ambiguous, their causes are unclear and vital pieces of information required to solve them are unavailable, contradictory or suppressed (Brittain and Sitkin, 1990). A copy of the original case study was obtained from Professor Sitkin of Duke University (Prof S Sitkin, pers. comm., 26 June 2017).

To summarise the case study, it is centred upon a critical time-bound investment decision for the owner of a professional racing car business. The consequences may range from the creation of a serious threat to the ongoing viability of the business to an opportunity to realise a major commercial breakthrough for the racing team depending upon the team's performance in the next race. A number of uncertainties surround this critical decision, including the level to which a new innovative engine gasket sealing arrangement has prevented engine failure in recent races. This, combines with a range of possible responses from essential sponsors if engine failure should occur, or if a decision is made not to race, that determine the degree to which the consequences of the investment decision in question are irreversible.

Slight modifications were made to the case content prior to use within the context of this thesis.

The modifications were:

1. minor grammatical adjustments to suit the research methodology of this thesis
2. an emphasis upon the innovative and novel nature of the new engine gasket seating arrangement
3. conversion of ambient temperature scale from Fahrenheit to Celsius
4. changes to the instructions at the conclusion of the case content to provide the necessary linkage to the online survey.

The 'Carter Racing' case study was determined to be highly suitable to the purposes of this thesis for five reasons:

1. The case is central to the work of Sitkin and Weingart (1995), which underpins the origin of the psychographic determinants used within this thesis.
2. Given that the original case study was written to illustrate the challenges of managerial decision making in circumstances where problems are ambiguous, actual causes are unclear and critical pieces of information required to solve them are either unavailable, contradictory or suppressed (Brittain and Sitkin, 1990), the case aligns well with the hypotheses to be tested within this thesis.
3. The case could easily be adapted with very little modification to satisfy the requirements of the survey methodology to test the variables in question within this thesis.
4. The case has been applied across a wide spectrum of applications within both university and corporate education contexts, as well as military leadership development programs. As such, it is an established and well-recognised document (Brittain and Sitkin, 1990, Sitkin and Weingart, 1995).
5. Valid measurement scales for both risk propensity and risk perception are provided by Sitkin and Weingart (1995) that could be readily applied for the purposes of this thesis.

The case study is contained in Appendix B.

### **5.3.2 Justification of the methodologies employed**

The methodology employed within this thesis is a combined approach involving both conjoint analysis and multi-level regression analysis. The former generates the necessary inputs for the latter either directly or by enabling a measurement for the required psychographic variables within the conjoint-based online survey.

There are two primary justifications for the selection of conjoint analysis as one part of the overall methodology of this thesis. The first justification is founded upon the argument that conjoint analysis provides the ideal means through which the main research problem addressed by this thesis may be answered in regard to actual decision choice preferences made by online survey respondents. The second justification is that the outputs of the method—in terms of both decision-making preferences and the ability to generate psychometric datasets to determine risk perception and individual risk propensity via a survey—enable the necessary moderation and mediation calculations to be performed to fully answer the main research problem of this thesis.

Conjoint analysis is a quantitative method of analysis that aims to measure decision-maker preferences, including reactions to and evaluations of differing combinations of predetermined attributes and their respective levels, which represent a subject of interest (Green and Wind, 1975, Hair et al., 2006). Through conjoint analysis, it is possible to gain valuable insights into how decision makers make decision trade-offs between multi-attribute subjects of interest based upon the calculated utility values associated with each alternative option and the part-worth estimates that are calculated for each level of each attribute (Gustafsson et al., 2007, Hair et al., 2006, Rao, 2014). While conjoint analysis is typically employed in the field of marketing products and services, the methodology may be employed in any circumstance where an understanding of how decision makers exercise judgement is sought, but especially so within environments where several decision options exist and trade-offs must be made across a range of multi-attribute choices (Ben-Akiva et al., 2019, Green and Rao, 1971, Green and Srinivasan, 1978, Green and Srinivasan, 1990, Green and Wind, 1975, Hair et al., 2006, Orme, 2014). The method originated in the work of Debreu (1959), followed by the seminal important advancements of Luce and Tukey (1964) and others, as described in detail by Ben-Akiva et al. (2019). Within the field of marketing, early references to the technique were discussed by Green and Rao (1971), and widespread penetration occurred across a range of applications during subsequent decades (Ben-Akiva et al., 2019, Green and Srinivasan, 1978, Hair et al., 2006). Several software packages, such

as that provided by Sawtooth Software Inc., now enable the calculation of the requisite conjoint analysis outputs. Appropriate conjoint analysis software that aligned with the purposes and needs of this thesis was provided by Sawtooth Software Inc. under the terms of an academic licence to enable the completion of this thesis using the conjoint methodology. The academic licence granting access to the software was originally provided from 27 October 2016 to 30 June 2018 and was subsequently extended to 30 June 2019.

Given that the main research problem that this thesis seeks to address explicitly refers to the question of moderation and mediation effects, justification of an analytical method to perform this means of analysis is considered unnecessary. In regard to the multi-level moderation mediation analysis component of the thesis, there are two primary means through which this method of analysis can be performed: regression analysis and structural equation modelling (Darlington and Hayes, 2017, Hayes, 2018, Hayes et al., 2017, Hayes and Rockwood, 2019, Iacobucci et al., 2007). Within the body of literature that refers to the use of regression analysis and structural equation modelling for the purpose of quantitative analysis involving moderation and mediation effects, debate exists surrounding the merits and relative advantages and disadvantages of each approach (Darlington and Hayes, 2017, Hayes, 2018, Hayes et al., 2017, Hayes and Rockwood, 2019, Iacobucci et al., 2007, Preacher et al., 2007, Song, 2018). A regression-based methodology for the analysis of the necessary moderation and mediation effects has been employed to address the main research problem of this thesis. The selection of a regression-based methodology to address these moderation and mediation analysis requirements is justified as outlined below:

1. The requirements of the thesis can be accommodated by readily available regression-based methodologies and are not of such complexity as to demand the capabilities provided by structural equation modelling.
2. There are no missing data within the relevant datasets.
3. No latent variables are required to be measured to address the main research problem of the thesis.

Hayes et al. (2017) stated that for models where the dataset is complete, where only observed variables exist within the model and where the nature of the model does not require great flexibility to specify the required relationships, the choice between regression-

based methods and structural equation modelling is generally inconsequential. Nevertheless, it is recognised that a primary weakness of regression analysis is the possibility of biases arising during the estimation of effects stemming from random measurement errors, which cannot be managed within the regression methodology (Darlington and Hayes, 2017, Hayes, 2018, Hayes et al., 2017). However, all linear regression-based models are susceptible to random measurement errors, and while it is possible to manage the effects of such errors using an appropriate measurement model in combination with a structural model, the level of complexity created in doing so can outweigh any benefit derived, and in some cases other unforeseen adverse consequences can arise (Hayes et al., 2017).

To calculate and examine the multi-level moderation and mediation effects within this thesis, the computational macro MLmed for SPSS, developed by Dr Nicholas Rockwood (formerly of The Ohio State University) in collaboration with Dr Andrew Hayes (also of The Ohio State University) has been employed. The MLmed computational macro, which was released for use in May 2017, provides for the fitment of multi-level moderated mediation models within the SPSS environment and is an extension of the PROCESS macro developed by Dr Andrew Hayes (Rockwood, 2017). The application of the MLmed macro within the context of this thesis, in combination with CVA, generates additional novelty and originality within the work given that, as far as can be understood, the MLmed macro has not previously been employed in this manner.

### **5.3.3 Justification of the unit of analysis**

The unit of analysis within this thesis for the main survey is, as stated in the main research problem contained in Section 1.4, a population of 400 executive managers employed by the publicly listed global resources company BHP during the fourth quarter of calendar year 2018. There are three principle justifications for the selection of this group as the population of interest for the main survey.

The first justification stems from the fact that this group of executive managers represents the population of 400 most senior leaders within the BHP global organisation according to both the scope of their leadership responsibilities and the materiality of the decision-making accountabilities attributable to each role. Accordingly, they are experienced managers who have experienced the need to exercise judgement within a commercial context where the nature of the decisions made is often ambiguous, complex and reliant upon incomplete

information. The second justification is that the population of 400 executive managers forms a relevant population in and of itself. This, coupled with the first assumption stated in Section 1.8, stating that this discrete population is representative of the broader population of executive managers within other Australian and global industrial organisations, may enable inferences to be made more broadly. The third justification arises from the ease of accessibility to this group. I am an employee of BHP and, by nature of my role within the organisation, a member of the target population; therefore, access to this population was easily enabled once the necessary legal, risk and ethical clearances within the BHP organisation were assessed and approved. The following two sections address both the methodology and the application of that methodology, relative to this thesis, first in regard to conjoint analysis and then through the use of multi-level models.

#### **5.4 Conjoint analysis**

As mentioned in Section 5.3.2, the purpose of conjoint analysis is to measure how individuals evaluate and trade-off a range of alternatives that characterise particular attributes associated with a subject of interest (Green and Wind, 1975, Hair et al., 2006). Doing so enables decision-making preferences to be identified both at the level of the subject of interest and in terms of the attributes and levels that serve to describe differing versions of that subject of interest (Gustafsson et al., 2007, Hair et al., 2006, Rao, 2014).

There are two approaches to the determination of preferences: compositional and decompositional models (Hair et al., 2006). In the case of compositional models, preference ratings at the level of the attribute are first determined and, from this overall subject, preferences are calculated based upon the manner through which the various attributes relevant to the decision in question come together to comprise it. In contrast, decompositional models require that preference evaluations of the subject of interest be conducted and, from this, preferences associated with the constituent attributes are calculated. Conjoint analysis is a decompositional model (Hair et al., 2006, Orme, 2014, Rao, 2014).

Conjoint analysis can be applied to a wide range of applications wherever an understanding of decision-making preferences is sought. The subject of interest may be either tangible or intangible provided that it can be described in terms of constituent elements that are considered relevant (Gustafsson et al., 2007, Hair et al., 2006, Orme, 2014, Rao, 2014). In the



case of automobile marketing, one constituent element of relevance may be colour, which is an attribute of the automobile product. Each constituent element must itself be characterised in an appropriate manner (Hair et al., 2006). Again, in the case of automobile marketing, the attribute colour may be characterised in the form of three options: white, red and grey. These three colour options represent the levels of this attribute. Within this thesis, an attribute is defined as a characteristic of interest that is manipulated to evaluate respondent preferences and that is represented by at least two mutually exclusive levels (Hair et al., 2006, Orme, 2014). Similarly, the operational definition of a level is that it is a description or value that defines an attribute (Hair et al., 2006, Orme, 2014). Through the conjoint analysis method, a corresponding preference denoted as the part-worth estimate is calculated for each level (Hair et al., 2006). The part-worth estimate is operationally defined as a measured value calculated through the conjoint analysis process that represents the desirability of discrete attribute levels determined from the choices made by the conjoint survey respondents (Hair et al., 2006, Orme, 2014).

An important initial step within the conjoint analysis process is selection of the model that defines the relationships between the part-worth estimates. Defining this relationship determines the manner through which the part-worth estimates combine to comprise total utility values. This decision is known as the composition rule for the conjoint analysis, and one of two possible options can be selected: the additive model or the interactive model (Hair et al., 2006, Orme, 2014, Rao, 2014). The simplest composition rule is the additive model wherein it is, in effect, assumed that a respondent sums the values of the relevant part-worth estimates associated with a given product, service or circumstance to determine its total utility value, with each level having its effect independent of any other. As such, a utility value determined according to the additive model is representative of the sum of its part-worth estimates. The additive model is the most often used version of the composition rule (Hair et al., 2006, Orme, 2014). The alternative interactive model relies upon the sum-of-the-parts method employed by the additive model, but it allows for the amplification or dampening of certain part-worth estimate combinations (Hair et al., 2006, Orme, 2014). Relative to the additive model, the interactive model reduces the statistical efficiency of the part-worth estimation process due to the need to calculate additional part-worth estimates, which may be compensated for if specific interaction effects are known and are properly modelled within part-worth estimate interactions (Hair et al., 2006). Given that no specific interaction effects are known that will require modelling within the part-worth estimation process, the additive model is the appropriate composition rule choice for this thesis.

The notion of utility applicable to conjoint analysis stems from the work of Lancaster (1966, 1971) in that, instead of a good being considered a homogenous entity and a direct object of utility, its utility could be thought to be derived from the amalgamation of the good's own properties and characteristics. Using this approach, even the simplest of goods will possess more than one property or characteristic of interest, which enables comparisons and preference evaluations to be made based upon these properties or characteristics (Lancaster, 1966). Aligned with the approach of Lancaster (1966, 1971), conjoint analysis provides a means by which these comparisons and preference evaluations can be measured (Hair et al., 2006). The operational definition of utility within this thesis is that it represents the desirability of an overall concept or alternative that is equal to the sum of its part-worth estimates (Hair et al., 2006, Orme, 2014).

A series of sequential stages comprise the process of conjoint analysis. These can be broadly categorised into six stages as described by Green and Srinivasan (1990), Hair et al. (2006) and Gustafsson et al. (2007). A diagrammatic overview of these six stages, together with salient points applicable to each, is provided in Figure 5.2.

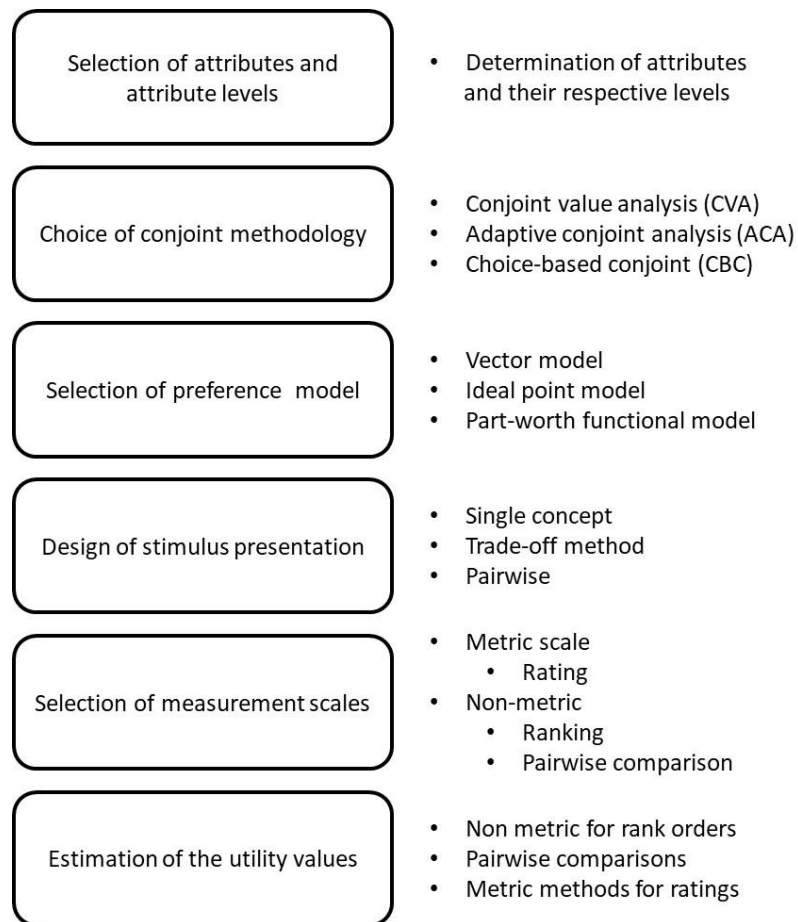


Figure 5.2: Six stages of the conjoint analysis process

The following six sections of this chapter are aligned with and explain each of the six stages that represent the conjoint analysis process.

#### 5.4.1 Selection of attributes and attribute levels

One of the first steps in the design of conjoint analysis is the identification and selection of attributes and levels that are based upon and commensurate with the objectives and purpose of the subject in question (Hair et al., 2006). As stated in Section 4.3, the variables of uncertainty and irreversibility are operationalised within this thesis in the form of decision uncertainty and decision outcome irreversibility respectively, with each represented by two attributes. Decision uncertainty is represented by the two attributes of solution uncertainty and problem uncertainty, whereas decision outcome irreversibility is represented by the two attributes of irreversible consequence failure and irreversible consequence postponement. All four attributes are dichotomous in nature, with each defined by mutually exclusive high

and low levels. Accordingly, the number of levels is balanced across the range of attributes; this outcome is preferred to avoid potential attribute preference effects arising, which have been shown to favourably bias attributes within a study that are represented by a greater number of levels compared with others (Currim et al., 1981, Hair et al., 2006, Orme, 2014). Further, no prohibited pairs exist among the eight attribute levels.

Inter-attribute correlation must be accounted for during the process of conjoint analysis design to ensure that the attribute levels are conceptually independent of each other so as to avoid violation of a basis assumption of conjoint analysis (Hair et al., 2006, Orme, 2014) and the creation of possibly absurd combinations of attribute levels (Hair et al., 2006). An example of inter-attribute correlation would occur if maximum car speed, engine power and fuel consumption were included as attributes within a single conjoint analysis design given that all three are most likely to be positively correlated (Hair et al., 2006). Potential inter-attribute correlations between the four attributes applicable to this thesis were considered, and no violations of conceptual independence were noted. Each attribute referred to something distinctly unique, as demonstrated in Table 5.1.

<b>Attribute</b>	<b>Attribute description</b>
Solution uncertainty	# of races completed using new gasket arrangement since last failure using old gasket
Problem uncertainty	% of finished races in season with air temp in 18–24° C range
Irreversible consequence failure	Sponsor funding outcomes if decision is to race and then blow up racing car engine
Irreversible consequence postponement	Sponsor funding outcomes if decision is not to race

Table 5.1: Demonstration of conceptual interdependence of attributes

Attribute levels should reflect realistic and believable outcomes for the circumstance, product or service that is under consideration; doing otherwise would distort the results and defeat the purpose of the analysis (Hair et al., 2006). Each mutually exclusive attribute level specified within this thesis satisfies these requirements, and they are summarised in Table 5.2. For clarity, the content of this table repeats the information in Table 1.1 and Table 4.1.

<b>Attribute</b>	<b>Attribute description</b>	<b>High-level state</b>	<b>Low-level state</b>
Solution uncertainty	# of races completed using new gasket arrangement since last failure using old gasket	2 races completed	5 races completed
Problem uncertainty	% of finished races in season with air temp in 18–24° C range	60% of races completed with air temp in 18–24° C range	73% of races completed with air temp in 18–24° C range
Irreversible consequence failure	Sponsor funding outcomes if decision is to race and then blow up racing car engine	Lose both oil and tyre sponsorships	Retain option to negotiate oil sponsorship next season but lose tyre sponsorship
Irreversible consequence postponement	Sponsor funding outcomes if decision is not to race	Lose oil sponsorship but retain option to negotiate tyre sponsorship	Retain options to negotiate both oil and tyre sponsorships next season

Table 5.2: Attribute and attribute levels employed within this thesis

The origin of the levels for each of the four attributes shown in Table 5.2, along with the justification for them and an explanation of the choice of a dichotomous pair in each instance, is provided in Section 4.3. The implications of these choices for the hypothesised relationships under examination within this thesis are explored in Section 4.4.

#### **5.4.2 Choice of conjoint methodology**

Following the selection of appropriate attributes and levels, the next step within the conjoint analysis process is the determination of an appropriate conjoint methodology suited to the needs of the circumstance in question (Green and Srinivasan, 1978, Green and Srinivasan, 1990, Hair et al., 2006). Three basic conjoint methodologies exist: traditional CVA, adaptive conjoint analysis and choice-based conjoint analysis (Gustafsson et al., 2007, Hair et al., 2006, Orme, 2014). Determination of the correct conjoint design, which commences at this point in the overall process, is vital to the development of a sound conjoint experiment, as a poor or inappropriately designed study cannot be corrected or compensated for after its administration if flaws are detected (Hair et al., 2006). The three basic conjoint methodologies are as follows:

1. Conjoint value analysis (CVA) is the traditional full-profile methodology whereby survey respondents are required to rank or rate a series of different stimuli, each of which is characterised by the appropriate attributes and attribute levels relevant to it. Within the process, each respondent is presented with all attributes within each conjoint task. Because of the nature of the methodology and limitations in the capability of respondents to rank or rate stimuli based upon higher numbers of attributes, the method is generally limited to a maximum of nine attributes (Hair et al., 2006), while others advise no more than six (Orme, 2009). The method is robust and can be administered via a paper or computer-based form. CVA is a main-effects only model (Orme, 2009).
2. Adaptive conjoint analysis (ACA) moves beyond what is possible with CVA. It is specifically developed to address circumstances where the number of attributes and levels is greater than what is possible through CVA (Hair et al., 2006, Orme, 2014). As with CVA, ACA is a main-effects only model (Orme, 2009). The ACA methodology can efficiently capture a large volume of information from respondents. The maximum possible number of attributes is 30, and because of this, ACA can only be administered by computer (Orme, 2014).
3. Choice-based conjoint (CBC) relies upon sets of attribute combinations being presented to the respondent. It includes, if required, the option of the 'none' case, and the respondent is required to select a preferred option from each set rather than rank or rate each single offering (Hair et al., 2006). CBC can be administered via a paper or computer-based form, and the maximum number of possible attributes is ten (Orme, 2014).

The preferred conjoint methodology for this thesis is CVA. This choice is justified on the basis that:

- CVA is a robust and reliable methodology (Green and Rao, 1971, Green and Srinivasan, 1978, Green et al., 2001, Hair et al., 2006, Orme, 2014)
- the number of attributes demanded by this thesis is less than the maximum possible with CVA; therefore, it does not require the additional capability of ACA
- ratings are required to be entered by the respondent for each conjoint task, which precludes CBC as a viable option.

While the more complex ACA method is a viable option for estimating the necessary utility values, its use precludes the presentation of the full profile of attributes and applicable levels associated with each conjoint task, which may be used by the respondent to evaluate the overall merits of each discrete attribute level set. Use of the ACA method also precludes the inclusion of discrete risk perception scales within the content of each conjoint task. This necessitates a more complex solution of some form and, in doing so, creates the potential for additional confusion and fatigue to arise in the mind of the respondent. For parsimony, CVA is favoured over ACA because it satisfies all needs of the thesis without the generation of unnecessary complexity.

### **5.4.3 Selection of a preference model**

Following the choice to employ an additive model in regard to the composition rule as stated above, which determines the means through which part-worth estimates are combined to form the corresponding utility values, is the requirement to specify the means through which the part-worth estimates themselves will be determined (Hair et al., 2006). Three different types of preference model are typically presented within the literature as described by Cattin and Punj (1984), Green and Srinivasan (1978), Hair et al. (2006) and Orme (2014):

- The vector model is the simplest and most restrictive form of model given that it relies upon the estimation of a single part-worth value and a regression coefficient for the calculation of all other levels within a given attribute.
- The ideal point form model differs from the vector model in that the assumption of linearity is relaxed to allow for curvilinear relationships that are often associated in circumstances where an optimal level exists. Further, the model requires the estimation of two part-worth values rather than one.
- The part-worth functional model relies upon no a priori assumptions regarding relationships between levels within an attribute but instead allows for the separate estimation of a discrete part-worth for each attribute level.

The part-worth functional model is the most commonly used model of the three discussed above (Green and Srinivasan, 1990, Hair et al., 2006, Orme, 2014). It imposes no functional form restriction upon the analysis and so is free of the possibility that such restrictions may

reduce the adequacy of the model fit (Hair et al., 2006, Orme, 2014). Compared with the vector and ideal point form models, part-worth models require more parameters to be estimated, which potentially lowers their reliability (Cattin and Punj, 1984, Green and Srinivasan, 1978, Hair et al., 2006). Further, if intermediate levels are required to be calculated, these need to be approximated through linear interpolation (Green and Srinivasan, 1978, Hair et al., 2006). Determination of the most appropriate preference model depends upon (a) whether a priori assumptions can be made concerning the form of the relationships across part-worth estimates and (b) whether the statistical efficiency of the vector and ideal point form models outweighs the potential for superior representation of respondent preferences and decision making gained through the part-worth functional model (Cattin and Punj, 1984, Hair et al., 2006). Based upon the information in this section, the part-worth functional model has been employed within this thesis to calculate the part-worth estimates.

#### **5.4.4 Design of stimulus presentation**

The selection of the full-profile CVA in Section 5.4.2 to a large extent predetermines the design of the stimulus presentation, which is represented by each conjoint task. Three choices of presentation are possible using full-profile CVA: a single-concept presentation, the trade-off method and the pairwise presentation (Hair et al., 2006, Orme, 2014). With the single-concept presentation, all attributes are presented within each conjoint task, with a corresponding level representing each attribute (Orme, 2014). Single-concept presentations are the recommended stimuli presentation form where the number of attributes is six or less (Hair et al., 2006). This method is especially suited to cases where likelihood- or probability-based rating scales are employed to evaluate the dependent variable (Orme, 2014). The trade-off method differs from the single-concept presentation in that it involves the presentation of a series of attribute pairs, with the respondent required to indicate preferences based upon the levels presented through each attribute combination. Only nonmetric responses are possible using the trade-off methodology, thus preventing the possibility of likelihood- or probability-based measurement scales for the dependent variable (Hair et al., 2006). The pairwise presentation method combines the approaches of the single-concept presentation and the trade-off method in that two discrete sets of attributes are shown within each conjoint task, with appropriate levels representing each attribute. For each conjoint task using the pairwise presentation method, the respondent must select a



preference, or indicate a strength of preference, based upon what is presented to them (Hair et al., 2006, Orme, 2014).

To enable survey respondents to individually characterise each conjoint task in terms of risk perception using appropriate measurement scales as described in Section 5.4.5.2, the single-concept form of presentation has been employed within this thesis. The single-concept presentation allows for the display of a discrete set of levels that represent all of the attributes that are relevant to the study within each conjoint task. This enables the evaluation of risk perception by the respondent for each conjoint task based upon what is presented to them. The selection of this stimuli presentation method also enables the use of a probability rating scale as described in the following sections.

In parallel to the selection of an appropriate design for the stimulus presentation, the number of stimuli required for the analysis to be performed must be determined (Orme, 2014). According to Hair et al. (2006) and Orme (2014), the minimum number of stimuli required to be presented to each CVA survey respondent is equal to the number of parameters to be estimated, as calculated in Equation 5.1:

$$\text{Parameters to be estimated} = \text{total number of levels} - \text{total number of attributes} + 1$$

*Equation 5.1*

Within this conjoint study, there are eight levels and four attributes. Therefore, the minimum number of parameters to be estimated is five. To ensure the derivation of stable part-worth estimates, it is recommended that the number of stimuli presented to each CVA respondent is 1.5–3 times the minimum number of parameters to be estimated. However, the effect of this must be balanced against the possibility of respondent fatigue arising from the need to complete a greater number of tasks, as in the case of a full factorial design (Hair et al., 2006, Kuhfeld et al., 1994, Orme, 2014). A full factorial design comprises all possible combinations of attribute levels, which enables all main effects, bivariate interactions and higher-order interactions to be estimated avoiding correlation (Kuhfeld et al., 1994). As this study contains four attributes, and each attribute is represented by two dichotomous levels, the number of stimuli presentations required to achieve a full factorial design is  $2^4$  or 16. This exceeds the number that would cause respondent fatigue; therefore, a fractional factorial design must be employed. A fractional factorial design displays a lower number of stimuli presentations than is required if a full factorial design is employed (Kuhfeld et al., 1994, Hair et al., 2006, Orme, 2014), but this advantage comes at the risk of some effects being confounded (Kuhfeld

et al., 1994). The measure of the goodness of a fractional factorial design relative to a hypothetical full factorial optimal design for the same number of attributes and levels is the D-efficiency value (Kuhfeld et al., 1994). An optimal design that is both orthogonal and balanced will result in a D-efficiency score of 100 (Hair et al., 2006, Kuhfeld et al., 1994, Orme, 2014). Fractional factorial designs that achieve D-efficiency scores of less than 100 have diminished levels of balance and orthogonality, which contribute to greater variation in the parameter estimates (Kuhfeld et al., 1994).

For this thesis, a fractional factorial design has been employed with the CVA survey design consisting of ten conjoint tasks. This number of tasks provides twice the minimum number of stimuli required but, based upon feedback received during the pretesting of the survey design and from the pilot survey, it does not overly risk the chance of respondent fatigue. The D-efficiency of this approach was calculated to be 97.03% using the iterative design process of Sawtooth Software, thereby providing near optimal design efficiency while also limiting the burden placed upon the survey respondents.

#### **5.4.5 Selection of measurement scales**

The primary task of the respondent during a conjoint experiment is to evaluate the subjects presented to them using an appropriate means of assessment (Green and Srinivasan, 1978, Hair et al., 2006). Therefore, the selection of measurement scales is a critical element in the overall conjoint analysis development process. The means of assessment include both metric and non-metric scales, and the choice between the two options is determined in large part by the objectives that have given rise to the conjoint study being undertaken, as well as the prior selection of a conjoint methodology and preference model for the calculation of part-worth estimates (Green and Srinivasan, 1990, Hair et al., 2006, Orme, 2014). Rating-based scales are an example of metric scales, while pair comparisons and ranking scales reflect non-metric scales. The primary advantage of rating-based scales is their potential to derive a larger volume of information content from their use in comparison with non-metric scales (Green and Srinivasan, 1978). The CVA methodology selected for this thesis enables the use of both metric and non-metric scales (Hair et al., 2006). The measurement scales for innovativeness, risk perception and risk propensity are addressed in the next three sections.

### 5.4.5.1 Measurement scale: innovativeness

The innovativeness variable is the dependent variable within this thesis. It is used to evaluate each respondent's intention based upon selections made that indicate the probability that they, in the role of Pat Carter as described within the 'Carter Racing' case study, would be willing to race in the Pocono event and rely upon an innovative new gasket arrangement to prevent engine failure. Green and Srinivasan (1978, 1990) stated that metric-based rating scales are suited to circumstances where the purpose of conjoint analysis is to gain insights into likely behavioural intent concerning a subject of interest. Accordingly, the primary means for the measurement of innovativeness is a metric-based rating scale. In parallel with this primary means of measurement, a secondary means is employed in the form of a dichotomous forced choice item measure. The use of a metric rating scale for the measurement of innovativeness is aligned with the operational definition of the term in that a rating scale enables the analysis of behaviour based upon relative differences between the selections made for each conjoint task at the respondent level and between respondents. Further, based upon choices made in regard to the conjoint analysis as described in the preceding sections, a metric-based rating scale can be used to calculate utility values and, as an extension of this, the mediation and moderated mediation effects that are of interest in this thesis can be examined.

The primary means for the measurement of innovativeness is a nine-point probability-based rating scale, with the scale points ranging from 'definitely not race' to 'definitely race', with the limits separated by seven discrete interval points as shown in Figure 5.3. The Sawtooth Software used for the CVA calculations within this thesis limits the number of scale points to a maximum of nine, thus causing the distribution of the points as shown in Figure 5.3.

Scenario *n*: considering both the additional engine reliability and sponsor funding decision outcomes shown below, what is the probability you would decide to race at Pocono?

# races completed using new gasket since last failure using old gasket

% of finished races with air temp in 18C to 24C range

Sponsor funding outcomes if you decide to race and blow up engine

Sponsor funding outcomes if you decide not to race

For each conjoint task a discrete set of four attribute levels shown here

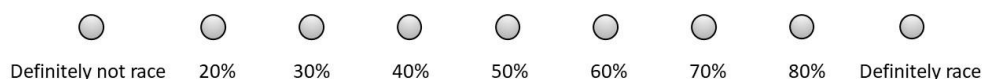


Figure 5.3: The nine-point scale used for the measurement of innovativeness

This nine-point scale is assumed to be an interval-based scale as the end points can be interpreted as representing 10% and 90% respectively in accordance with the semantic argument of Simon-Vandenberg (2008) concerning the term 'definitely'.

The secondary means of measurement is conducted using a dichotomous forced choice measure as shown in Figure 5.4. Whereas the purpose of the primary means of measurement is to capture data concerning respondents' behaviour intentions in the form of a probability, the purpose of the secondary means is to provide a measure of the absolute behavioural intent of each respondent and, in doing so, provide a complimentary parameter for the measurement of innovativeness.

To ask the question another way for this scenario, would you decide to race or not?

In this situation I would race  In this situation I would not race

Figure 5.4: The dichotomous forced choice measurement scale of innovativeness

#### **5.4.5.2 Measurement scale: risk perception**

The measurement scale employed within this thesis for the evaluation of risk perception within each conjoint task reflects the semantic differential scale that was employed within studies one and two by Sitkin and Weingart (1995). The measurement scale employed by Sitkin and Weingart (1995) was adapted from MacCrimmon and Wehrung (1985, 1986a, 1986b) and Wehrung et al. (1989). It comprises four bipolar rating scales, with the second and fourth scales being of reversed polarity to avoid the possibility of respondents becoming anchored in their reading of the polar scales, as described by Saunders et al. (2003). The measurement scale for risk perception is shown in Figure 5.5. The total risk perception score for a given conjoint task is calculated following a standard process as described by Oppenheim (1992) and Spector (1992). The sum of the four selections made by each respondent for each conjoint task, after reversal of scores for items two and four, is averaged to determine the respondent's risk perception.

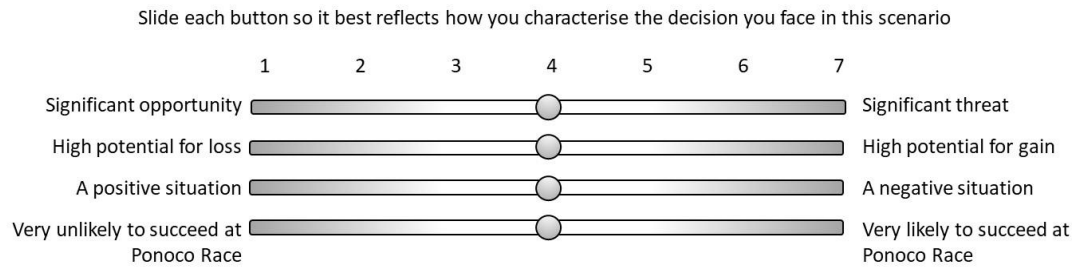


Figure 5.5: The risk perception measurement scale

It is apparent from Sitkin and Weingart (1995) that this scale was assumed to be an interval-based measure, and this assumption is maintained within this thesis. This is justified as the scale comprises seven evenly scaled points, and multiple items are included within the scale, with each containing an identical number of meaningful points. Further, each item requires cognitive evaluation by the respondent, and robust parametric statistical techniques are employed within the associated analysis. Each of these characteristics has been highlighted by others as factors that serve to strengthen claims that a given Likert-type measurement scale is interval rather than ordinal in nature (see Carifio and Perla, 2008, Jamieson, 2004, Madsen, 1989, Maurer and Andrews, 2000, Norman, 2010, Schertzer and Kernan, 1985, Willits et al., 2016).

#### 5.4.5.3 Measurement scale: risk propensity

Similar to the measurement scale for risk perception, the measurement scale employed within this thesis for the self-rating of risk propensity is also drawn from Sitkin and Weingart (1995). Instead of a semantic differential scale, a five-item seven-point Likert-style rating scale is employed, as depicted in Figure 5.6. The determination of risk propensity, which is applicable to each survey respondent, is the average of the sum of the five selections made by each respondent.

For each question below, how would you rate your own personal tendency to:

	Strong tendency to avoid risks	2	3	4	5	6	Strong tendency to take risks
Choose more or less risky alternatives based on the assessment of others on whom you must rely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choose more or less risky alternatives which rely upon analyses high in technical complexity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choose more or less risky alternatives which could have a major impact on the strategic direction of your organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Initiate a strategic corporate action which has the potential to backfire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Support a decision when I was aware that relevant analyses were done while missing several pieces of information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 5.6: The risk propensity measurement scale

As with the risk perception measurement scale, it is apparent that Sitkin and Weingart (1995) assumed this risk propensity scale to be an interval-based measure, and this assumption been maintained. Justification for this position is identical to that employed for the risk perception scale.

#### 5.4.6 Estimation method and estimation of utility values

The preceding sections have provided the foundations to undertake the necessary CVA. Based upon the above sections, the specification of the CVA programming using Sawtooth Software is outlined in Appendix C. This specification enables both the execution of the CVA online survey and the calculation of the required part-worth estimates and utility values based upon the selected estimation method. The focus of this section is upon the estimation of the utility values.

Selection of an appropriate estimation method has traditionally been governed by the type of preference model and measurement scales that have themselves been selected within the prior steps (Green and Srinivasan, 1990). However, the development of more advanced estimation methodologies has led to some methods being suited to a range of otherwise separate applications (Hair et al., 2006). The estimation methods can be classified into three broadly based categories that can be defined as follows.

- methods suited to circumstances where the independent variable is at best ordinally scaled, with a range of methodologies being categorised within this class, such as monotonic analysis of variance (MONANOVA), LINMAP (Green and Srinivasan, 1978, Hair et al., 2006) and PREFMAP (Green and Srinivasan, 1978)
- methods such as LOGIT and PROBIT, which employ choice probability models to analyse paired-comparison datasets (Green and Srinivasan, 1978)
- methods suited to circumstances where the independent variable is assumed to be interval-scaled, with methods within this class typically being of the ordinary least squares (OLS) regression-based type (Green and Srinivasan, 1978, Hair et al., 2006).

The use of an OLS-based method is deemed appropriate given the primary scale employed for measurement of the dependent variable, as described previously within Section 5.4.5.1.

OLS is a method of statistical estimation used to predict an outcome for the dependent variable  $Y$  while using a linear combination of corresponding regression coefficients for each independent variable (Darlington and Hayes, 2017, Orme, 2014). The objective of the OLS method of statistical estimation is to establish an optimal set of beta regression coefficients that correspond to the set of independent variables within a given multiple regression equation, which has the effect of minimising the sum of the squares of the differences between the predicted and actual outcomes (Darlington and Hayes, 2017, Hair et al., 2006, Orme, 2014). In doing so, OLS, through the minimisation of the differences between the predicted and actual outcomes, prescribes the line of best fit based upon the data collected (Field, 2009, Darlington and Hayes, 2017, Hair et al., 2006). Within a CVA regression equation, each attribute is represented by a unique independent variable. The assigned respondent rating for each conjoint task provides the value of the dependent variable  $Y$ , and the value of each regression coefficient represents the part-worth estimate attributable to the relevant level under consideration for each corresponding attribute included within the equation (Orme, 2014).

As shown within Equation 5.2, the value of  $Y$  is equal to the sum of the respective part-worth estimates.

$$Y_{im} = \sum_{j=1}^J \sum_{k=1}^K \beta_{ijk} * x_{ijkm}$$

Equation 5.2: The basic conjoint value analysis model equation from Cui and Curry (2005) and Steiner and Meißner (2018)

Where:

- $Y_{im}$ : total utility respondent  $i$  derived from alternative  $m$
- $\beta_{ijk}$ : part-worth utility for level  $j$  of attribute  $k$  for respondent  $i$
- $x_{ijkm}$ : binary coding for level  $j$  of attribute  $k$  for alternative  $m$  and respondent  $i$ , which takes the value of 1 if level  $j$  is present and 0 if otherwise
- $J$ : number of attribute levels
- $K$ : number of attributes
- $m$ : unique conjoint task identifier
- $i$ : unique respondent identifier.

Traditional CVA using the OLS calculation methodology typically relies upon a dummy variable approach to calculate part-worth estimates wherein the first level of each attribute is set to a raw utility value of zero. In doing so, it is eliminated from the analysis to avoid linear dependence and singularity among the independent variables, which leads to indeterminacy within the regression computation (Hair et al., 2006, Sawtooth Software, n.d., Steiner and Meißner, 2018). This approach to the calculation of CVA part-worth estimates is standard practice (Hair et al., 2006). The value of all other part-worth estimates associated with the respective levels of each attribute is interpreted relative to this dummy variable–derived baseline (Hair et al., 2006, Sawtooth Software, n.d.). As part of the OLS calculation, an intercept term is also calculated, but this is not reported separately within the Sawtooth CVA software part-worth estimate outputs (Sawtooth Software, n.d.). The value of this intercept is nevertheless employed within the calculation of the part-worth estimates by the Sawtooth CVA software to avoid one level of each attribute presenting a raw utility value of zero. Accordingly, the value of the intercept is divided by the number of attributes, and the value of the quotient is added to the value of all part-worth estimates across each attribute level (Sawtooth Software, n.d.). Doing so, as with other forms of part-worth estimate rescaling, has no effect upon the relative differences between the levels of any attribute (Hair et al., 2006, Sawtooth Software, n.d.). As such, across the Sawtooth CVA software outputs, the raw utility value of the first level of each attribute is equal to the intercept value divided by the number of attributes (Sawtooth Software, n.d.). This is discussed further in Section 6.4.1.



#### **5.4.7 Goodness of fit evaluation**

The purpose of the goodness of fit evaluation is to enable the assessment of an estimated model through a comparison of the actual values of the dependent variable against those predicted through the use of the estimated model. Within conjoint analysis, separate goodness of fit evaluations are performed for each respondent (Hair et al., 2006), with no correction applied to the coefficient of determination ( $R^2$ ) based upon degrees of freedom. This gives rise to the risk of overfitting the data if the number of conjoint tasks within a CVA survey begins to approach, or is equal to or less than, the number of parameters (Hair et al., 2006, Sawtooth Software, n.d.). Given that the number of conjoint tasks within the CVA online survey upon which this thesis relies exceeds the number of parameters by a factor of two, as discussed in Section 5.4.4, the risk represented by overfitting is considered low in this instance. An analysis of goodness of fit outcomes is undertaken in Section 6.4.1.

#### **5.5 Survey execution**

The final CVA survey design was derived from that described within the prior sections. The specification for the CVA survey using Sawtooth CVA software is provided in Appendix C. The design of the online CVA survey enables all variables that are essential to the execution of this thesis to have either their effect evaluated or their values measured. As shown in Figure 5.1, both pre-testing and pilot testing of the CVA online survey was planned to be completed prior to the execution of the main survey. A summary of the pre-testing and pilot testing processes is provided within the following two sections.

##### **5.5.1 Pilot study pre-test**

While an extensive literature review was undertaken and existing measurement scales were employed for the evaluation of risk perception and risk propensity, it was considered necessary to pre-test the pilot survey prior to its execution. Pre-testing of the survey was undertaken during August 2017 with employees within BHP's Western Australian Iron Ore engineering division. The objectives of the pre-testing were threefold. The first objective was to verify that the introductory email, supporting documents and case study, as well as the survey structure itself, could be understood by managers within the Australian operations of the BHP business. All pre-test participants were able to understand the written content and

navigate the online survey structure without concern, with only minor adjustments to wording being noted as opportunities for improvement. The second objective was to enable an assessment of the face validity of the survey measurement instruments. Feedback from the pre-test participants indicated that the measurement scales employed for the determination of willingness to race, risk perception and risk propensity demonstrated good face validity. The third objective was to gain an understanding of the duration of time required for a respondent to read the necessary documents and complete the online survey and, in doing so, evaluate the level of respondent burden created through the online survey process. The pre-testing showed that the level of respondent burden was not excessive. Based upon the feedback received, the decision was made to proceed to the pilot testing stage.

### **5.5.2 Pilot study execution**

A pilot study was completed in September 2017 to validate the online CVA survey instrument. The process followed during the execution of the pilot study mirrored that which was anticipated to be employed within the main survey. The pilot study was again conducted with team members from BHP's Western Australian Iron Ore engineering division. For the pilot study, a sample of convenience was drawn from the population of that team that represented 56 employees who held managerial accountability of some form. The online survey was fully completed by 18 respondents, representing a participation rate of 32%. Through the pilot study, the following was established:

- The time required to read the necessary documents and complete the survey was reasonable. The average time taken to complete the survey was 23 minutes, and the longest duration was 52 minutes.
- The survey method produced a dataset that generated promising insights concerning the hypothesised relationships.
- The psychometric measurement scales were reliable. For the pilot test, Cronbach's alpha for the risk perception measurement scale was shown to be .90, while for the risk propensity measurement scale it was shown to be .76. In both instances, it was deemed that no Likert item should be removed from either measurement scale to improve its reliability.

### 5.5.3 Sample size considerations for full-profile CVA

Conjecture exists within the literature concerning the appropriate means to evaluate the adequacy of sample sizes when using traditional full-profile CVA, with numerous ‘rules of thumb’ proposed across the spectrum of conjoint methods to guide research efforts (Orme, 2014, Orme and Chrzan, 2017). As a result, Professor Vithala R. Rao of Cornell University was contacted via email on 16 January 2020 to request his advice concerning the determination of adequate sample sizes for full-profile CVA studies (Vithala R. Rao 2020, pers. comm., 16 January). Professor Rao stands among the pioneering figures of conjoint analysis, as demonstrated in the seminal work of Green and Rao (1971), and the approach undertaken below reflects his guidance.

Professor Rao verified the use of a formula for the sample size determination for the mean, as shown in Equation 5.4, with a Z score value representative of the desired confidence interval, an appropriately justified standard deviation value calculated in correspondence with the nature of the response measurement scale and an appropriate sampling error value. The single Likert item scale employed for the measurement of innovativeness, as shown in Figure 5.3, can be considered a discrete uniform probability distribution because the likelihood of each scale point being selected is identical (Vithala R. Rao 2020, pers. comm., 16 January). The formula for the calculation of a discrete uniform probability distribution standard deviation value is shown in Equation 5.3, as described by Zwillinger et al. (2003), with the formula for the sample size determination for the mean shown in Equation 5.4 as discussed in Berenson and Levine (1999):

$$\sigma = \sqrt{\frac{n^2 - 1}{12}}$$

*Equation 5.3*

$$n_o = \frac{Z^2 \sigma^2}{e^2}$$

*Equation 5.4*

Where:

- $\sigma$ : standard deviation
- $n$ : total number of points in the interval-based response measurement scale
- $n_o$ : calculated sample size required based upon an infinite population size
- $Z$ : critical value for the corresponding confidence level
- $e$ : sampling error.

Given that a finite population of 400 applies in the case of this thesis, the calculated sample size  $n_o$  can be refined further using a finite population correction factor calculation. The sample size formula based upon the finite population correction factor is as shown in Equation 5.5, as discussed by Berenson and Levine (1999):

$$n_f = \frac{n_o N}{n_o + (N - 1)}$$

*Equation 5.5*

Where:

- $n_f$ : calculated sample size required for a finite population size  $N$
- $n_o$ : calculated sample size required based upon an infinite population size
- $N$ : known finite population size.

The standard deviation ( $\sigma$ ) for a nine-point interval-based measurement scale ranging from one to nine, based upon Equation 5.3, is 2.58. From this, using Equation 5.4, it can be shown that, based upon a standard deviation ( $\sigma$ ) of 2.58, a 95% confidence level (Z score = 1.96) and a sampling error of 0.5, a sample size of 103 or more is required based upon an infinite or unknown population size. Using Equation 5.5, it can be shown that for a population size of 400, a sample size of 83 or more is adequate for this unit of analysis. A sampling error value of 0.5 has been selected for the purpose of defining the permissible difference between the sample and population means because it is considered that one half of one interval increment within a nine-point interval-based measurement scale provides sufficient sampling accuracy. From a sample size perspective, Sawtooth Software (n.d.) advises that the number of conjoint tasks completed by each CVA survey respondent is an issue for consideration concerning a measurement error rather than a sampling error. Accordingly, for the determination of an adequate sample size for full-profile CVA, the number of conjoint tasks completed by each respondent is ignored. Further sample size considerations, as appropriate, are provided in the relevant sections of Chapter 6.

#### **5.5.4 Main survey implementation**

Following the encouraging results obtained through the execution of the pilot survey, the main survey for this thesis was executed using the same structure as that of the pilot survey, the specification of which is provided in Appendix C. The main survey was implemented online during November and December 2018. The population of interest being the group of

400 executive managers employed by the global resources company BHP during this period commonly referred to as the 'Top 400'. The main survey was executed following receipt from BHP Risk and Governance approving the implementation of the online survey within the BHP organisation. Justification for the engagement of the 'Top 400' as the unit of analysis appropriate to the requirements of this thesis was provided in Section 5.3.3.

### **5.5.5 Consideration of non-response and common method biases**

As part of the chosen methodology, it is important to consider the possible existence and influence of non-response bias and common method bias. Consideration of non-response bias is an important aspect of a survey methodology because it tests whether respondents to a survey are statistically different, in terms of observable characteristics, to those members of a sample or population set who did not complete the survey, thus enabling an assessment of the extent to which generalisation is possible. As such, non-response bias concerns statistical effects that arise through respondent participation and the existence of relevant differences between those who participate in a survey and those who elect, for whatever reason, not to participate (Armstrong and Overton, 1977, Atif et al., 2012, Whitehead et al., 1993). Separately, common method bias is isolated to those who are respondents to a survey, and its presence may cause biased measurement error and relationships between variables to be spuriously modified, typically through an inflationary influence caused by a methods effect (Meade et al., 2007, Podsakoff et al., 2012, Spector, 2006).

A range of causes give rise to common method bias, and its existence can have serious deleterious effects upon research findings. Hence, it is important to both identify the potential for its existence and, as a minimum, test for the effect of its presence (see Coltman et al., 2008, Meade et al., 2007, Podsakoff et al., 2012, Podsakoff and Organ, 1986, Podsakoff et al., 2003). To summarise the causes, method effects may stem from the predictor and outcome variables being associated with a common source (e.g., a self-rating single respondent), the nature of the items within the measurement instruments themselves, the context surrounding those items and the contextual environment within which the measurements are made (see Podsakoff et al., 2012, Podsakoff and Organ, 1986, Podsakoff et al., 2003). While some methodologists claim that the threat from common method bias is often overstated (Spector, 2006), the existence of a materially significant level of either non-respondent or common method bias is recognised within the relevant literature as a

potential threat to the validity of research findings, and it is for this reason that both are explicitly tested for within this thesis.

No survey participation reminder email message was sent to the target survey population to prompt an increased level of participation during the period within which the online survey was open; therefore, measures of non-response bias that rely upon reminder prompts cannot be employed in this instance. Alternative substitute means exist to evaluate non-response bias as described by Linder et al. (2001), such as the 'days to respond method' and the arbitrary partitioning of the respondent group into two halves based upon a time-ranked order of response. The use of the arbitrary approach enables the total number of survey responses received to be partitioned into two groups, with the first group representing those who comprise the first half of the total number of respondents received, ordered according to time of response, and the second group representing those who comprise the second half of the total. While any arbitrary grouping of respondents may suffice, partitioning at any point other than the midpoint reduces the statistical power of comparison (Linder et al., 2001).

Partitioning of the total respondent pool in a manner such as this facilitates consideration of the second group as being non-responders relative to those who comprise the first group; accordingly, this enables the consideration of them as representative of a broader set of non-responders (Armstrong and Overton, 1977, Atif et al., 2012, Linder et al., 2001, Whitehead et al., 1993). This approach is aligned with that described by Armstrong and Overton (1977), Atif et al. (2012), Linder et al. (2001) and Whitehead et al. (1993) for the estimation of non-response bias in that partitioning of the total respondent pool into 'waves' of respondents allows for differences between the 'wave' groupings, based upon relevant observable characteristics, to be examined using appropriate statistical techniques. It is important to recognise that other means of non-response bias evaluation exist, as discussed by Armstrong and Overton (1977), Atif et al. (2012) and Linder et al. (2001). However, the method of evaluation selected for use within this thesis is procedurally consistent with that which describes the most commonly used approaches (Armstrong and Overton, 1977, Atif et al., 2012, Linder et al., 2001, Whitehead et al., 1993). The observable characteristics of interest for this thesis are the variables of race probability (the selections made using the scale shown in Figure 5.3, through which innovativeness is calculated), risk propensity and risk perception. The results of the appropriate statistical testing for non-response bias are provided within Section 6.2.3.

Techniques for the testing and control of common method biases are discussed at length by Podsakoff et al. (2012), Podsakoff and Organ (1986) and Podsakoff et al. (2003). In this thesis, Harman's single-factor test was selected to evaluate the presence and nature of common method bias. This test enables the assessment of the extent to which common method bias may be problematic, but it does not provide any means through which method effects may be statistically controlled if found (Podsakoff et al., 2003). Harman's single-factor test requires that all variables within a study be loaded into an exploratory factor analysis, and the unrotated factor solution is then examined to identify whether a general factor emerges or whether a single factor accounts for the majority of the variance among the loaded variables (Podsakoff et al., 2003, Tehseen et al., 2017). The result obtained using Harman's single-factor test to examine the extent of common method bias is provided in Section 6.3.1.

## **5.6 Multi-level modelling**

The nature of the CVA methodology and research design described in Section 5.4.4, wherein each respondent completes ten separate conjoint tasks, gives rise to collections of nested data in regard to the variables of innovativeness and risk perception because for each conjoint task completed, ten separate innovativeness and risk perception measurement scores are created. This differs from the determination of individual respondent risk propensity, as only one measurement score is created for each respondent. The nesting of data in a clustered hierarchical form based upon, for example, respondent, patient, school class, school or geographic area gives rise to a lack of independence among the data contained within each nested cluster, leading to the possibility of statistical anomalies such as incorrect estimation of standard errors and erroneous determination of statistical significance (Darlington and Hayes, 2017, Robson and Pevalin, 2016, Snijders and Bosker, 2004). This is because the nested clustering of cases within the data, based upon a subject of interest common to the cases contained within each cluster, causes a violation of the assumption of independent sampling. Thus, individual cases within a dataset should be independent from one another if conventional regression analysis and linear modelling techniques are to be used (Darlington and Hayes, 2017, Hair et al., 2006, Robson and Pevalin, 2016). To separately identify collections of data within clusters from the clusters themselves, labelling in the form of unique levels serves as a form of identification (Bickel, 2007). Multiple nesting and clustering levels can be conceived, such as in the case of pupils within a school, who are first clustered by grade, followed by school identified by name and finally by

geographic region in the form of a state or district, with four unique levels existing within this example.

The structure of the data resulting from the selection of the CVA methodology and the research design of this thesis, as mentioned above, creates clustering and nesting as shown in Figure 5.7.

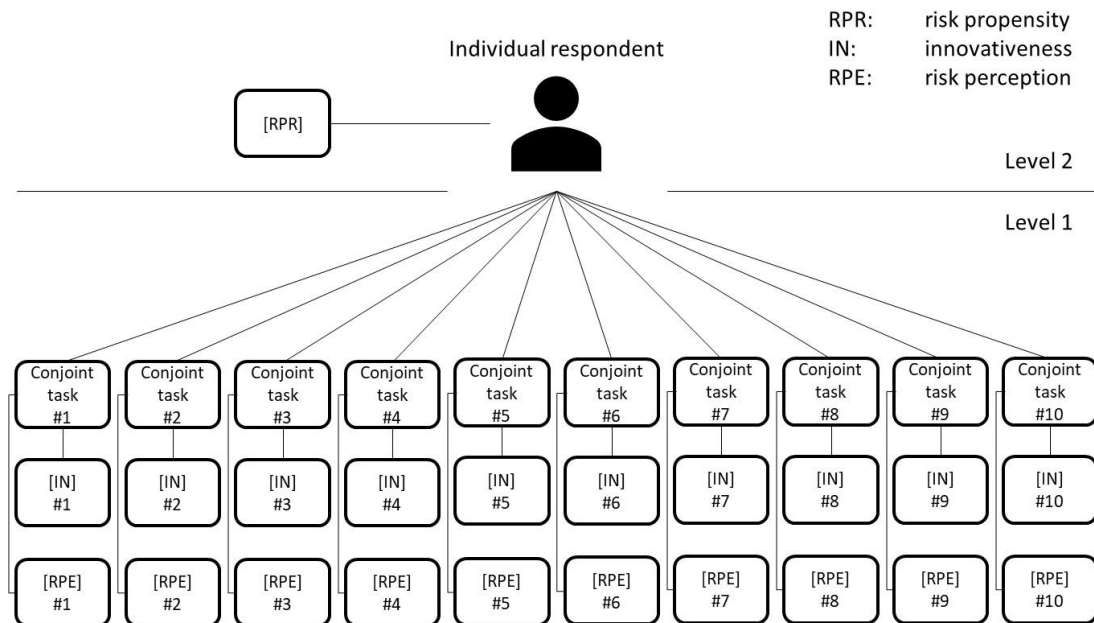


Figure 5.7: The multi-level nesting structure of the design showing levels one and two

As shown in Figure 5.7, for each of the ten conjoint tasks completed, ten unique utility values are calculated, which are each representative of the variable of innovativeness relative to a particular conjoint task. Similarly, for each of the ten conjoint tasks completed, ten unique risk perception scores are created based upon selections made by each respondent via the summated semantic differential measurement scale shown in Figure 5.5. However, as shown in Figure 5.7, only one risk propensity score is calculated for each respondent, with this being accomplished via the summated five-item measurement scale shown in Figure 5.6. Given this, it can be observed that both innovativeness and risk perception are clustered according to individual survey respondent, whereas risk propensity is not. As the individual respondents themselves are not nested in any form, there are only two levels within the data that are applicable to this thesis. In level one, the variables of innovativeness and risk perception are clustered based upon individual respondent. In level two, the individual respondents themselves accumulate together with the corresponding variable of risk



propensity, which is itself singularly unique to each respondent. This distinction between the levels relevant to respondent, innovativeness, risk perception and risk propensity is shown in Figure 5.7. The following two sections explain and justify the multi-level quantitative methods employed within this thesis to address the research problems that concern predictive relationships, mediation effects and moderated mediation effects.

### 5.6.1 Multi-level regression analysis

The purpose of multi-level regression analysis is to overcome the violation of the assumption of independence caused by the clustering of data around subjects of shared association within a dataset (see Bickel, 2007, Darlington and Hayes, 2017, Heck et al., 2014, Kreft and de Leeuw, 2007, Robson and Pevalin, 2016, Snijders and Bosker, 2004). As such, multi-level regression analysis should not be thought of as an alternative form of quantitative analysis when compared with traditional regression analysis, but rather as an extension of the form that is tailored to suit special circumstances to enable the proper analysis of subjects that are grouped within identifiable contexts (see Bickel, 2007, Darlington and Hayes, 2017, Field, 2009, Heck et al., 2014, Snijders and Bosker, 2004). It is this capability that justifies the use of multi-level regression analysis within the context of this thesis. Accordingly, the balance of this section focuses upon an explanation of the multi-level regression method that underpins the relevant analyses, the results of which are provided in Chapter 6. As mentioned, multi-level modelling is an extension of traditional regression analysis; thus, it is appropriate to commence any explanation of a multi-level model specification with a summary of single-level regression analysis. A single-level regression model that explains an outcome variable  $Y$  associated with an individual case identified as  $i$  in regard to a subject of interest  $X$  is shown in Equation 5.6:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \tag{Equation 5.6}$$

where  $\beta_0$  represents the  $Y$  intercept, the value of  $\beta_1$  describes the slope parameter and  $\varepsilon_i$  represents an error in the prediction of  $Y$  based upon the equation (Darlington and Hayes, 2017). The purpose of this model is to establish the line of best fit relative to the actual data drawn from a sample. The error term  $\varepsilon$  represents the difference between the actual and calculated values, with the objective being minimisation of the error (Darlington and Hayes, 2017, Field, 2009, Hayes, 2006, Heck et al., 2014, Snijders and Bosker, 2004). It is important

to note that, within a single-level model, both the estimate of the intercept and the slope are fixed to a single value that reflects the average of the sample upon which the calculation is based; that is, both will be common to all cases (Heck et al., 2014). Unlike single-level regression models, multiple individual cases may be considered within one multi-level regression model. Each level one case is represented by its own unique regression equation that comprises an individual intercept value, which defines the value of  $Y$  adjusted for  $X$ , and a slope parameter, which describes the relationship between  $X$  and  $Y$  for each individual case (Darlington and Hayes, 2017). Each unique level one case-based regression equation nested beneath each individual level two entity, identified as  $j$ , represents one case within the set of cases applicable to and nested beneath that entity (Hayes, 2006, Heck et al., 2014, Luke, 2004). The relationship between individual cases denoted as  $i$  and the individual entity denoted as  $j$ , against which individual cases are nested, is shown in Figure 5.8. The structure of Figure 5.8 reflects that of Figure 5.7 and depicts the structure of the ten conjoint tasks and their association with the individual respondent.

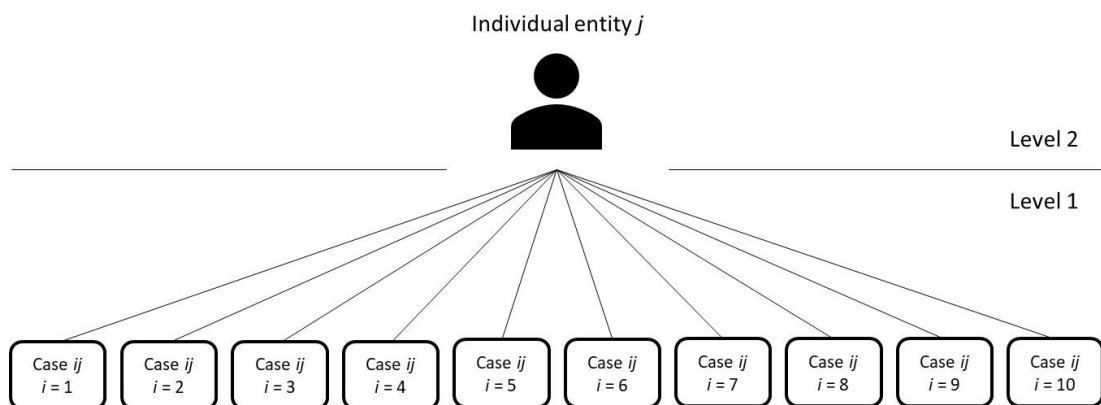


Figure 5.8: Relational structure of cases  $i$  and entities  $j$

Where hierarchies and nested clustering exist among the data, the  $Y$  intercepts of each individual case will most likely vary across the sample of individual entities that comprise the study, as will the slope parameters (Hayes, 2006, Heck et al., 2014). Accordingly, where there are clustered data, it is most likely that a distribution of intercepts and slopes exists relative to the average fixed effects, which reflects the uniqueness of each nested cluster associated with each individual entity, however so described (Hayes, 2006). Depending upon the objectives and circumstances, the multi-level regression equation can be configured for the estimation of either fixed or random effects for both the  $Y$  intercepts and the  $\beta$  coefficients,

with the random effect enabling variation between level two entities (Bickel, 2007, Darlington and Hayes, 2017, Hayes, 2006, Heck et al., 2014, Jackson and Brashers, 1994, Luke, 2004, Snijders and Bosker, 2004). Almost universally, the  $Y$  intercept within a multi-level model is estimated in the form of a random effect, as this enables the mean of the level one cases nested beneath a common level two entity to vary between the level two entities (Hayes, 2006). In the case of a simple regression, both the  $Y$  intercept and the  $\beta$  coefficient are fixed (Heck et al., 2014). Within a random intercept-only model, the slope coefficient  $\beta$  is fixed for all cases. Between-group variation across intercepts can be represented as shown in Equation 5.7 (Hayes, 2006, Heck et al., 2014):

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \tag{Equation 5.7}$$

Within Equation 5.7,  $\gamma_{00}$  is representative of the grand mean intercept for all cases and is a fixed component within the equation, while  $\mu_{0j}$  is a random parameter that captures variation between the mean intercept of each entity  $j$  and the value of the grand mean  $\gamma_{00}$  (Hayes, 2006). Given that the slope coefficient is fixed for each entity within a random-intercept only model, the slope coefficient  $\beta_1$  from Equation 5.6 can be substituted as shown in Equation 5.8:

$$\beta_{1j} = \gamma_{10} \tag{Equation 5.8}$$

where  $\gamma_{10}$  is the slope coefficient for all cases within a sample (Hayes, 2006, Heck et al., 2014). Substituting Equation 5.7 for the fixed intercept component  $\beta_0$  of Equation 5.6 and Equation 5.8 for the fixed slope component of Equation 5.6, the single-level regression model is transformed into a random intercept-only model as shown within Equation 5.9 and in expanded form within Equation 5.10:

$$Y_{ij} = \beta_{0j} + \gamma_{10}X_{ij} + \varepsilon_{ij} \tag{Equation 5.9}$$

$$Y_{ij} = \gamma_{00} + \mu_{0j} + \gamma_{10}X_{ij} + \varepsilon_{ij} \tag{Equation 5.10}$$

The multi-level regression analysis necessary for the execution of this thesis based upon the random intercept-only model, as represented in Equation 5.10, is conducted using SPSS Version 24 software.

## 5.6.2 Multi-level moderated mediation analysis

The intent of this section is to provide a clear explanation of the methodology employed within this thesis concerning multi-level moderated mediation analysis, the purpose of which is to address the hypotheses that relate to research questions four, five and six. The section commences with a rebuttal of the causal steps approach to mediation analysis advocated by Baron and Kenny (1986), which provides justification as to why this approach has not been followed within this thesis. This is followed, as a necessary background, by a summary of the process through which both mediation and moderation effects are examined in the absence of a multi-level structure. Finally, building upon this background, the multi-level moderated mediation analysis methodology undertaken within this thesis is explained.

Both mediation analysis and moderated mediation analysis may be executed using appropriately capable statistical software such as SPSS or the PROCESS macro for SPSS (Hayes, n.d.). Multi-level mediation and multi-level moderated mediation analysis may also be executed using appropriately capable statistical software such as SPSS or the MLmed macro for SPSS (Rockwood, n.d.). The necessary multi-level mediation and multi-level moderated mediation analysis required to address the hypotheses that relate to research questions four, five and six was executed using the MLmed macro for SPSS.

### 5.6.2.1 Rebuttal of the causal steps approach of Baron and Kenny

The causal steps approach advocated by Baron and Kenny (1986) for executing mediation analysis, often described within the literature as the 'Baron and Kenny method' (Hayes, 2018), has not been followed within this thesis. The purpose of this section is to justify that decision. The Baron and Kenny method has traditionally been a popular method for establishing whether a mediation relationship could exist—that is, whether a certain variable  $M$  may function as a mediator within a relationship between two other variables identified as  $X$  and  $Y$  (Hayes, 2018). The method relies upon satisfying four conditions based on Figure 5.9, with the total effect of  $X$  upon  $Y$  shown as  $c$ , the corresponding direct effect shown as  $c'$  and the associated indirect effect shown as the compound relationship  $ab$  via  $M$ .

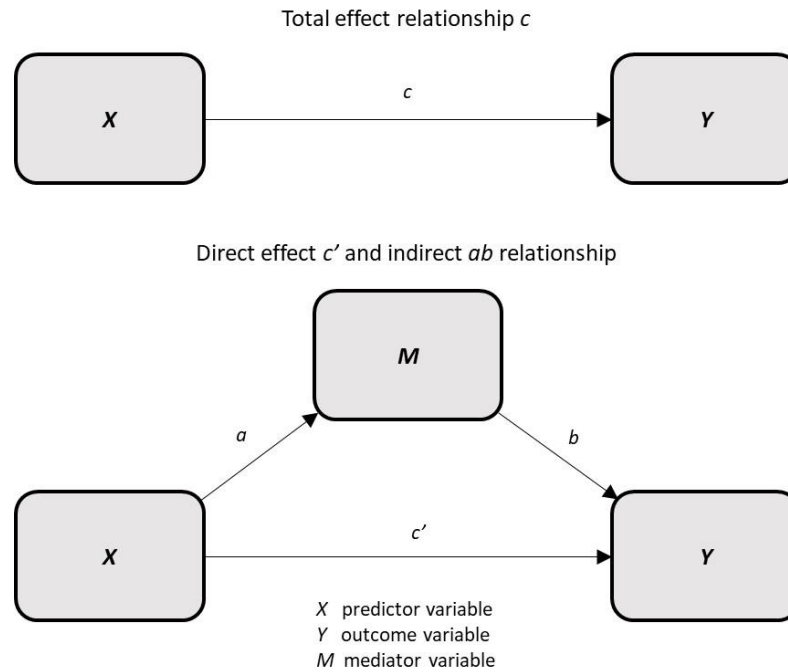


Figure 5.9: Path diagrams for the Baron and Kenny method

According to the Baron and Kenny method, satisfying the following four necessary stepwise conditions gives rise to mediation (Baron and Kenny, 1986, Hayes, 2018, James and Brett, 1984, Judd and Kenny, 1981):

1. The total estimated effect of  $X$  on  $Y$  shown as path  $c$  is statistically significant.
2. The estimated effect of  $X$  on  $M$  shown as path  $a$  is statistically significant.
3. Controlling for  $X$ , the estimated effect of  $M$  on  $Y$  shown as path  $b$  is statistically significant.
4. Controlling for  $M$ , the estimated direct effect of  $X$  on  $Y$  shown as path  $c'$  is not statistically significant.

In cases where steps 1, 2 and 3 are satisfied but the direct effect shown as  $c'$  remains statistically significant, the mediation effect can be said to be a partial effect rather than full (James and Brett, 1984, Hayes, 2018). The logic of the Baron and Kenny method is considered flawed based upon the following four arguments drawn from the relevant literature:

1. The Baron and Kenny method is heavily reliant upon tests that have been shown to be of low statistical power compared with other alternative inferential methods (Hayes and Scharkow, 2013).
2. Condition one concerning the existence of a statistically significant estimated total effect  $c$  does not need to be satisfied as a precondition for the operation of a mediation effect because it is possible for the indirect and direct effects to be of opposite signs, thus causing the total effect to be measured as insignificant (Hayes, 2018, Krause et al., 2010, Rucker et al., 2011, Shrout and Bolger, 2002). The indirect effect can be significant when the total effect is not (Hayes, 2018); therefore, the presence of a statistically significant total effect should not be a precondition for the testing of the possible existence of an indirect effect (see Bollen, 1989, Cerin and MacKinnon, 2009, Hayes, 2009, LeBreton et al., 2009, MacKinnon, 2008, Rucker et al., 2011, Shrout and Bolger, 2002, Zhao et al., 2010).
3. Condition four concerning the extinguishment of the statistical significance of the direct effect  $c'$  as verification of a mediation effect may be reliant upon an entirely trivial change. For example, if the  $p$  value associated with  $c'$  prior to controlling for  $M$  is significant at .049, while after controlling for  $M$ , the  $p$  value associated with  $c'$  rises slightly to .051 and is therefore shown to be insignificant (Krause et al., 2010).
4. The Baron and Kenny method does not test for an indirect effect but instead makes inferences about the existence of an indirect effect by separately testing both individual indirect paths  $a$  and  $b$  (Hayes, 2009, Hayes, 2018).

Further to the four points above, claims regarding mediation effects based upon whether a partial mediation effect can be said to exist while the path  $c'$  remains statistically significant are considered fruitless and add very little to the appreciation of the phenomenon under examination because such a distinction adds no theoretical meaning or substantive value of consequence (Hayes, 2018). On the strength of these arguments, the causal steps approach advocated by Baron and Kenny (1986) has not been employed within the overall methodology for the investigation of mediation effects within this thesis.

### 5.6.2.2 Mediation analysis

Simple mediation analysis is a statistical methodology that aims to examine how the effect of one variable upon another is transmitted via an intervening variable called the mediator (Baron and Kenny, 1986, James and Brett, 1984, Judd and Kenny, 1981, Hayes, 2018, Mackinnon et al., 2002). A basic mediation model in conceptual form, drawn from Hayes (2018) and as shown previously within this thesis, is repeated in Figure 5.10. This conceptual diagram contains two predictor variables,  $X$  and  $M$ , as well as two outcome variables,  $M$  and  $Y$ , with  $X$  exercising a causal influence over both  $Y$  and  $M$ , and  $M$  having a causal influence over  $Y$ . As such, there are two pathways through which  $X$  can influence  $Y$ : the direct pathway from  $X$  to  $Y$  and the indirect pathway from  $X$  to  $Y$  via  $M$ . It is the indirect pathway that is of primary interest within the analysis of the mediation effects (Hayes, 2018).

The simple mediation model is, in a multi-level form, the mediation model used within this thesis to address research question four as well as research questions five and six when combined with the moderator. The simple mediation model is the most rudimentary mediation structure (Hayes, 2018). It is acknowledged that this structure may grossly simplify the complex decision-making processes that give rise to how variable  $X$  influences variable  $Y$ . Nevertheless, the simple mediation model is widely used within empirical research settings across a broad spectrum of environments to gain insights into relationships between variables (Darlington and Hayes, 2017, Hayes, 2018).

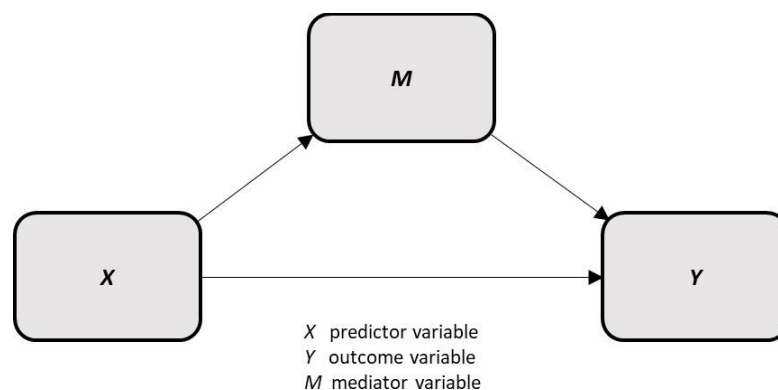


Figure 5.10: Conceptual diagram of a simple mediation model

The simple mediation model is typically estimated using an OLS regression, unless the outcome variable is dichotomous or ordinal, and gives rise to the following three equations (Hayes, 2018, Hayes and Rockwood, 2019):

$$M_i = d_1 + aX_i + \varepsilon_{1i}$$

*Equation 5.11*

$$Y_i = d_2 + c'X_i + bM_i + \varepsilon_{2i}$$

*Equation 5.12*

$$Y_i = d_3 + cX + \varepsilon_{3i}$$

*Equation 5.13*

Referring to Equation 5.11 and Equation 5.12,  $d_1$  and  $d_2$  are the regression constants,  $\varepsilon_{1i}$  and  $\varepsilon_{2i}$  represent the error estimates of  $M_i$  and  $Y_i$  respectively, and  $a$ ,  $b$  and  $c'$  represent the regression coefficients of the model for the estimation of  $M$  and  $Y$  (Hayes, 2018, Hayes and Rockwood, 2019). Within Equation 5.13, which is the equation for the total effect,  $d_3$  is the regression constant for the equation,  $c$  represents the expected change in the value of  $Y$  resulting from a change in the value of  $X$  of one unit, and  $\varepsilon_{3i}$  is the error estimate. The regression coefficient  $c$  is therefore referred to as the total effect, whereas the regression coefficient  $c'$  in Equation 5.12 represents the direct effect of variable  $X$  on  $Y$  arising from a one unit change in the value of  $X$  while holding the value of  $M$  constant (Hayes, 2018). The indirect effect, which is a product of  $a$  and  $b$  within Equation 5.12, quantifies the effect on  $Y$  of a one unit change in the value of  $X$  based upon the magnitude and sign of  $ab$ . Where  $X$  is a dichotomous variable and each group within  $X$  is coded accordingly, typically 0 or 1, the value of  $a$  is equivalent to the difference between the two group means on  $M$  based upon Equation 5.11 (Hayes, 2018). Provided that OLS is used to estimate the model, the total effect is the sum of the direct and indirect effects—that is,  $c = c' + ab$ . From this, it can be seen that the determination of  $ab$  is the difference between the total effect  $c$  and the direct effect  $c'$  (Hayes, 2018, Hayes and Rockwood, 2019). The statistical diagram shown in Figure 5.11, which is adapted from Hayes (2018), shows the relationships between  $X$ ,  $M$ ,  $Y$ ,  $a$ ,  $b$ ,  $c'$ ,  $\varepsilon_1$  and  $\varepsilon_2$ .

Statistical inference concerning the direct and total effects may be undertaken through the calculation of the estimated effect to its standard error ratio and comparing the result with the appropriate  $t$  distribution given the applicable degrees of freedom (Rockwood, 2017). Statistical inference concerning the indirect effect is the subject of considerable debate within the literature, as mentioned in Section 5.6.2.1 and as described by Hayes and Scharkow (2013) and Mackinnon et al. (2002). The normal theory approach, or 'Sobel Test', is an often-used test of statistical inference for the indirect effect that relies upon the same theory as employed in the inference tests for the direct and total effects. However, the method assumes that the sampling distribution for  $ab$  is normal, which it is typically not, and



it has been found to be less powerful than more recently developed methods such as bootstrapping (Hayes, 2018). Appropriate methods for inference testing to satisfy the needs of this thesis are discussed further in the next section.

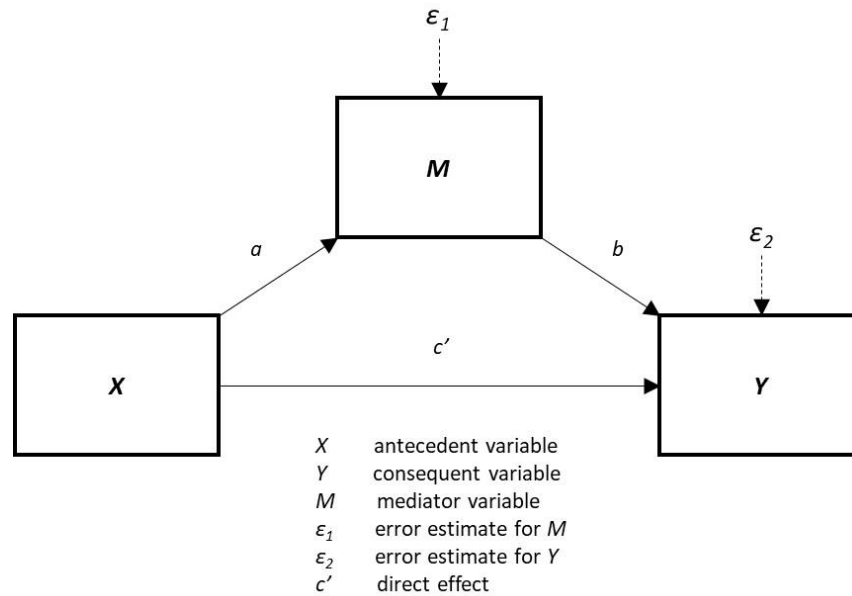


Figure 5.11: Statistical diagram of a simple mediation model

### 5.6.2.3 Moderated mediation analysis

Building upon the simple mediation model described in Section 5.6.2.2, the process of moderated mediation refers to circumstances where the magnitude of the indirect effect alters as a function of a moderating variable denoted as *W*. Based upon a simple mediation model, the moderated mediation effect of *W* may be on the *X* to *M* indirect pathway, the *M* to *Y* indirect pathway, both, the direct pathway *c'* or a combination of all three (Hayes, 2018). The hypotheses that refer to research problems five and six, as described in Section 1.4, concern only the moderation of the *M* to *Y* indirect pathway; therefore, the following explanation will be limited to that condition. A conceptual diagram depicting a simple moderated mediation model, drawn from Hayes (2018), with the moderation effect of *W* applying to the *M* to *Y* indirect pathway, is shown in Figure 5.12.

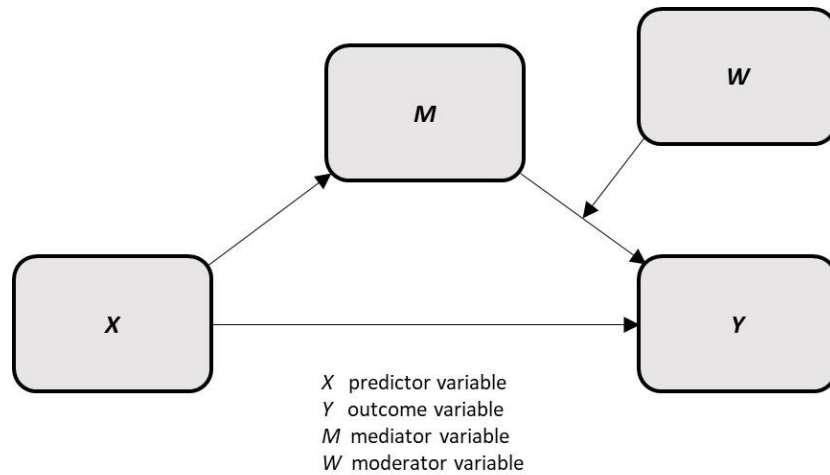


Figure 5.12: Conceptual diagram depicting the moderation effect of W upon M to Y

As with the simple mediation model described in Section 5.7.2.2, the simple moderated mediation model is typically estimated using OLS regression techniques, and as with the simple mediation model, it can be represented by a set of appropriate equations. In the case of the moderated mediation model shown in Figure 5.12, where the relationship between  $M$  and  $Y$  is conditioned on  $W$ , the equations are formulated as follows (Hayes, 2018, Hayes and Rockwood, 2019):

$$M_i = d_1 + aX_i + \epsilon_{1i} \tag{Equation 5.14}$$

$$Y_i = d_2 + c'X_i + b_1M_i + b_2W_i + b_3M_iW_i + \epsilon_{2i} \tag{Equation 5.15}$$

Equation 5.14 is identical to Equation 5.11, which describes the relationship between  $X$  and  $M$  within the previous simple mediation model. The moderating effect of  $W$  is contained within Equation 5.15, where the equation includes  $W$  as well as the product of  $M$  and  $W$  to enable the relationship between  $M$  and  $Y$  to be conditional on the value of  $W$ . This is best demonstrated by factoring for  $W$  to produce an equivalent equation to Equation 5.15, denoted as Equation 5.16:

$$Y_i = d_2 + c'X_i + b_2W_i + (b_1 + b_3W_i) M_i + \epsilon_{2i} \tag{Equation 5.16}$$

Equation 5.15 and Equation 5.16 directly relate to the statistical diagram for moderated mediation shown in Figure 5.13, which is drawn from Hayes (2018), with the effect of  $M$  on  $Y$  conditioned by  $W$ .

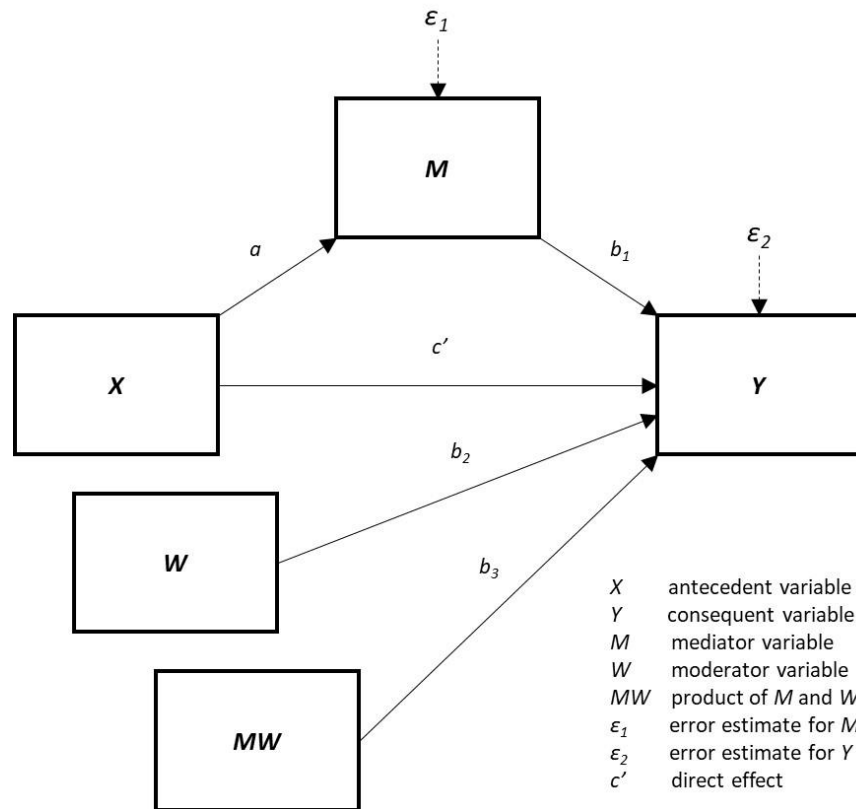


Figure 5.13: Statistical diagram of a simple moderated mediation model

As shown in Equation 5.16, the  $M$  to  $Y$  pathway is conditioned by the value of  $W$ , as is the effect of  $X$  on  $Y$  indirectly via  $M$ , and this conditional effect is represented by  $a(b_1 + b_3W)$ . This indirect conditional effect determines how variations in  $X$  translate indirectly to differences in  $Y$  via  $M$ , with this being dependent upon the value of  $W$  (Hayes, 2018, Hayes and Rockwood, 2019). Statistical inference concerning the indirect effect is determined by whether  $ab_3$  is significant—not simply on the basis of the significance of  $b_3$ , with the appropriate test being termed the index of moderated mediation (Hayes, 2015, Hayes, 2018). This test relies upon the generation of a bootstrapped confidence interval and an examination of whether zero lies within the confidence limits. This outcome is automatically calculated by the PROCESS macro. Where zero does not lie between the limits of the confidence interval using this approach, a mediation effect can be said to be moderated by the appropriate moderating variable (Hayes, 2018, Hayes and Rockwood, 2019).

#### 5.6.2.4 The multi-level mediation and moderated mediation methodologies

The methodological approach employed for the analysis of multi-level mediation and multi-level moderated mediation processes is conceptually similar to that undertaken as described in Sections 5.6.2.2 and 5.6.2.3 respectively, but with the fundamental difference that the equations used in the multi-level approaches must accommodate the multi-level structure of the data (Hayes, 2006). The requirement to accommodate the multi-level structure of the data is identical to that expressed in Section 5.6.1 concerning the execution of multi-level regression equations, and a similar approach is articulated within this section. However, a detailed explanation using formulaic expressions to demonstrate the various forms and nature of multi-level mediation and multi-level moderated mediation analysis is beyond the scope of this thesis. The following equations that concern the processes of multi-level mediation analysis should nevertheless, by way of example, provide sufficient insights into the nature of the methodology to convey a proper appreciation of the overall method. For a 1-1-1 mediation model—this being the nomenclature typically used to describe the lowest level at which the  $X$ ,  $M$  and  $Y$  variables are measured—the lower-level equations can be specified as shown within Equation 5.17, Equation 5.18 and Equation 5.19, each with random intercepts  $d$ , using notation and explanation based upon that provided by Kenny et al. (2003) and Bauer et al. (2006):

$$Y_{ij} = d_{0j} + c_j X_{ij} + \varepsilon_{ij} \quad \text{Equation 5.17}$$

$$M_{ij} = d_{Mj} + a_j X_{ij} + \varepsilon_{ij} \quad \text{Equation 5.18}$$

$$Y_{ij} = d_{Yj} + c'_j X_{ij} + b_j M_{ij} + \varepsilon_{ij} \quad \text{Equation 5.19}$$

Within these three equations, as with simple mediation,  $c$  is representative of the total effect of  $X$  on  $Y$ ,  $a$  is representative of the effect of  $X$  on  $M$ ,  $c'$  is representative of the direct effect of  $X$  on  $Y$  controlling for  $M$ , and  $b$  is representative of the effect of  $M$  on  $Y$  controlling for  $X$ , with the three error terms  $\varepsilon_{ij}$  being independent and assumed to be normally distributed. It is important to note that, as is the case in Section 5.6.1 concerning multi-level regression, individual cases clustered against each individual entity are denoted by  $i$ , and each individual entity is denoted by  $j$ . Again, it is through this means of identification that the process of multi-level estimation of intercepts and slope coefficients is executed.

Reflecting the multi-level nature of Equation 5.17, Equation 5.18 and Equation 5.19, level two fixed slopes for each individual entity  $j$  can also be expressed in equation form, with each  $j$ 's slope representing a function of the grand mean across all level two individual entities for the relevant slope term and each individual entity  $j$ 's own deviation  $u$  relative to that grand mean (Kenny et al., 2003). The corresponding slope equations for the total effect of  $X$  on  $Y$  (Equation 5.20), the effect of  $X$  on  $M$  (Equation 5.21), the effect of  $M$  on  $Y$  controlling for  $X$  (Equation 5.22) and the effect of  $X$  on  $Y$  controlling for  $M$  (Equation 5.23) are as follows:

$$c_j = c + u_{0j} \quad \text{Equation 5.20}$$

$$a_j = a + u_{1j} \quad \text{Equation 5.21}$$

$$b_j = b + u_{2j} \quad \text{Equation 5.22}$$

$$c'_j = c' + u_{3j} \quad \text{Equation 5.23}$$

The extension of these multi-level mediation equations to enable the accommodation of level one and level two covariates and level two moderator variables to explain variation between individual entities and to explain within-group variance of random slopes was described by Rockwood (2017). As discussed earlier, a detailed description and examination of the corresponding equations associated with the inclusion of covariates and moderators is beyond the scope of this thesis given the complexity of the calculations and given that this thesis focuses upon the application of these techniques rather than the analysis of them.

As mentioned earlier, the necessary multi-level mediation and multi-level moderated mediation analysis required to address the hypotheses that relate to research questions four, five and six was executed using the MLmed macro for SPSS sourced from Rockwood (n.d.). The graphical user interface of this macro enables the entry of all salient variables and the selection of the necessary parameters and settings to run both multi-level mediation and multi-level moderated mediation analyses, as well as the production of the necessary statistical inference tests. The results from the appropriate analyses using MLmed are presented in Chapter 6. The  $X$ ,  $M$ ,  $W$  and  $Y$  variables used within the analysis have each been described previously within this thesis. The level one covariates within each analysis task undertaken using MLmed, as detailed in Chapter 6, are three of the four possible  $X$  variables not subject to total, direct and indirect examination within that task. The level two covariates

common to all MLmed analysis tasks are respondent age, gender and duration of career. The effect and implications of both the fixed and random slopes within the required multi-level mediation and multi-level moderated mediation analyses necessary to address both the research questions and the corresponding hypotheses are considered in each respective section of Chapter 6.

## **5.7 Ethical considerations**

The primary ethical considerations relevant to this thesis are confidentiality, informed consent and the right to withdraw. This thesis requires the collection of data from human subjects; as such, important ethics considerations arise (Oppenheim, 1992). The execution of this thesis requires that the online survey participants, all of whom are adults, provide a response to each of the following categories, with each category being representative of information that satisfies the definition of data of a personal nature. For each category, a set of ranges was provided, as shown in detail in Appendix C. For example, for 'age group', the options were '18 to 35', '36 to 45', '46 to 55' and 'greater than 55', and for 'organisational grade of current role', the options were '14 or less', '15 to 16', '17 to 18' and '19 or greater'. The categories for which personal information was sought were:

- age group
- years working for BHP
- time in current role (years)
- duration of working career to date (years)
- organisational grade of current role
- gender.

No respondents were required to provide their name, location or email address. The respondents were not able to be identified from the survey data collected, and no other means of respondent engagement occurred other than through the email distribution of the necessary participant information sheet, the 'Carter Racing' case study document and the online survey link. Accordingly, satisfaction of confidentiality requirements was achieved primarily through the survey design. The requirement for acknowledgement of informed

consent was achieved via the online survey itself, as the survey was designed to prevent participants from commencing it unless they had indicated their willingness to participate beforehand, with this acknowledgement being recorded within each respondent's dataset. The CVA survey specification is contained within Appendix C, and the participant information sheet is contained within Appendix D. As with the requirement for confidentiality, informed consent and acknowledgement of this by each survey participant was achieved through the survey design.

Both the survey design specification, as shown in Appendix C, and the participant information sheet, as contained in Appendix D, explicitly stated that participation in the survey was entirely voluntary, and that participants could elect to withdraw from the survey at any time without reason or explanation. While the dataset generated through the online survey process did not contain identifiable data, the withdrawal and removal of a particular respondent's data could be achieved after commencement of the survey provided that the respondent seeking to withdraw after commencement was able to provide the date on which they accessed the online survey and the approximate time at which they commenced and closed the survey. For the pilot survey that was executed in advance of the final survey, identical arrangements were in place to manage the relevant ethical considerations.

## **5.8 Conclusion**

This chapter has discussed and justified the research paradigm within which this thesis is framed, the research methodology employed for the execution of this thesis and the 'Carter Racing' case study upon which the methodology relies. The opening sections of the chapter provided an overview of the research design that summarised, in diagrammatic form, the series of steps that have been followed. A quantitative approach has been employed to address the main research problem that this thesis seeks to address, with the research methodology combining full-profile CVA and multi-level moderated mediation analysis to test the relationships of interest described by the main research problem. Justification for the selection of these two quantitative methodologies, in combination, was provided within this chapter, as was justification for the unit of analysis—namely executive managers employed by the publicly listed global resources company BHP.

This chapter also provided an explanation of the multi-step decision-making process required to design a robust and proper conjoint analysis. In parallel, justification was provided at each

step for the selected approach employed in the formulation of the CVA design specification, which resulted in the execution of the online survey necessary for the fulfilment of the thesis objectives. Within this design process, the selection of appropriate measurement instruments was explained, with reliance placed upon pre-existing measurement scales wherever possible. As part of the selection process, consideration was given to issues associated with the use of Likert and Likert-like scales, with appropriate justifications provided, including explanations of assumptions made where required to avoid, as far as possible, the presence of doubt.

In regard to the CVA component of the research methodology, the chapter also described the empirical method through which the necessary part-worth estimates and utility values were derived, the means through which the goodness of fit of the estimation models was evaluated, and the process through which the execution of the online survey was both tested and administered. Multi-level regression analysis, multi-level mediation analysis and multi-level moderated mediation analysis techniques were also discussed within this chapter, as were the primary ethical considerations relevant to this thesis. The multi-level quantitative techniques employed were made clear within the chapter, and it was from this that their relevance and use within the overall suite of analytical methods was justified. Results of the data analysis derived from the employment of the research methodology described and justified within this chapter are presented in Chapter 6.



## **6. DATA ANALYSIS AND RESULTS**

### **6.1 Introduction**

Building upon the specification of the analytic model of this thesis as defined in Section 4.2, as well as the measurement scales and methodologies described in Chapter 5, analysis was undertaken of the responses generated through the CVA online survey. The purpose of this chapter is to provide a full account of that analysis aligned with the six research questions that have guided this thesis and are defined in Section 1.4. The chapter commences with an analysis of the survey response demographics and includes an examination of non-response bias. Then follows an examination of the overall dataset generated through the CVA online survey, with a particular focus on addressing the possibility of common method bias, the strength of correlation between the two dependent variables employed within the survey, and the unidimensionality and internal consistency of both psychographic variables. Each of the research questions stated in Section 1.4 is then addressed by testing the relevant hypotheses associated with each question, as developed in Chapter 4. The focus of this chapter is the presentation and analysis of the data; as such, it does not provide commentary regarding the results obtained beyond that which is necessary to describe them. Consideration of these results, discussion concerning them and conclusions that may be drawn, both directly and within the broader context, are contained within Chapter 7. Unless otherwise stated, a statistical significance level of .05 has been adopted throughout this chapter, and maximum likelihood was selected as the estimation method for the regression modelling undertaken.

### **6.2 Survey response analysis**

The purpose of this section is to summarise the survey response rate achieved, present a demographic picture of the respondent group and test for non-response bias.

#### **6.2.1 Survey response rate**

Of the population of 400, 149 online surveys were commenced following receipt of the online agreement to participate in the survey through the informed consent process. Of these, 106 online surveys were fully completed, yielding a participation rate of 26.5%. The balance of

43 online surveys represent those that were commenced, but not completed, after informed consent was provided. Of the 43 not completed, 21 ceased after the first of ten conjoint task pages were presented to the respondent, which suggests that these respondents were not prepared to engage with the requirements of the survey design. The balance of 22 who did not complete the survey failed to complete all ten conjoint tasks and the respondent risk propensity evaluation section of the online survey. Twelve members of the population elected not to participate in the survey after reading the informed consent page. This represents 3% of the total population and 7.5% of those who responded to the participant statement on the informed consent page, which was a prerequisite of gaining access to the survey.

Of the 106 surveys that were fully completed, three had an associated coefficient of determination ( $R^2$ ) of 0.000, indicating that the respondents in these three cases did not vary their response across each of the ten conjoint tasks they completed. Given this, the conjoint tasks completed by those three respondents were purposefully excluded from the analysis. A total of 103 completed surveys, each containing ten completed conjoint tasks, and with each task demonstrating a non-zero coefficient of determination ( $R^2$ ) value, were transferred to an SPSS file for subsequent analysis. Based upon what was described within Section 5.5.3 concerning sample size considerations for full-profile CVA, a total of 103 completed surveys exceeds the minimum sample size requirement for a finite population of 400 (83 samples) and is equivalent to what is necessary for an infinite population (103 samples). Hence, the sample size objective of a 95% confidence level and a sampling error of 0.5 increments, within the nine-point measurement scale employed for the measurement of innovativeness, is satisfied.

### **6.2.2 Survey respondent demographics**

The online CVA survey was purposefully designed to capture a range of respondent demographic characteristics that were considered relevant to this thesis. A summary of the respondent demographics segmented by category is provided in Table 6.1.

Category		Count by category	Cum. count	% by category	Cum. %
Gender	Male	78	78	75.7%	75.7%
	Female	25	103	24.3%	100.0%
Respondent age (years)	18 to 35	5	5	4.9%	4.9%
	36 to 45	27	32	26.2%	31.1%
	46 to 55	53	85	51.5%	82.5%
	> 55	18	103	17.5%	100.0%
Duration of career to date (years)	<5	0	0	0.0%	0.0%
	5 to 10	4	4	3.9%	3.9%
	11 to 20	37	41	35.9%	39.8%
	>20	62	103	60.2%	100.0%
Years working for BHP is closest to	2	16	16	15.5%	15.5%
	4	16	32	15.5%	31.1%
	6	23	55	22.3%	53.4%
	>8	48	103	46.6%	100.0%
Time in current role is closest to (years)	1	8	8	7.8%	7.8%
	2	31	39	30.1%	37.9%
	3	37	76	35.9%	73.8%
	>4	27	103	26.2%	100.0%
Level of current role	14 or less	12	12	11.7%	11.7%
	15 or 16	68	80	66.0%	77.7%
	17 or 18	19	99	18.4%	96.1%
	19 or greater	4	103	3.9%	100.0%

Table 6.1: Respondent demographics by category in total and percentage terms

The six categories contained in Table 6.1 are represented graphically in Figure 6.1. Based upon the data contained in Table 6.1 and shown in Figure 6.1, approximately 75% of the respondent sample group were male, almost 70% were 46 years of age or older, and almost half had been employed by BHP for more than eight years. Slightly more than 60% indicated that the duration of their career exceeded 20 years, and 66% reported as being at either Level 15 or 16, which reflects roles such as operating general managers or functional vice presidents. More than 90% reported that they had held their current role for more than one year.

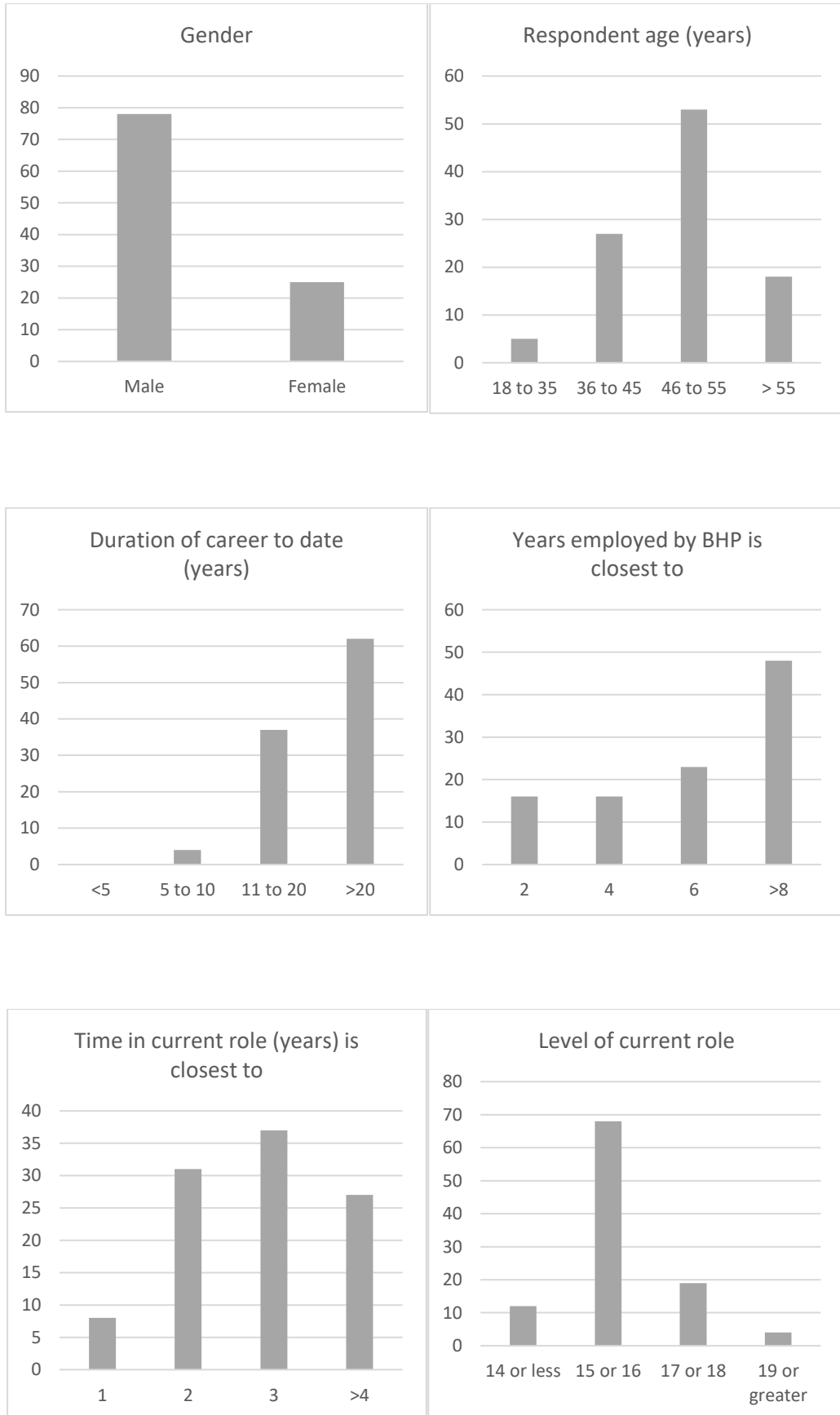


Figure 6.1: The demographic characteristics of the respondent group

### 6.2.3 Non-response bias

The possible presence of non-response bias was tested as part of the overall survey results analysis process to verify that no significant differences existed among respondents based upon three observable characteristics of interest: race probability, risk propensity and risk perception. These three variables were selected because they represent the primary respondent-related variables used in the analytic model described previously, and that are relied upon by the subsequent analysis detailed within this chapter. The descriptive statistics for these three variables are shown in Table 6.2.

	<b>N</b>	<b>Mean</b>	<b>Median</b>	<b>Std deviation</b>	<b>Minimum</b>	<b>Maximum</b>
Race probability	1030	-	5	2.31	1	9
Risk propensity	103	3.92	4.00	1.23	1.20	6.40
Risk perception	1030	4.15	4.25	1.23	1.00	7.00

Table 6.2: Descriptive statistics for non-response bias

Using the methodology described in Section 5.5.5 to separate the online survey respondents into two groups based upon order of completion, the 103 respondents who completed the survey were partitioned into two approximately equal-sized groups labelled as Group One and Group Two. Given that the total number of respondents is an odd number, the number of respondents segregated into each group, and the relevant descriptive statistics for each group, is shown within Table 6.3.

	<b>Group 1</b>	<b>Group 2</b>
Number of respondents	52	51
Race probability median	5	5
Risk propensity mean	3.96	3.88
Risk propensity median	4.10	4.00
Risk perception mean	4.15	4.15
Risk perception median	4.25	4.25

Table 6.3: Descriptive statistics for non-response bias partitioned by group

Based upon the partitioning of the respondent pool as described and identified as Group One and Group Two, and considering those respondents contained within Group Two as non-respondents to Group One, as described in Section 5.5.5, non-response bias was examined

by testing whether statistically significant differences exist between the two groups based upon the characteristics of interest. This approach is consistent with the extrapolation method described by Armstrong and Overton (1977) and Linder et al. (2001). To enable the selection of the correct statistical test to evaluate differences between the two separate groups, the normality of the distribution for each of the three variables of interest was first examined. The results of the analysis undertaken to assess the normality of the distribution of scores for each variable of interest are shown in Table 6.4.

	Kolmogorov–Smirnov <sup>a</sup>			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Race probability	.112	1030	.000	.951	1030	.000
Risk propensity	.089	103	.000	.964	103	.000
Risk perception	.091	1030	.000	.980	1030	.000

a. Lilliefors Significance Correction

Table 6.4: Normality test results—race probability, risk propensity and risk perception

This analysis demonstrated that each of the three variables of interest was found to exhibit significantly non-normal distributions: race probability  $D(1030) = 0.11$ ,  $p < .05$ ; risk propensity  $D(103) = 0.09$ ,  $p < .05$ ; and risk perception  $D(1030) = 0.09$ ,  $p < .05$ . The output of the more powerful Shapiro–Wilk test (Field, 2009) validated this result, also reporting  $p < .05$  for all relevant variables under consideration. Accordingly, a non-parametric test was necessary to evaluate whether Group One was significantly different from Group Two across the three variables of interest. For this reason, the Mann–Whitney test was employed, as the purpose of this test is to establish whether significant differences exist between two independent non-parametric groups across variables that are common to both (Field, 2009, Pallant, 2016). The results of the Mann–Whitney test for the variables of interest are provided in Table 6.5.

	Race probability	Risk propensity	Risk perception
Mann–Whitney U	132387	130650	131898
z-score	-0.045	-0.409	-0.147
Asymp. sig. (2-tailed)	.964	.682	.883
r effect size	-.001	-.040	-.005

Table 6.5: Output of Mann–Whitney test for non-response bias

The comparison between Group One and Group Two, based upon the results of the Mann–Whitney test, demonstrated no significant difference between the groups based upon the variables of interest given that no  $p$  value  $< .05$ . Race probability within Group One (*median* = 5) did not differ significantly from that of Group Two (*median* = 5), with  $U = 132387$ ,  $z = -0.05$ ,  $p = .96$ ,  $r = -.001$ . Risk propensity within Group One (*median* = 4.10) did not differ significantly from that of Group Two (*median* = 4.00), with  $U = 130650$ ,  $z = -0.41$ ,  $p = .68$  and  $r = -.040$ . Risk perception within Group One (*median* = 4.25) did not differ significantly from that of Group Two (*median* = 4.25), with  $U = 131898$ ,  $z = -0.15$ ,  $p = .88$  and  $r = -.005$ . From this result, it can be concluded that the respondents who comprised Group One did not differ significantly from the respondents who comprised Group Two based upon the three variables of interest; accordingly, it is concluded that non-response bias is not of major concern within this thesis.

### **6.3 Examination of the data**

Prior to commencing the necessary analysis to test the hypotheses of this thesis, it was vital to examine the extent to which the data obtained through the CVA online survey method satisfied criteria such as missing data and outliers, scale unidimensionality and internal consistency, the nature of the dependent variable, and the vital assumptions upon which the statistical methods relied. The possibility of common method bias is also considered within this section.

Given the nature of the CVA survey design, there were no missing data within any of the completed online surveys. No outliers were observed other than the three mentioned in Section 6.2.1, which had coefficient of determination ( $R^2$ ) values of 0.000.

#### **6.3.1 Common method bias**

Given that common method bias has been shown to be problematic and a threat to research findings—and especially so for self-reporting studies—the importance of investigating and addressing common method bias must not be underestimated (Coltman et al., 2008). Within this thesis, Hartman’s single-factor test was employed to examine the extent to which the effect of common method bias was observable within the data.

Based upon this post hoc methodology, the following variables were loaded for exploratory factor analysis:

- race probability
- solution uncertainty
- problem uncertainty
- irreversible consequence failure
- irreversible consequence postponement
- each of the four Likert items that comprise the risk perception scale
- each of the five Likert items that comprise the risk propensity scale.

Of the four Likert items that comprise the risk perception scale, items two and four were reversed to counteract the reverse polarity of these two items within the measurement scale, as mentioned in Section 5.4.5.2.

Using principal axis factoring and single-factor extraction, the unrotated factor solution from the exploratory factor analysis was then examined to check whether a general factor emerged or whether a single factor accounted for a majority of the total variance among the loaded variable set. The process followed within this thesis for the analysis of common method bias using exploratory factor analysis reflects the process described by Podsakoff and Organ (1986) and Podsakoff et al. (2003). The results from the exploratory factor analysis are provided in Table 6.6.

From Table 6.6, it is evident that no general factor emerged from the exploratory factor analysis, nor did any single factor account for a majority of the total variance among the loaded variable set, with the first unrotated factor capturing 37.17% of the variance. From this result, it is concluded that a method effect is not of significant concern to this thesis.



Factor	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.688	40.630	40.630	5.203	37.166	37.166
2	2.170	15.498	56.128			
3	1.129	8.063	64.192			
4	1.031	7.366	71.557			
5	.917	6.551	78.108			
6	.650	4.645	82.753			
7	.531	3.795	86.547			
8	.425	3.037	89.584			
9	.340	2.427	92.011			
10	.298	2.130	94.141			
11	.264	1.883	96.023			
12	.228	1.630	97.653			
13	.185	1.318	98.971			
14	.144	1.029	100.000			

Extraction Method: Principal Axis Factoring.

Table 6.6: Results from Harman's single-factor test

### 6.3.2 Correlation between the two dependent variable scales

A check was conducted to examine the level of correlation between the two dependent variable scales of race probability and the dichotomous forced choice race item question, which represented the race/not race choice, to enable an evaluation of the extent to which each respondent's behavioural intentions aligned with their direct behavioural forced choice-making behaviour. Given that the variable of race probability was shown to exhibit a significantly non-normal distribution in Section 6.2.3, the measurement of correlation between race probability and the dichotomous forced choice race item question was investigated using Spearman's correlation coefficient ( $r_s$ ). A strong positive correlation was observed between these two variables ( $r_s(1030) = .82, p < .01$ ), which provides validation of the alignment between behavioural intent measured in the form of a probability and forced choice decision making. This result is similar to that achieved from the pilot test ( $r_s(180) = .85, p < .01$ ).

### **6.3.3 Unidimensionality and internal consistency of the psychometric scales**

Within this thesis, two psychometric measurement scales are employed: risk propensity and risk perception. The risk propensity scale consisted of five items, and the risk perception scale consisted of four items, as described in Sections 5.4.5.3 and 5.4.5.2 respectively. While both the risk propensity and risk perception measurement scales were pre-existing, as described by Sitkin and Weingart (1995), the unidimensionality and internal consistency of both measurement scales was checked to verify the adequacy of their actual performance. Testing of both the internal consistency and the unidimensional nature of each scale was undertaken because testing for internal consistency alone does not provide adequate evidence of unidimensionality (Gardner, 1995). As such, factor analysis was undertaken for confirmatory purposes to verify that all scale items in each case loaded correctly onto a single general factor using a similar approach to that followed by Coulson (1992). The results of the factor analysis and internal consistency testing for each measurement scale are presented within the following two sections.

#### **6.3.3.1 Risk propensity: unidimensionality and internal consistency**

The five items that comprise the risk propensity measurement scale were subjected to principal component analysis (PCA) using SPSS. In advance of PCA, the suitability of the data for factor analysis was evaluated. All inter-item correlations exceeded the coefficient value of .3, which was specified by Tabachnick and Fidell (2013) as the minimum permissible for the performance of factor analysis. All inter-item correlations for the five items that comprise the risk propensity scale are shown in Table 6.11. Results from the PCA for the five-item risk propensity scale yielded a Kaiser–Meyer–Olkin (KMO) value of .81, which exceeds the minimum recommended value of .6 (Kaiser, 1970, Kaiser, 1974), and Bartlett’s Test of Sphericity (Bartlett, 1954) demonstrated statistical significance ( $p < .05$ ), thus providing support for the factoring of the correlation matrix.

Based upon the five items of the risk propensity scale, the PCA revealed the presence of a single factor with an eigenvalue greater than one, which explained 71.91% of the variance. Cattell’s scree test (Cattell, 1966) also revealed a single factor with a definitive break being exhibited following the first factor. As only one factor was revealed, factor rotation was unnecessary. The results of the PCA verified that the five items that comprise the risk propensity scale all loaded onto a single general factor and, in doing so, demonstrated that

the risk propensity scale can be justifiably employed as a single attitudinal measure. Table 6.7 presents the results of the KMO test and Bartlett's Test of Sphericity. Table 6.8 provides the results of the factor analysis, revealing one factor with an eigenvalue greater than one, and the output of Cattell's scree test is shown in Figure 6.2.

KMO measure of sampling adequacy		.805
Bartlett's Test of Sphericity	Approx. chi-square	3383.386
	df	10
	Sig.	.000

Table 6.7: KMO test results and Bartlett's Test of Sphericity - risk propensity scale

Component	Initial eigenvalues			Extraction sum of squared loadings		
	Total	% of variance	Cum. %	Total	% of variance	Cum. %
1	3.595	71.907	71.907	3.595	71.907	71.907
2	.547	10.948	82.855			
3	.392	7.843	90.698			
4	.311	6.214	96.911			
5	.154	3.089	100.000			

Extraction method: PCA

Table 6.8: Results of factor loading - risk propensity scale

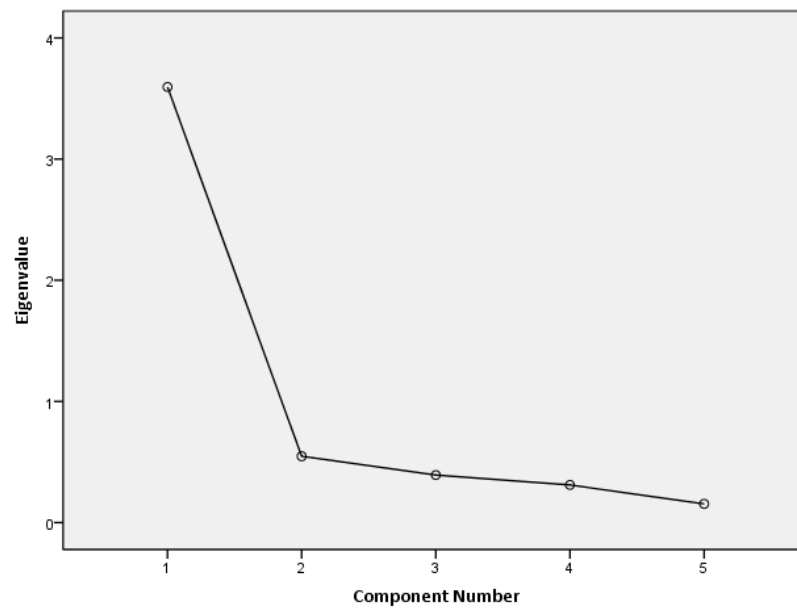


Figure 6.2: Factor analysis scree plot output - risk propensity scale

For the risk propensity scale, Cronbach’s alpha was .90, which exceeds the minimum threshold level of .70 specified by Hair et al. (2006) and Pallant (2016), and compares favourably with the Cronbach’s alpha value from the pilot study ( $\alpha = .76$ ). This result is also comparable to that achieved by Sitkin and Weingart (1995) using the same five scale items ( $\alpha = .86$ ). As shown in Table 6.10, the level of internal consistency achieved could not be improved through the exclusion of any one of the five items. For simplicity of presentation within this section, each of the five items that comprise the risk propensity scale, as described in Section 5.4.5.3, was assigned a unique scale item number as shown in Table 6.9. Identification of the scale item number in Table 6.10 is accomplished by reference to Table 6.9.

<b>Scale item number</b>	<b>Scale item descriptor</b>
1	Choose more or less risky alternatives based on the assessment of others on whom you must rely
2	Choose more or less risky alternatives that rely upon analyses high in technical complexity
3	Choose more or less risky alternatives that could have a major impact on the strategic direction of your organisation
4	Initiate a strategic corporate action that has the potential to backfire
5	Support a decision when I was aware that relevant analyses were done while missing several pieces of information

Table 6.9: Risk Propensity scale item identifier

	<b>Corrected item total correlation</b>	<b>Cronbach’s alpha if item deleted</b>
Scale item 1	.713	.889
Scale item 2	.765	.878
Scale item 3	.842	.861
Scale item 4	.724	.888
Scale item 5	.737	.884

Table 6.10: Risk propensity corrected item correlation and Cronbach’s alpha if deleted

The risk propensity scale inter-item correlations are provided in Table 6.11. The mean inter-item correlation for risk propensity is .648, demonstrating an acceptably strong relationship among the scale items (Pallant, 2016).

	Scale item 1	Scale item 2	Scale item 3	Scale item 4	Scale item 5
Scale item 1	1.000	.677	.697	.492	.608
Scale item 2	.677	1.000	.739	.573	.633
Scale item 3	.697	.739	1.000	.759	.631
Scale item 4	.492	.573	.759	1.000	.666
Scale item 5	.608	.633	.631	.666	1.000

Table 6.11: Risk propensity scale inter-item correlation matrix

### 6.3.3.2 Risk perception: unidimensionality and internal consistency

Following the same approach as that employed for the risk propensity scale, the four items that comprise the risk perception measurement scale were subjected to PCA using SPSS. In advance of PCA, the suitability of the data for factor analysis was evaluated. Again, all inter-item correlations exceeded the minimum coefficient value of .3 specified by Tabachnick and Fidell (2013). All inter-item correlations for the four items that comprise the risk perception scale are shown in Table 6.16. Results from the PCA for the four-item risk perception scale yielded a KMO value of .84, which exceeds the minimum recommended value of .6 (Kaiser, 1970, Kaiser, 1974), and Bartlett's Test of Sphericity (Bartlett, 1954) demonstrated statistical significance ( $p < .05$ ), thus providing support for the factoring of the correlation matrix.

Based upon the four items of the risk perception scale, the PCA revealed the presence of a single factor with an eigenvalue greater than one, which explained 76.92% of the variance. Cattell's scree test (Cattell, 1966) also revealed a single factor with a definitive break being exhibited following the first factor. Again, as only one factor was revealed, factor rotation was unnecessary. The results of the PCA verified that the four items that comprise the risk perception scale all loaded onto a single general factor and, in doing so, demonstrated that the risk perception scale can be justifiably employed as a single attitudinal measure. Table 6.12 presents the results of the KMO test and Bartlett's Test of Sphericity. Table 6.13 provides the results of the factor analysis, revealing one factor with an eigenvalue greater than one, and the output of Cattell's scree test is shown in Figure 6.3.

KMO measure of sampling adequacy		.838
Bartlett's Test of Sphericity	Approx. chi-square	2609.806
	df	6
	Sig.	.000

Table 6.12: KMO test results and Bartlett's Test of Sphericity - risk perception scale

Component	Initial eigenvalues			Extraction sum of squared loadings		
	Total	% of variance	Cum. %	Total	% of variance	Cum. %
1	3.077	76.919	76.919	3.077	76.919	76.919
2	.433	10.832	87.751			
3	.276	6.895	94.646			
4	.214	5.354	100.000			

Extraction method: PCA

Table 6.13: Results of factor loadings - risk perception scale

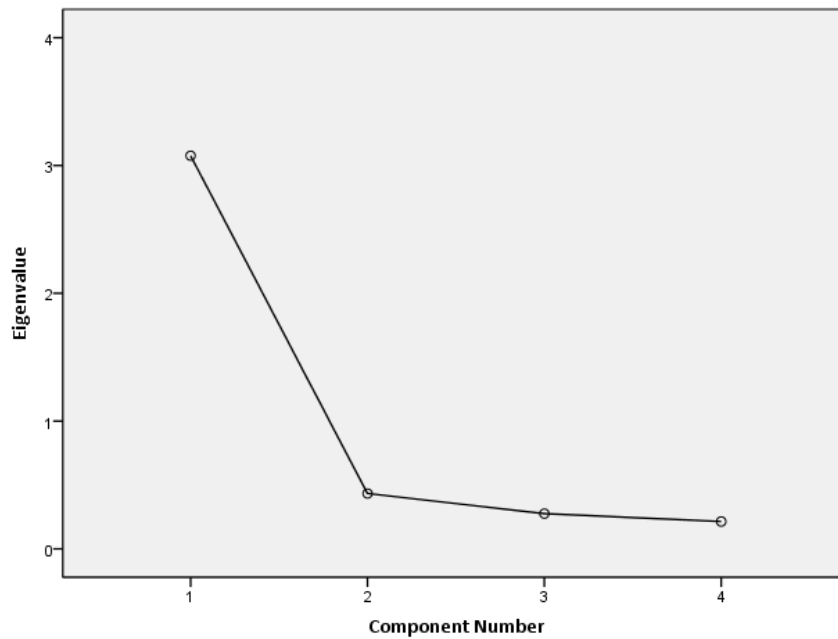


Figure 6.3: Factor analysis scree plot output - risk perception scale

Cronbach's alpha for the four-item risk perception scale was .90, which, as with the result for risk propensity, exceeds the minimum threshold limit of .7 specified by Hair et al. (2006) and Pallant (2016). This result also compares favourably with the result achieved within the pilot study ( $\alpha = .90$ ) and with Sitkin and Weingart (1995) using the same four-item scale ( $\alpha = .75$ ). The level of internal consistency achieved for the four-item risk perception scale could not be improved upon through the exclusion of any one of the four items, as demonstrated in Table 6.15. Similar to the means of item identification employed in Section 6.3.3.1, each of the four items that comprise the risk perception scale, as described in Section 5.4.5.2, was assigned a unique scale item number as shown in Table 6.14. Identification of the scale item number in Table 6.15 is accomplished by reference to Table 6.14.

	Semantic scale point limit	
	1	7
Scale item 1	Significant opportunity	Significant threat
Scale item 2*	High potential for loss	High potential for gain
Scale item 3	A positive situation	A negative situation
Scale item 4*	Very unlikely to succeed**	Very likely to succeed**

\* indicates scale item was a reverse scale

\*\* indicates 'at Ponoco race'

Table 6.14: Risk perception scale item identifier

	Corrected item total correlation	Cronbach's alpha if item deleted
Scale item 1	.814	.855
Scale item 2*	.766	.870
Scale item 3	.834	.848
Scale item 4*	.694	.895

\* indicates scale item was a reverse scale

Table 6.15: Risk perception corrected item correlation and Cronbach's alpha if deleted

The inter-item correlations for the risk perception scale are provided in Table 6.16. The mean inter-item correlation value for the risk perception scale was .691, demonstrating an acceptably strong relationship among the scale items (Pallant, 2016).

	Scale item 1	Scale item 2*	Scale item 3	Scale item 4*
Scale item 1	1.000	.715	.779	.657
Scale item 2*	.715	1.000	.751	.585
Scale item 3	.779	.751	1.000	.657
Scale item 4*	.657	.585	.657	1.000

\* indicates scale item was a reverse scale

Table 6.16: Risk perception scale inter-item correlation matrix

#### 6.4 Testing of hypotheses

The following six sections provide an analysis of the results structured in accordance with the order of the research questions contained in Section 1.4. Discussion concerning the results contained within these six sections is not undertaken in this chapter, as mentioned within this chapter's introduction. Rather, discussion of these results and consideration of the conclusions that may be drawn from them are presented within Chapter 7.

#### **6.4.1 Analysis of preferences for conditions of uncertainty and irreversibility**

The purpose of this section is to examine respondent decision-making preferences based upon the average CVA utility values associated with each of the levels that represent the four attributes of the study and, in doing so, test the following four hypotheses:

***H1a:** Solution uncertainty is negatively associated with innovativeness.*

***H1b:** Problem uncertainty is negatively associated with innovativeness.*

***H1c:** Irreversible consequence failure is negatively associated with innovativeness.*

***H1d:** Irreversible consequence postponement is positively associated with innovativeness.*

Following the upload of the full-profile CVA survey results from the Sawtooth CVA software online survey hosting portal in the final week of December 2018, average utility values for each of the attribute levels together with the coefficients of determination ( $R^2$ ) for each respondent were calculated using the Sawtooth CVA software analysis manager module. The average utility values were initially calculated in both scaled zero-centre difference and raw-scale forms. The raw-scaled form utility values were employed for analysis within this section because the raw-scaled form utility value set has been used within the subsequent analyses of this chapter. Table 6.17 summarises the coefficient of determination ( $R^2$ ) outcomes for all respondents who successfully completed the CVA online survey and who have been considered within the analysis. From Table 6.17, it can be observed that a broad range of coefficient of determination ( $R^2$ ) outcomes are exhibited. However, the mean value (.72) and the interquartile range (.26) together demonstrate that while the spread of values is large, 75% of the total values are greater than .58. This is further illustrated in Figure 6.4, which shows the spread of coefficient of determination ( $R^2$ ) values across the range in Pareto form.



Number of respondents	103	
Mean	.72	
Median	.76	
Lowest value mode	.78	
Minimum	.16	
Maximum	.99	
Percentiles	25th	.58
	50th	.76
	75th	.84

Table 6.17: CVA coefficient of determination ( $R^2$ ) outcomes for all respondents

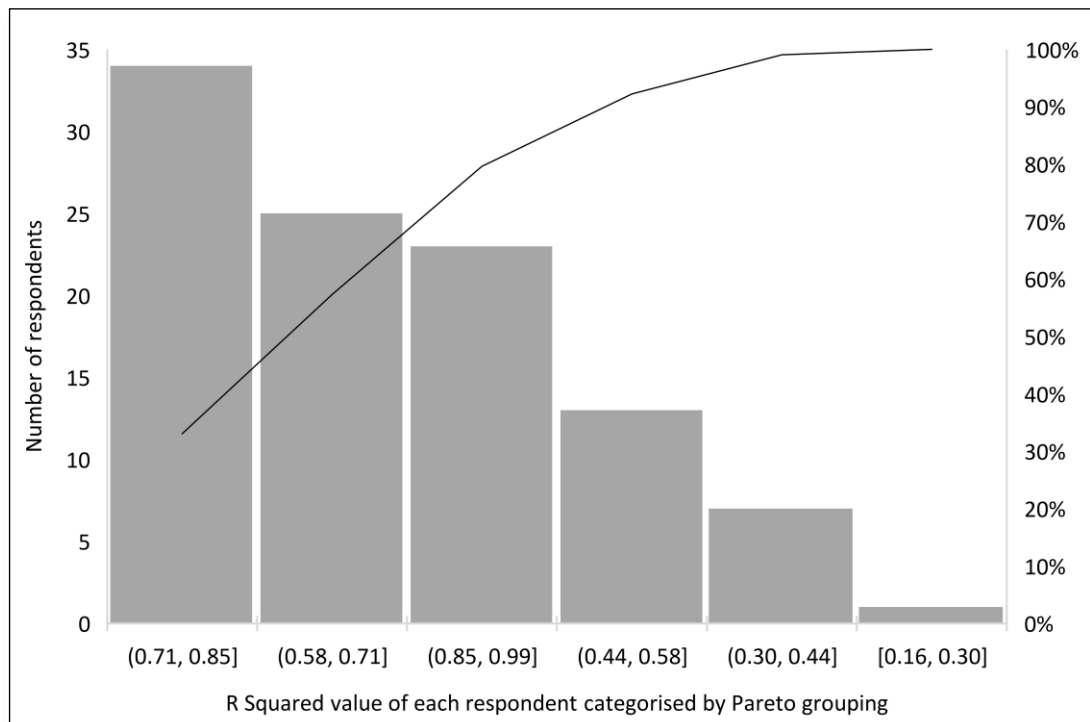


Figure 6.4: CVA coefficient of determination ( $R^2$ ) spread for all respondents

To ensure that the study remained correctly representative of the sample, it was important to retain those respondents who returned coefficient of determination ( $R^2$ ) values of less than .58 but greater than zero within the study. Doing so ensured the analysis was grounded on the actual behaviour of the sample group rather than a subset of it in within which the coefficient of determination values each exceeded a threshold of what might be considered an acceptable level of fit.

Table 6.18 contains the average raw utility values calculated for each level of each attribute as an output from the full-profile CVA evaluation process using the Sawtooth CVA software

analysis manager module together with the corresponding standard deviation values and confidence intervals.

	Utility	Std deviation	Lower 95% CI	Upper 95% CI
<b>Solution uncertainty</b>				
# of races completed using new gasket arrangement since last failure using old gasket is 5	0.20	-	-	-
# of races completed using new gasket arrangement since last failure using old gasket is 2	-0.41	0.45	-0.50	-0.33
<b>Problem uncertainty</b>				
% of finished races in season with air temp in 18–24° C range is 73%	0.20	-	-	-
% of finished races in season with air temp in 18–24° C range is 60%	-0.32	0.39	-0.39	-0.24
<b>Irreversible consequence failure</b>				
Lose oil sponsorship but retain option to negotiate tyre sponsorship	0.20	-	-	-
Lose both oil and tyre sponsorships	-0.23	0.54	-0.34	-0.13
<b>Irreversible consequence postponement</b>				
Retain options to negotiate both oil and tyre sponsorships next season	0.20	-	-	-
Retain option to negotiate oil sponsorship next season but lose tyre sponsorship	0.39	0.39	0.32	0.47

Table 6.18: CVA results showing the average raw utilities for each attribute level

Before advancing further, it is important to repeat that the estimation of utility values using traditional full-profile CVA methods relies upon a dummy variable approach that causes the first level of each attribute to be set to zero, as described in Section 5.4.6. This requires interpretation of the relationship between the utility values associated with a common attribute to be evaluated relative to the first level (Hair et al., 2006, Sawtooth Software, n.d., Steiner and Meißner, 2018). This approach is standard practice (Hair et al., 2006). To avoid the presence and subsequent effect of zero values, the Sawtooth CVA software is programmed to set the utility value for the first level of each attribute equal to the intercept value divided by the number of attributes. The software subsequently rescales all part-worth estimates accordingly so there is no effect upon the relative differences between the levels of any attribute (Sawtooth Software, n.d.). For this reason, the first level of each attribute

shown in Table 6.18 displays a common utility value, and because of this, the standard deviation and confidence interval for the first level of each attribute have been omitted.

The relative difference between the two utility values associated with each attribute shown in Table 6.18 illustrates the decision-making preference, on average, of all respondents for each attribute. The level with the larger utility value represents the preferred level within each attribute based upon the magnitude of the relevant utility values. The most and least preferred levels associated with each attribute are summarised in Table 6.19.

<b>Attribute</b>	<b>Most preferred level</b>	<b>Least preferred level</b>
Solution uncertainty	# of races completed using new gasket arrangement since last failure using old gasket is 5	# of races completed using new gasket arrangement since last failure using old gasket is 2
Problem uncertainty	% of finished races in season with air temp in 18–24° C range is 73%	% of finished races in season with air temp in 18–24° C range is 60%
Sponsor funding outcomes if you decide to race and blow up racing car engine	Lose oil sponsorship but retain option to negotiate tyre sponsorship	Lose both oil and tyre sponsorships
Sponsor funding outcomes if you decide not to race	Retain option to negotiate oil sponsorship next season but lose tyre sponsorship	Retain options to negotiate both oil and tyre sponsorships next season

Table 6.19: Most and least preferred levels for each attribute

As stated previously, utility value is the means through which innovativeness is measured. The results of the CVA process, summarised in Table 6.19, can be cross-referenced with the corresponding high-level and low-level attribute states provided in Table 5.2 of Section 5.4.1. Table 5.2 is repeated below as Table 6.20 for convenience and to avoid potential confusion.

Attribute	Attribute description	High-level state	Low-level state
Solution uncertainty	# of races completed using new gasket arrangement since last failure using old gasket	2 races completed	5 races completed
Problem uncertainty	% of finished races in season with air temp in 18–24° C range	60% of races completed with air temp in 18–24° C range	73% of races completed with air temp in 18–24° C range
Irreversible consequence failure	Sponsor funding outcomes if decision is to race and then blow up racing car engine	Lose both oil and tyre sponsorships	Retain option to negotiate oil sponsorship next season but lose tyre sponsorship
Irreversible consequence postponement	Sponsor funding outcomes if decision is not to race	Lose oil sponsorship but retain option to negotiate tyre sponsorship	Retain options to negotiate both oil and tyre sponsorships next season

Table 6.20: Attribute and attribute levels employed within this thesis

The results show that, on average, a higher level of innovativeness is associated with a lower level of solution uncertainty, a lower level of problem uncertainty and a lower level of irreversible consequence of failure, demonstrating a negative association for each of these relationships. The results also show that, on average, a higher level of innovativeness is associated with a higher level of irreversible consequence of postponement, demonstrating a positive association for this relationship. The results from this section support hypotheses *H1a*, *H1b*, *H1c* and *H1d*. Further verification of these relationships was conducted using multi-level regression analysis using fixed slopes. The four direct effect relationships from this verification are summarised as follows. The three covariates for respondent age, gender and career length were included within the analysis:

- The relationship between solution uncertainty and innovativeness showed a negative statistically significant relationship between the two variables ( $\gamma_{10} = -0.620$ ,  $t(927.9) = -21.395$ ,  $p < .001$ ), leading to rejection of the null hypothesis of no relationship between solution uncertainty and innovativeness.
- The relationship between problem uncertainty and innovativeness showed a negative statistically significant relationship between the two variables ( $\gamma_{10} = -0.495$ ,

$t(928.4) = -16.936, p < .001$ ), leading to rejection of the null hypothesis of no relationship between problem uncertainty and innovativeness.

- The relationship between irreversible consequence failure and innovativeness showed a negative statistically significant relationship between the two variables ( $\gamma_{10} = -0.420, t(927.5) = -14.469, p < .001$ ), leading to rejection of the null hypothesis of no relationship between irreversible consequence failure and innovativeness.
- The relationship between irreversible consequence postponement and innovativeness showed a positive statistically significant relationship between the two variables ( $\gamma_{10} = 0.186, t(927.5) = 6.414, p < .001$ ), leading to rejection of the null hypothesis of no relationship between irreversible consequence postponement and innovativeness.

Each outcome corresponds with the outcomes obtained from the CVA preference analysis.

#### **6.4.2 Analysis of predictors of risk perception**

Contained within this section are five subsections that address hypotheses *H2a*, *H2b*, *H2c* and *H2d*, which concern the nature of the relationships between the four dichotomous predictor variables and risk perception, as well as hypothesis *H2e*, which concerns the nature of the relationship between risk propensity and risk perception. Hypotheses *H2a*, *H2b*, *H2c* and *H2d* were tested using the outputs generated by the MLmed macro for SPSS in regard to the corresponding mediation analysis. Hypothesis *H2e* was tested using SPSS multi-level regression analysis.

In each case, the level two variables of respondent age, respondent career span and respondent gender were included as covariates. Other than for hypothesis *H2e*, the three dichotomous predictor variables not mentioned within the hypothesis were included within the analysis as level one covariates. For these four instances, the relationship to which the hypothesis refers was first tested using a random intercepts and fixed slopes model structure. A further test was then conducted that allowed for the slopes within the regression equation for each respondent to vary to accommodate variation between the respondents. In each instance, the covariance structure for the random slopes case was calculated using the unstructured covariance matrix setting within MLmed. A likelihood ratio test was undertaken to determine which approach provided the best modelled fit.

#### **6.4.2.1 Analysis of predictive capability: solution uncertainty**

This section summarises the results obtained from testing the relationship between solution uncertainty and risk perception. The purpose of this section is to test hypothesis *H2a*:

*H2a: Solution uncertainty is positively associated with risk perception.*

The relationship between solution uncertainty and risk perception showed a positive statistically significant relationship between the two variables ( $\gamma_{10} = 0.757$ ,  $t(927) = 16.705$ ,  $p < .001$ ), with the regression equation constrained to fixed slopes. Allowing for the slopes of the regression equation to vary between respondents showed that the relationship between solution uncertainty and risk perception continued to exhibit a positive statistically significant relationship ( $\gamma_{10} = 0.758$ ,  $t(103.2) = 13.444$ ,  $p < .001$ ). A likelihood ratio test was conducted, which determined that the random slopes model was a better fit for this relationship ( $\chi^2_{\text{change}} = 71.517$ ;  $df_{\text{change}} = 2$ ;  $p < .001$ ). This result leads to rejection of the null hypothesis of no relationship between solution uncertainty and risk perception, and it supports hypothesis *H2a*; thus, solution uncertainty is positively associated with risk perception.

#### **6.4.2.2 Analysis of predictive capability: problem uncertainty**

This section summarises the results obtained from testing the relationship between problem uncertainty and risk perception. The purpose of this section is to test hypothesis *H2b*:

*H2b: Problem uncertainty is positively associated with risk perception.*

The relationship between problem uncertainty and risk perception showed a positive statistically significant relationship between the two variables ( $\gamma_{10} = 0.685$ ,  $t(927) = 14.980$ ,  $p < .001$ ), with the regression equation constrained to fixed slopes. Allowing for the slopes of the regression equation to vary between respondents showed that the relationship between problem uncertainty and risk perception continued to exhibit a positive statistically significant relationship ( $\gamma_{10} = 0.684$ ,  $t(104.2) = 13.020$ ,  $p < .001$ ). A likelihood ratio test was conducted, which determined that the random slopes model was a better fit for this

relationship ( $\chi^2_{\text{change}} = 63.228$ ;  $df_{\text{change}} = 2$ ;  $p < .001$ ). This result leads to rejection of the null hypothesis of no relationship between problem uncertainty and risk perception and supports hypothesis *H2b*; thus, problem uncertainty is positively associated with risk perception.

#### **6.4.2.3 Analysis of predictive capability: irreversible consequence failure**

This section summarises the results obtained from testing the relationship between irreversible consequence failure and risk perception. The purpose of this section is to test hypothesis *H2c*:

*H2c: Irreversible consequence failure is positively associated with risk perception.*

The relationship between irreversible consequence failure and risk perception showed a positive statistically significant relationship between the two variables ( $\gamma_{10} = 0.572$ ,  $t(927) = 12.609$ ,  $p < .001$ ), with the regression equation constrained to fixed slopes. Allowing for the slopes of the regression equation to vary between respondents showed that the relationship between irreversible consequence failure and risk perception continued to exhibit a positive statistically significant relationship ( $\gamma_{10} = 0.570$ ,  $t(103.9) = 9.155$ ,  $p < .001$ ). A likelihood ratio test was conducted, which determined that the random slopes model was a better fit for this relationship ( $\chi^2_{\text{change}} = 63.017$ ;  $df_{\text{change}} = 2$ ;  $p < .001$ ). This result leads to rejection of the null hypothesis of no relationship between irreversible consequence failure and risk perception and supports hypothesis *H2c*; thus, irreversible consequence failure is positively associated with risk perception.

#### **6.4.2.4 Analysis of predictive capability: irreversible consequence postponement**

This section summarises the results obtained from testing the relationship between irreversible consequence postponement and risk perception. The purpose of this section is to test hypothesis *H2d*:

*H2d: Irreversible consequence postponement is positively associated with risk perception.*

The relationship between irreversible consequence postponement and risk perception showed no significant relationship between the two variables ( $\gamma_{10} = -0.088$ ,  $t(927) = -1.951$ ,  $p = .051$ ), with the regression equation constrained to fixed slopes. Allowing for the slopes of the regression equation to vary between respondents showed that the relationship between irreversible consequence postponement and risk perception continued to exhibit no statistically significant relationship ( $\gamma_{10} = -0.088$ ,  $t(104.2) = -1.874$ ,  $p = .064$ ). A likelihood ratio test was conducted, which determined that the random slopes model was a better fit for this relationship ( $\chi^2_{\text{change}} = 58.421$ ;  $df_{\text{change}} = 2$ ;  $p < .001$ ). This result fails to reject the null hypothesis of no relationship between irreversible consequence postponement and risk perception and does not support hypothesis *H2d*; thus, irreversible consequence postponement is not positively associated with risk perception.

#### **6.4.2.5 Analysis of predictive capability: risk propensity**

This section summarises the results obtained from testing the relationship between risk propensity and risk perception. The purpose of this section is to test hypothesis *H2e*:

***H2e:** Risk propensity is negatively associated with risk perception.*

The relationship between risk propensity and risk perception showed a negative statistically significant relationship between the two variables ( $\gamma_{10} = -0.487$ ,  $t(103) = -10.042$ ,  $p < .001$ ). As risk propensity is the level two variable within a two-level structure, a test using random slopes was not conducted. The result leads to rejection of the null hypothesis of no relationship between risk propensity and risk perception and supports hypothesis *H2e* thus, risk propensity is negatively associated with risk perception.

#### **6.4.3 Analysis of predictors of innovativeness**

This section contains two subsections that aim to address hypotheses *H3a* and *H3b*, which concern the nature of the relationships between risk perception and innovativeness and risk propensity and innovativeness, with each relationship examined separately.



#### 6.4.3.1 Analysis of predictive capability: risk perception

This section summarises the results obtained from testing the relationship between risk perception and innovativeness. The purpose of this section is to test hypothesis *H3a*:

*H3a: Risk perception is negatively associated with innovativeness.*

The relationship between risk perception and innovativeness showed a negative statistically significant relationship between the two variables ( $\gamma_{10} = -0.373$ ,  $t(1003.7) = -21.635$ ,  $p < .001$ ), with the regression equation constrained to fixed slopes. Allowing for the slope of the regression equation to vary between respondents showed that the relationship between risk perception and innovativeness continued to exhibit a negative statistically significant relationship using an unstructured covariance structure ( $\gamma_{10} = -0.352$ ,  $t(138) = -15.027$ ,  $p < .001$ ). A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance structure model was a better fit for this relationship than that achieved through the fixed slopes model ( $\chi^2_{\text{change}} = 45.779$ ;  $df_{\text{change}} = 2$ ;  $p < .001$ ). These results lead to rejection of the null hypothesis of no relationship between risk perception and innovativeness and supports hypothesis *H3a*; thus, risk perception is negatively associated with innovativeness.

#### 6.4.3.2 Analysis of predictive capability: risk propensity

This section summarises the results obtained from testing the relationship between risk propensity and innovativeness. The purpose of this section is to test hypothesis *H3b*:

*H3b: Risk propensity is positively associated with innovativeness.*

The relationship between risk propensity and innovativeness showed a positive statistically significant relationship between the two variables ( $\gamma_{10} = 0.456$ ,  $t(103) = 8.342$ ,  $p < .001$ ). As risk propensity is a level two variable within a two-level structure, a test using random slopes was not conducted. The result leads to rejection of the null hypothesis of no relationship between risk propensity and innovativeness and supports hypothesis *H3b*; thus, risk propensity is positively associated with innovativeness.

#### 6.4.4 Analysis of mediation effects

This section contains four subsections that aim to address hypotheses *H4a*, *H4b*, *H4c* and *H4d*, which concern the nature of the indirect relationships between each of the four dichotomous predictor variables and innovativeness via the psychographic variable of risk perception. Each hypothesis is examined within its own section and is ordered in accordance with the sequential nature of the hypotheses themselves. All four hypotheses were tested using the outputs generated by the MLmed macro for SPSS in regard to the corresponding mediation analysis. For the analysis of each hypothesis, the three dichotomous predictor variables not mentioned within that hypothesis were instead included within the analysis as level one covariates, while the variables of respondent age, respondent career span and respondent gender were included as level two covariates. In each instance, the relationship to which the hypothesis refers was tested using a random intercepts and fixed slopes model structure. A further test was then conducted that allowed for the slopes within the regression equation for each respondent to vary to accommodate variation between the respondents. A likelihood ratio test was undertaken to examine which of these two approaches was of the best fit, excluding hypothesis *H4d*, as it was found that this test was not required. In all instances within this section, the covariance structure for the random slopes case was calculated using the unstructured covariance setting within MLmed.

A sample size check was conducted as part of the analysis of mediation effects to verify the adequacy of statistical power. While only a small body of literature exists concerning sample size and power associated with mediation analysis (Hayes, 2018), Fritz and Mackinnon (2007) provided guidelines for the determination of mediation analysis sample size adequacy formulated from empirical studies and categorised by mediation test method and the absolute magnitude of the combined indirect parameter coefficients (*a* and *b*). Based upon the absolute magnitude of the indirect parameter coefficients within this study, and the use of a percentile bootstrap test of mediation, it was concluded that the sample size (103) exceeded the prorated lower limit (94) that was calculated according to that specified by Fritz and Mackinnon (2007) to achieve .8 power.

#### 6.4.4.1 Analysis of mediation effect: solution uncertainty

The purpose of this section is to test hypothesis *H4a*:

*H4a: Risk perception mediates the effect of solution uncertainty upon innovativeness.*

Examination of the indirect relationship between solution uncertainty and innovativeness via the variable of risk perception showed that risk perception indirectly influenced the within-respondent relationship through a mediation effect. Through simple mediation analysis using fixed slopes, a change from the lower level of solution uncertainty to the higher level resulted in an increase in the average reported level of risk perception by respondents ( $a = 0.757$ ), with an increase of one unit in the level of respondent risk perception resulting in a reduction in the average level of innovativeness of respondents ( $b = -0.345$ ). Using a bootstrapped confidence interval for the analysis, the within-respondent indirect effect ( $ab = -0.261$ ) was found to be significantly different from zero, as the entire confidence interval, based upon 10,000 bootstrapped samples, was less than zero (MCLL =  $-0.303$ , MCUL =  $-0.223$ ). The direct effect of solution uncertainty upon innovativeness remained statistically significant ( $c' = -0.360$ ,  $t(927) = -12.928$ ,  $p < .001$ ) after taking into account the indirect relationship.

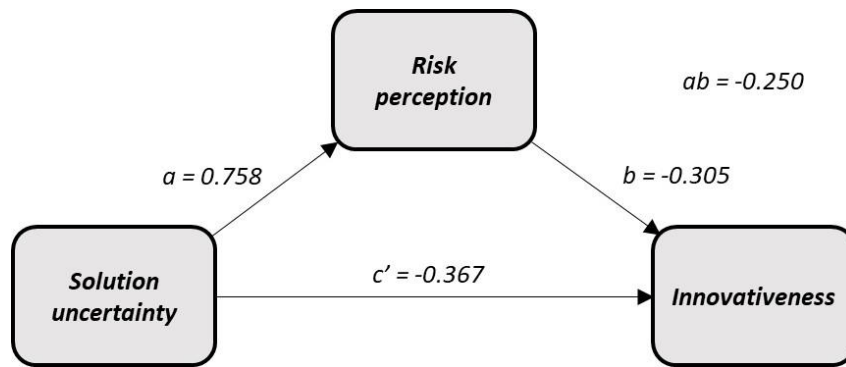
A subsequent test of the indirect pathway relationship was conducted in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. This test again showed that risk perception was a mediator of the relationship between solution uncertainty and innovativeness ( $a = 0.758$ ;  $b = -0.305$ ;  $ab = -0.250$ ;  $c' = -0.367$ ), with the bootstrapped confidence interval for the test, based upon 10,000 bootstrapped samples, being entirely less than zero (MCLL =  $-0.312$ , MCLL =  $-0.193$ ). A summary of the outputs for the relevant variables from both the fixed and random slopes MLmed analysis is contained in Table 6.21.

		Estimate	Standard error	df	t	p	LL	UL
Fixed slopes	a	0.757	0.045	927	16.705	.000	0.668	0.846
	b	-0.345	0.018	927	-19.477	.000	-0.380	-0.310
	c'	-0.360	0.028	927	-12.928	.000	-0.415	-0.306
Random slopes	a	0.758	0.056	103.221	13.444	.000	0.646	0.870
	b	-0.305	0.025	124.339	-11.970	.000	-0.355	-0.254
	c'	-0.367	0.026	882.522	-13.939	.000	-0.418	-0.315
<b>Within-respondent indirect effect</b>								
		Within-respondent indirect effect	Standard error	Z	p	MCLL	MCUL	
Fixed slopes	ab	-0.261	0.021	-12.671	.000	-0.303	-0.223	
Random slopes	ab	-0.250	0.304	-8.228	.000	-0.312	-0.193	

Coefficient *a* represents the effect upon risk perception of a change in the state of solution uncertainty from low to high. Coefficient *b* represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient *c'* represents the difference in innovativeness between two cases that differ in the state of solution uncertainty but are equal for risk perception. Coefficient *ab* represents the indirect effect upon innovativeness through risk perception of a change in the state of solution uncertainty from low to high.

Table 6.21: Summary of mediation analysis outcomes for hypothesis *H4a*

A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit for this indirect relationship ( $\chi^2_{\text{change}} = 73.878$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The results lead to rejection of the null hypothesis that risk perception does not influence the indirect relationship between solution uncertainty and innovativeness through a mediation effect. These results support hypothesis *H4a*. Figure 6.5 shows the results obtained from the testing of hypothesis *H4a* based upon random slopes analysis.



Coefficient  $a$  represents the effect upon risk perception of a change in the state of solution uncertainty from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $c'$  represents the difference in innovativeness between two cases that differ in the state of solution uncertainty but are equal for risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of solution uncertainty from low to high.

Figure 6.5: Results obtained from the testing of hypothesis  $H4a$  using random slopes

#### 6.4.4.2 Analysis of mediation effect: problem uncertainty

The purpose of this section is to test hypothesis  $H4b$ :

***H4b:*** Risk perception mediates the effect of problem uncertainty upon innovativeness.

Examination of the indirect relationship between problem uncertainty and innovativeness via the variable of risk perception showed that risk perception indirectly influenced the within-respondent relationship through a mediation effect. Through simple mediation analysis using fixed slopes, a change from the lower level of problem uncertainty to the higher level resulted in an increase in the average reported level of risk perception by respondents ( $a = 0.685$ ), with an increase of one unit in the level of respondent risk perception resulting in a reduction in the average level of innovativeness of respondents ( $b = -0.345$ ). Using a bootstrapped confidence interval for the analysis, the within-respondent indirect effect ( $ab = -0.236$ ) was found to be significantly different from zero, as the entire confidence interval, based upon 10,000 bootstrapped samples, was less than zero (MCLL =  $-0.276$ , MCUL =  $-0.199$ ). The direct effect of problem uncertainty upon innovativeness remained statistically significant ( $c' = -0.259$ ,  $t(927) = -9.438$ ,  $p < .001$ ) after taking into account the indirect relationship.

A subsequent test of the indirect pathway relationship was conducted in which the slopes of the regression equations were allowed to vary between respondents using an unstructured

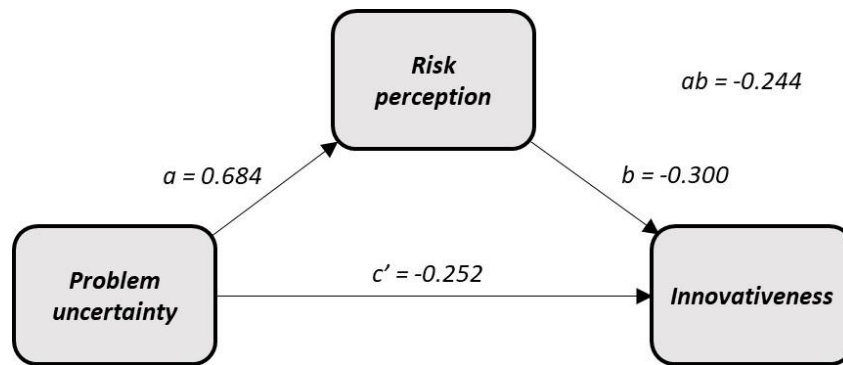
covariance matrix structure within the MLmed model. This test again showed that risk perception was a mediator of the relationship between problem uncertainty and innovativeness ( $a = 0.684$ ;  $b = -0.300$ ;  $ab = -0.244$ ;  $c' = -0.252$ ), with the bootstrapped confidence interval for the test, based upon 10,000 bootstrapped samples, being entirely less than zero (MCLL =  $-0.303$ , MCUL =  $-0.189$ ). A summary of the outputs for the relevant variables from both the fixed and random slopes MLmed analysis is contained in Table 6.22.

		Estimate	Standard error	df	t	p	LL	UL
Fixed slopes	a	0.685	0.046	927	14.980	.000	0.595	0.774
	b	-0.345	0.018	927	-19.477	.000	-0.380	-0.310
	c'	-0.259	0.027	927	-9.438	.000	-0.313	-0.205
Random slopes	a	0.684	0.053	104.183	13.019	.000	.580	.788
	b	-0.300	0.025	125.541	-11.825	.000	-0.350	-0.250
	c'	-0.252	0.026	896.104	-9.660	.000	-0.303	-0.201
		Within-respondent indirect effect	Standard error	Z	p	MCLL	MCUL	
Fixed slopes	ab	-0.236	0.020	-11.864	.000	-0.276	-0.199	
Random slopes	ab	-0.244	0.029	-8.303	.000	-0.303	-0.189	

Coefficient  $a$  represents the effect upon risk perception of a change in the state of problem uncertainty from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $c'$  represents the difference in innovativeness between two cases that differ in the state of problem uncertainty but are equal for risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of problem uncertainty from low to high.

Table 6.22: Summary of mediation analysis outcomes for hypothesis  $H4b$

A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit for this indirect relationship ( $\chi^2_{\text{change}} = 74.460$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The results lead to rejection of the null hypothesis that risk perception does not influence the indirect relationship between problem uncertainty and innovativeness through a mediation effect. These results support hypothesis  $H4b$ . Figure 6.6 shows the results obtained from the testing of hypothesis  $H4b$  based upon random slopes analysis.



Coefficient  $a$  represents the effect upon risk perception of a change in the state of problem uncertainty from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $c'$  represents the difference in innovativeness between two cases that differ in the state of problem uncertainty but are equal for risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of problem uncertainty from low to high.

Figure 6.6: Results obtained from the testing of hypothesis  $H4b$  using random slopes

#### 6.4.4.3 Analysis of mediation effect: irreversible consequence failure

The purpose of this section is to test hypothesis  $H4c$ :

***H4c: Risk perception mediates the effect of irreversible consequence failure upon innovativeness.***

Examination of the indirect relationship between irreversible consequence failure and innovativeness via the variable of risk perception showed that risk perception indirectly influenced the within-respondent relationship through a mediation effect. Through simple mediation analysis using fixed slopes, a change from the lower level of irreversible consequence failure to the higher level resulted in an increase in the average reported level of risk perception by respondents ( $a = 0.572$ ), with an increase of one unit in the level of respondent risk perception resulting in a reduction in the average level of innovativeness of respondents ( $b = -0.345$ ). Using a bootstrapped confidence interval for the analysis, the within-respondent indirect effect ( $ab = -0.197$ ) was found to be significantly different from zero, as the entire confidence interval, based upon 10,000 bootstrapped samples, was less than zero (MCLL =  $-0.235$ , MCUL =  $-0.163$ ). The direct effect of irreversible consequence failure upon innovativeness remained statistically significant ( $c' = -0.223$ ,  $t(927) = -8.435$ ,  $p < .001$ ) after taking into account the indirect relationship.

A subsequent test of the indirect pathway relationship was conducted in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. This test again showed that risk perception was a mediator of the relationship between irreversible consequence failure and innovativeness ( $a = 0.570$ ;  $b = -0.307$ ;  $ab = -0.218$ ;  $c' = -0.200$ ), with the bootstrapped confidence interval for the test, based upon 10,000 bootstrapped samples, being entirely less than zero (MCLL =  $-0.278$ , MCUL =  $-0.162$ ). A summary of the outputs for the relevant variables from both the fixed and random slopes MLmed analysis is contained in Table 6.23.

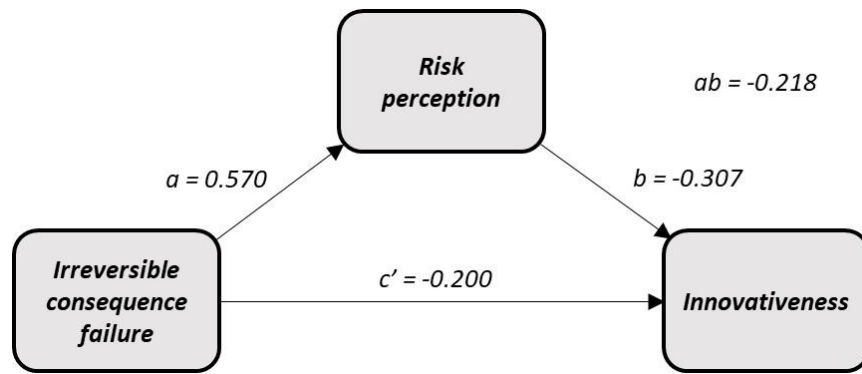
		Estimate	Standard error	df	t	p	LL	UL
Fixed slopes	a	0.572	0.045	927	12.609	.000	0.483	0.661
	b	-0.345	0.018	927	-19.477	.000	-0.380	-0.310
	c'	-0.223	0.265	927	-8.435	.000	-0.275	-0.171
Random slopes	a	0.570	0.062	103.864	9.158	.000	0.447	0.694
	b	-0.307	0.025	124.042	-12.328	.000	-0.356	-0.258
	c'	-0.200	0.025	898.565	-7.922	.000	-0.249	-0.150
		Within-respondent indirect effect	Standard error	Z	p	MCLL	MCUL	
Fixed slopes	ab	-0.197	0.019	-10.575	.000	-0.235	-0.163	
Random slopes	ab	-0.218	.0300	-7.293	.000	-0.278	-0.162	

Coefficient  $a$  represents the effect upon risk perception of a change in the state of irreversible consequence failure from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $c'$  represents the difference in innovativeness between two cases that differ in the state of irreversible consequence failure but are equal for risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of irreversible consequence failure from low to high.

Table 6.23: Summary of mediation analysis outcomes for hypothesis  $H4c$

A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit for this indirect relationship ( $\chi^2_{\text{change}} = 102.334$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The results lead to rejection of the null hypothesis that risk perception does not influence the indirect relationship between irreversible consequence failure and innovativeness through a mediation effect. These results support hypothesis  $H4c$ . Figure 6.7 shows the results obtained from the testing of hypothesis  $H4c$  based upon random slopes analysis.





Coefficient  $a$  represents the effect upon risk perception of a change in the state of irreversible consequence failure from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $c'$  represents the difference in innovativeness between two cases that differ in the state of irreversible consequence failure but are equal for risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of irreversible consequence failure from low to high.

Figure 6.7: Results obtained from the testing of hypothesis  $H4c$  using random slopes

#### 6.4.4.4 Analysis of mediation effect: irreversible consequence postponement

The purpose of this section is to test hypothesis  $H4d$ :

***H4d:*** *Risk perception does not mediate the effect of irreversible consequence postponement upon innovativeness.*

Examination of the indirect relationship between irreversible consequence postponement and innovativeness via the variable risk perception showed that risk perception did not indirectly influence the relationship through a mediation effect. Through a simple mediation analysis using fixed slopes, a change from the lower level of irreversible consequence postponement to the high level did not result in a significant increase in the average reported level of risk perception by respondents. Using a bootstrapped confidence interval for the analysis, the indirect effect ( $ab = 0.030$ ) was not found to be significantly different from zero, based upon 10,000 bootstrapped samples, as zero was within the confidence interval (MCLL = 0.000, MCUL = 0.062). The direct effect of irreversible consequence postponement upon innovativeness remained statistically significant ( $c' = 0.155$ ,  $t(927) = 6.336$ ,  $p < .001$ ). A summary of the outputs for the relevant variables from the fixed slopes MLmed analysis is contained in Table 6.24.

		Estimate	Standard error	df	t	p	LL	UL
Fixed slopes	<i>a</i>	-0.088	0.045	927	-1.951	.051	-1.177	0.001
	<i>b</i>	-0.345	0.018	927	-19.477	.000	-0.380	-0.310
	<i>c'</i>	0.155	0.024	927	6.336	.000	0.107	0.203
		Within-respondent indirect effect	Standard error	Z	p	MCLL	MCUL	
Fixed slopes	<i>ab</i>	0.030	0.016	1.939	.053	0.000	0.062	

Coefficient *a* represents the effect upon risk perception of a change in the state of irreversible consequence postponement from low to high. Coefficient *b* represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient *c'* represents the difference in innovativeness between two cases that differ in the state of irreversible consequence postponement but are equal for risk perception. Coefficient *ab* represents the indirect effect upon innovativeness through risk perception of a change in the state of irreversible consequence postponement from low to high.

Table 6.24: Summary of mediation analysis outcomes for hypothesis *H4d*

To check this outcome, a subsequent test of the direct pathway relationship was conducted in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. The test resulted in non-convergence of the model within MLmed. The results obtained lead to rejection of the null hypothesis that risk perception influences the indirect relationship between solution uncertainty and innovativeness through a mediation effect. This result supports hypothesis *H4d*. No diagram is provided to depict the results from the testing of hypothesis *H4d* because the mediation effect is not significant.

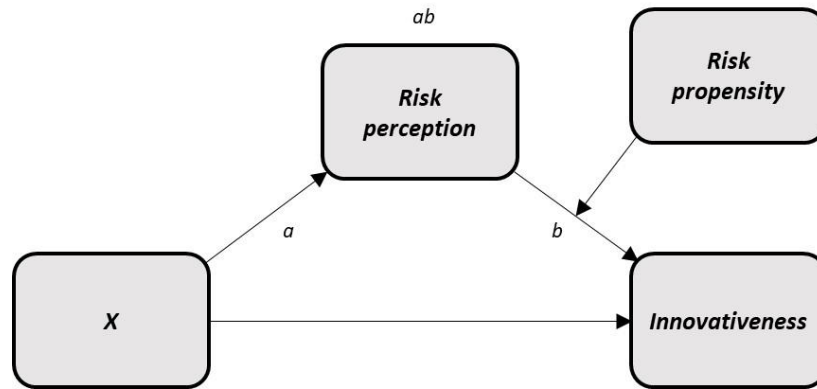
#### 6.4.5 Analysis of moderated mediation effects

This section contains three subsections that address hypotheses *H5a*, *H5b* and *H5c*, which concern whether the indirect relationships mentioned in Section 6.4.4, which were shown to be mediated by risk perception, are moderated by risk propensity through the *M* to *Y* pathway. These three hypotheses address research question five. The purpose of the three subsections in Section 6.4.6 is to address hypotheses *H6a*, *H6b* and *H6c*, which concern whether the same three indirect relationships that were shown to be mediated by risk perception in Section 6.4.4 are moderated by irreversible consequence postponement through the *M* to *Y* pathway. These hypotheses address research question six. Each

hypothesis is addressed within its own subsection and ordered in accordance with the sequential nature of the hypotheses themselves. All six hypotheses were tested using the outputs generated by the MLmed macro for SPSS in regard to the corresponding moderated mediation analysis. In each case, the result expressed within the index of moderated mediation section of the MLmed macro output is used to test for a moderated mediation effect, with a statistically significant result demonstrated by the exclusion of zero from within the confidence limits of the index of moderated mediation.

In testing each of the six hypotheses, the dichotomous predictor variables not represented within a given hypothesis were instead included within the analysis as level one covariates, while the variables of respondent age, respondent career span and respondent gender were included as level two covariates. In each instance, the relationship to which the hypothesis refers was first tested using a random intercepts and fixed slopes model structure, and the index of moderated mediation was examined to verify whether zero was excluded from within the confidence limits. As with Section 6.4.4, a further test was then conducted that allowed for the slopes within the regression equation for each respondent to vary to accommodate variation between the respondents, and the index of moderated mediation was again examined. A likelihood ratio test was undertaken to examine which of these two approaches was of the best fit, and on this basis, the results from the testing of each hypothesis are stated. In all instances within this and the following section, the covariance structure for the random slopes case was calculated using the unstructured covariance setting within the MLmed macro.

Figure 6.8 shows a conceptual diagram depicting both the relationships between the variables under examination and the means through which the moderation effect is said to occur, relevant to the three subsections within this section. It is important to note that, for simplicity, no covariates are included within this conceptual diagram.



Variable  $X$  represents the dichotomous predictor variable of interest. Coefficient  $a$  represents the effect upon risk perception of a change in the state of  $X$  from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of  $X$  from low to high.

Figure 6.8: Depiction of the relationships relevant to Section 6.4.5

#### 6.4.5.1 Analysis of moderated mediation effect: solution uncertainty

The purpose of this section is to report the results from the testing of hypothesis  $H5a$ :

***H5a:*** *Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results reveal that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero within its range ( $ab_3 = -0.026$ ;  $MCLL = -0.044$ ;  $MCUL = -0.009$ ). This result was achieved using a risk propensity score of four, demonstrating that the within-respondent indirect effect varies systematically as a function of risk propensity. Based upon this result, the within-respondent indirect effect of solution uncertainty upon innovativeness through risk perception was expected to differ systematically for each unit change in value of risk propensity.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of risk propensity again entered as four, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit based upon the inclusion of risk propensity as a moderator within

the indirect relationship pathway ( $\chi^2_{\text{change}} = 66.837$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was contained within the range of its Monte Carlo confidence interval when using a risk propensity score of four ( $ab_3 = -0.020$ ; MCLL =  $-0.047$ ; MCUL =  $0.007$ ). This demonstrates that the within-respondent indirect effect does not vary systematically as a function of risk propensity when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of risk propensity within the fixed slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was systematically probed using the full seven-point range of the risk propensity variable. The results obtained from the probing of the interaction are contained in Table 6.25 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with each incremental change in the level of risk propensity, with zero not included within the Monte Carlo confidence interval in any of the seven cases.

RPR value	$a$	$b$	Within-respondent indirect effect ( $ab$ )	MCLL	MCUL
1	0.757	-0.241	-0.183	-0.247	-0.125
2	0.757	-0.276	-0.209	-0.261	-0.163
3	0.757	-0.310	-0.235	-0.279	-0.196
4	0.757	-0.345	-0.261	-0.303	-0.223
5	0.757	-0.379	-0.287	-0.335	-0.243
6	0.757	-0.413	-0.313	-0.373	-0.260
7	0.757	-0.448	-0.339	-0.413	-0.273

Coefficient  $a$  represents the effect upon risk perception of a change in the level of solution uncertainty from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception moderated by risk propensity (RPR). Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the level of solution uncertainty from low to high moderated by risk propensity (RPR).

Table 6.25: *H5a* within-respondent estimates for the risk propensity score range

The change in the value of both  $b$  and  $ab$  as a consequence of the change in the value of risk propensity, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of change in the level of risk perception associated with each increase in the level of risk propensity and a corresponding dampening effect for each reduction. In regard to Figure 6.8, a change

in the value of  $b$  and  $ab$ , moderated by the values of risk propensity, is depicted in Figure 6.9. Across all moderation cases considered, the value of coefficient  $a$  remained constant (0.757).

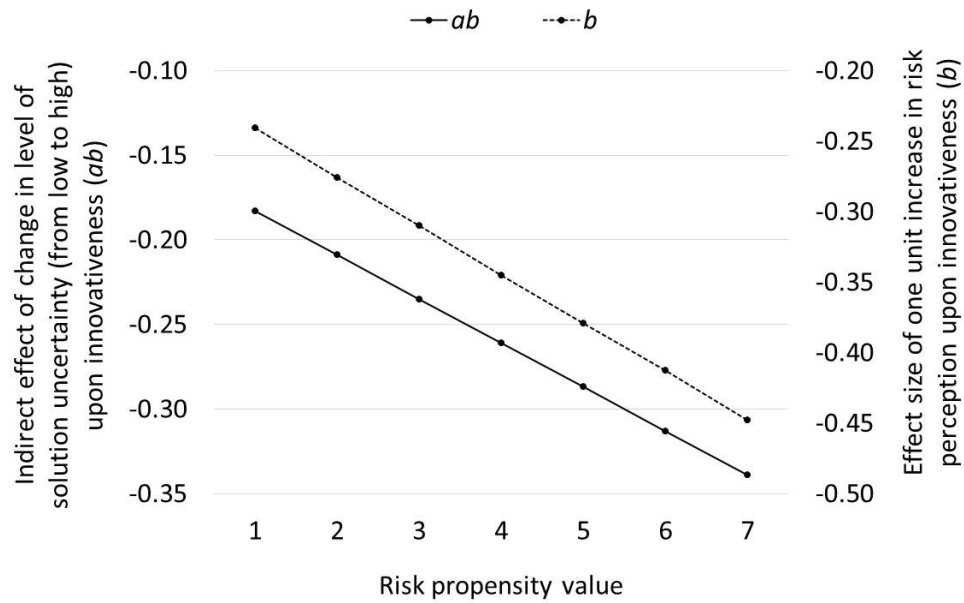


Figure 6.9: Moderation effect of risk propensity upon  $b$  and  $ab$  for hypothesis  $H5a$

These results lead to rejection of the null hypothesis that risk propensity, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between solution uncertainty and innovativeness for the fixed slopes case only. These results support hypothesis  $H5a$  for the fixed slopes case.

#### 6.4.5.2 Analysis of moderated mediation effect: problem uncertainty

The purpose of this section is to report the results from the testing of hypothesis  $H5b$ :

***H5b:** Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results revealed that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero

within its range ( $ab_3 = -0.024$ ; MCLL =  $-0.040$ ; MCUL =  $-0.008$ ). This result was achieved using a risk propensity score of four, demonstrating that the within-respondent indirect effect varies systematically as a function of risk propensity. Based upon this result, the within-respondent indirect effect of problem uncertainty upon innovativeness through risk perception was expected to differ systematically for each unit change in value of risk propensity.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of risk propensity again entered as four, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit based upon the inclusion of risk propensity as a moderator within the indirect relationship pathway ( $\chi^2_{\text{change}} = 66.746$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was contained within the range of its Monte Carlo confidence interval when using a risk propensity score of four ( $ab_3 = -0.014$ ; MCLL =  $-0.038$ ; MCUL =  $0.009$ ). This demonstrates that the within-respondent indirect effect does not vary systematically as a function of risk propensity when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of risk propensity within the fixed slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was systematically probed using the full seven-point range of the risk propensity variable. The results obtained from the probing of the interaction are contained in Table 6.26 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with each incremental change in the level of risk propensity, with zero not included within the Monte Carlo confidence interval in any of the seven cases.

RPR value	<i>a</i>	<i>b</i>	Within-respondent indirect effect ( <i>ab</i> )	MCLL	MCUL
1	0.685	-0.241	-0.165	-0.225	-0.112
2	0.685	-0.276	-0.189	-0.237	-0.146
3	0.685	-0.310	-0.213	-0.255	-0.175
4	0.685	-0.345	-0.236	-0.277	-0.199
5	0.685	-0.379	-0.259	-0.306	-0.218
6	0.685	-0.413	-0.283	-0.340	-0.233
7	0.685	-0.448	-0.307	-0.377	-0.244

Coefficient *a* represents the effect upon risk perception of a change in the level of problem uncertainty from low to high. Coefficient *b* represents the effect upon innovativeness of a one-unit increase in risk perception moderated by risk propensity (RPR). Coefficient *ab* represents the indirect effect upon innovativeness through risk perception of a change in the level of problem uncertainty from low to high moderated by risk propensity (RPR).

Table 6.26: *H5b* within-respondent estimates for the risk propensity score range

The change in the value of both *b* and *ab* as a consequence of the change in the value of risk propensity, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of change in the level of risk perception associated with each increase in the level of risk propensity and a corresponding dampening effect for each reduction. In regard to Figure 6.8, a change in the values of *b* and *ab*, moderated by the value of risk propensity, is depicted in Figure 6.10. Across all moderation cases considered, the value of coefficient *a* remained constant (0.685).

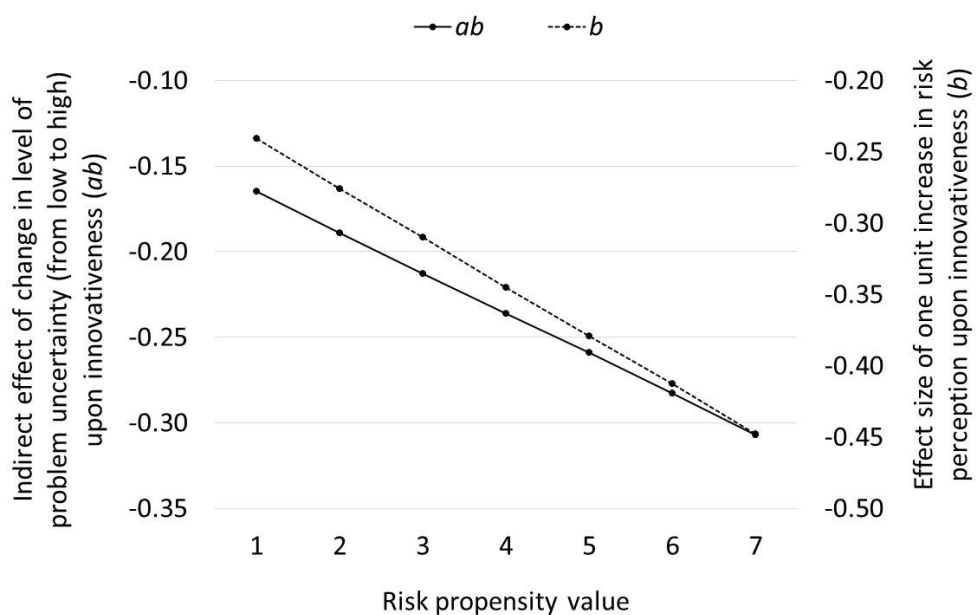


Figure 6.10: Moderation effect of risk propensity upon *b* and *ab* for hypothesis *H5b*



These results lead to rejection of the null hypothesis that risk propensity, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between problem uncertainty and innovativeness for the fixed slopes case only. These results support hypothesis *H5b* for the fixed slopes case.

#### **6.4.5.3 Analysis of moderated mediation effect: irreversible consequence failure**

The purpose of this section is to report the results from the testing of hypothesis *H5c*:

***H5c:** Where risk perception is shown to mediate the effect of irreversible consequence failure upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results revealed that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero within its range ( $ab_3 = -0.020$ ; MCLL =  $-0.033$ ; MCUL =  $-0.007$ ). This result was achieved using a risk propensity score of four, demonstrating that the within-respondent indirect effect varies systematically as a function of risk propensity. Based upon this result, the within-respondent indirect effect of irreversible consequence failure upon innovativeness through risk perception was expected to differ systematically for each unit change in value of risk propensity.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of risk propensity again entered as four, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit based upon the inclusion of risk propensity as a moderator within the indirect relationship pathway ( $\chi^2_{\text{change}} = 94.863$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was contained within the range of its Monte Carlo confidence interval when using a risk propensity score of four ( $ab_3 = -0.013$ ; MCLL =  $-0.032$ ; MCUL =  $0.006$ ). This demonstrates that the within-respondent indirect effect does not vary systematically as a function of risk

propensity when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of risk propensity within the fixed slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was systematically probed using the full seven-point range of the risk propensity variable. The results obtained from the probing of the interaction are contained in Table 6.27 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with each incremental change in the level of risk propensity, with zero not included within the Monte Carlo confidence interval in any of the seven cases.

RPR value	$a$	$b$	Within-respondent indirect effect ( $ab$ )	MCLL	MCUL
1	0.572	-0.241	-0.138	-0.189	-0.093
2	0.572	-0.276	-0.158	-0.201	-0.121
3	0.572	-0.310	-0.177	-0.217	-0.143
4	0.572	-0.345	-0.197	-0.236	-0.162
5	0.572	-0.379	-0.217	-0.260	-0.178
6	0.572	-0.414	-0.236	-0.288	-0.191
7	0.572	-0.448	-0.256	-0.319	-0.201

Coefficient  $a$  represents the effect upon risk perception of a change in the level of irreversible consequence failure from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception moderated by risk propensity (RPR). Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the level of irreversible consequence failure from low to high moderated by risk propensity (RPR).

Table 6.27: *H5c* within-respondent estimates for the risk propensity score range

The change in the value of both  $b$  and  $ab$  as a consequence of the change in the value of risk propensity, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of change in the level of risk perception associated with each increase in the level of risk propensity and a corresponding dampening effect for each reduction. In regard to Figure 6.8, a change in the values of  $b$  and  $ab$ , moderated by the value of risk propensity, is depicted in Figure 6.11. Across all moderation cases considered, the value of coefficient  $a$  remained constant (0.572).

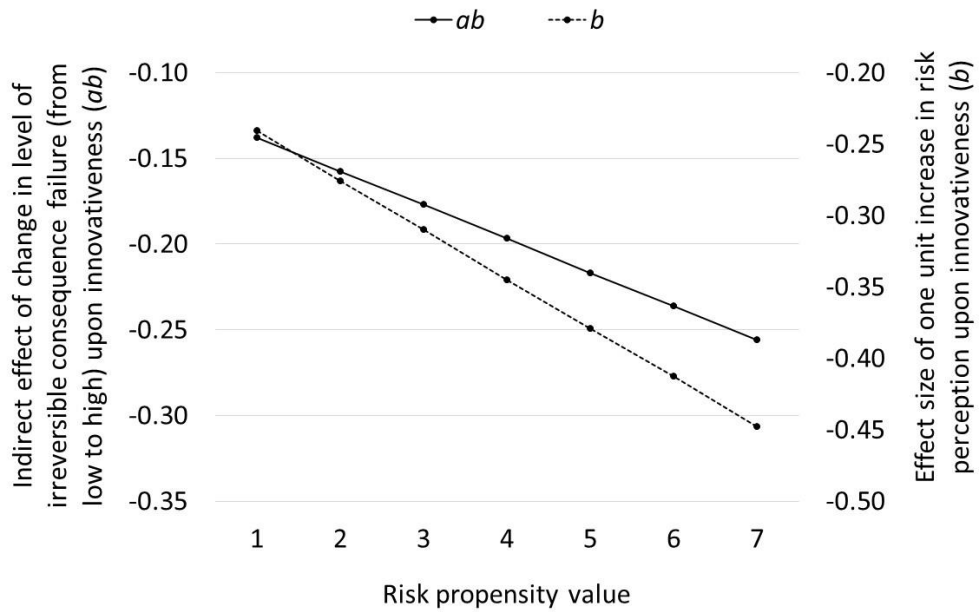


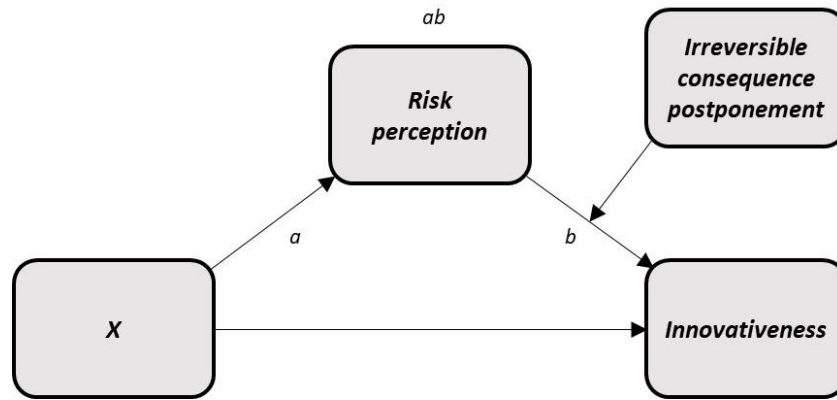
Figure 6.11: Moderation effect of risk propensity upon  $b$  and  $ab$  for hypothesis  $H5c$

These results lead to rejection of the null hypothesis that risk propensity, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between irreversible consequence failure and innovativeness for the fixed slopes case only. These results support hypothesis  $H5c$  for the fixed slopes case.

#### 6.4.6 Analysis of option value effects

This section contains the second set of three subsections mentioned in Section 6.4.5 that address research question six. As stated in that section, the purpose of these three subsections is to address hypotheses  $H6a$ ,  $H6b$  and  $H6c$ , which concern whether the indirect relationships mentioned in Section 6.4.4 that were shown to be mediated by risk perception are moderated by irreversible consequence postponement (PIC) through the  $M$  to  $Y$  pathway.

A conceptual diagram depicting both the relationships between the variables under examination and the means through which the moderation effect is said to occur, relevant to the three subsections within this section, is shown in Figure 6.12. For simplicity, no covariates are included in this conceptual diagram.



Variable  $X$  represents the dichotomous predictor variable of interest. Coefficient  $a$  represents the effect upon risk perception of a change in the state of  $X$  from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception. Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the state of  $X$  from low to high.

Figure 6.12: Depiction of the relationships relevant to Section 6.4.6

#### 6.4.6.1 Analysis of moderated mediation effect: solution uncertainty

The purpose of this section is to report the results from the testing of hypothesis  $H6a$ :

***H6a:*** *Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results revealed that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero within its range ( $ab_3 = -0.057$ ;  $MCLL = -0.099$ ;  $MCUL = -0.016$ ). This result was achieved using an irreversible consequence postponement value of zero (low case), demonstrating that the within-respondent indirect effect varies systematically as a function of irreversible consequence postponement. Based upon this result, the within-respondent indirect effect of solution uncertainty upon innovativeness through risk perception was expected to differ systematically for each unit change in value of irreversible consequence postponement.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of irreversible consequence postponement again entered as zero, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured

covariance matrix structure was a better fit based upon the inclusion of irreversible consequence postponement as a moderator within the indirect relationship pathway ( $\chi^2_{\text{change}} = 71.149$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was not contained within the range of its Monte Carlo confidence interval when using an irreversible consequence postponement value of zero ( $ab_3 = -0.051$ ; MCLL =  $-0.094$ ; MCUL =  $-0.010$ ). This result demonstrates that the within-respondent indirect effect varies systematically as a function of irreversible consequence postponement when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of irreversible consequence postponement within the random slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was probed using the high case (value = 1) for the irreversible consequence postponement variable. The results obtained from the probing of the interaction are contained in Table 6.28 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with a change in the level of irreversible consequence postponement.

PIC value	$a$	$b$	Within-respondent indirect effect ( $ab$ )	MCLL	MCUL
0	0.758	-0.271	-0.225	-0.288	-0.167
1	0.758	-0.338	-0.275	-0.344	-0.214

Coefficient  $a$  represents the effect upon risk perception of a change in the state of solution uncertainty from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception moderated by irreversible consequence postponement (PIC). Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the level of solution uncertainty from low to high moderated by irreversible consequence postponement.

Table 6.28: *H6a* within respondent estimates for the PIC score range

The change in the value of both  $b$  and  $ab$  as a consequence of the change in the value of irreversible consequence postponement, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of change in the level of risk perception associated with an increase in the level of irreversible consequence postponement. An identical but reverse effect can be shown to arise from a reduction from high to low in the level of irreversible consequence postponement. In regard to Figure 6.12, a change in the values of  $b$  and  $ab$ , moderated by

the level of irreversible consequence postponement (PIC), is depicted in Figure 6.13. For both moderation cases considered, the value of coefficient  $a$  remained constant (0.758).

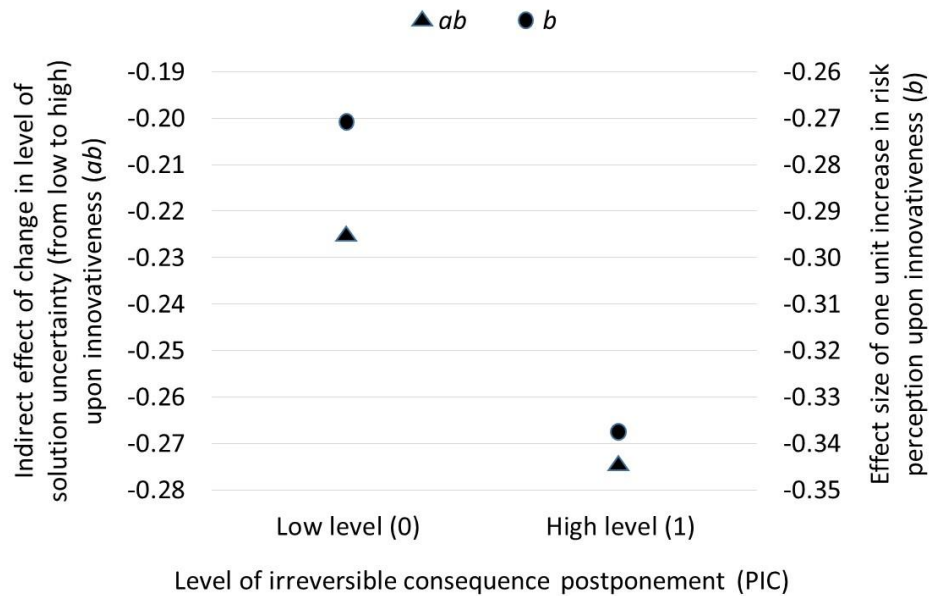


Figure 6.13: Moderation effect of PIC upon  $b$  and  $ab$  for hypothesis  $H6a$

These results lead to rejection of the null hypothesis that irreversible consequence postponement, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between solution uncertainty and innovativeness. These results support hypothesis  $H6a$ .

#### 6.4.6.2 Analysis of moderated mediation: problem uncertainty

The purpose of this section is to report the results from the testing of hypothesis  $H6b$ :

***H6b:*** *Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results revealed that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero

within its range ( $ab_3 = -0.052$ ; MCLL =  $-0.091$ ; MCUL =  $-0.015$ ). This result was achieved using an irreversible consequence postponement value of zero (low case), demonstrating that the within-respondent indirect effect varies systematically as a function of irreversible consequence postponement. Based upon this result, the within-respondent indirect effect of solution uncertainty upon innovativeness through risk perception was expected to differ systematically for each unit change in value of irreversible consequence postponement.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of irreversible consequence postponement again entered as zero, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit based upon the inclusion of irreversible consequence postponement as a moderator within the indirect relationship pathway ( $\chi^2_{\text{change}} = 72.546$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was not contained within the range of its Monte Carlo confidence interval when using an irreversible consequence postponement value of zero ( $ab_3 = -0.047$ ; MCLL =  $-0.086$ ; MCUL =  $-0.010$ ). This result shows that the within-respondent indirect effect varies systematically as a function of irreversible consequence postponement when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of irreversible consequence postponement within the random slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was probed using the high case (value = 1) for the irreversible consequence postponement variable. The results obtained from the probing of the interaction are contained in Table 6.29 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with a change in the level of irreversible consequence postponement.

PIC value	a	b	Within-respondent indirect effect ( <i>ab</i> )	MCLL	MCUL
0	0.691	-0.265	-0.221	-0.284	-0.167
1	0.691	-0.334	-0.269	-0.335	-0.210

Coefficient *a* represents the effect upon risk perception of a change in the state of problem uncertainty from low to high. Coefficient *b* represents the effect upon innovativeness of a one-unit increase in risk perception moderated by irreversible consequence postponement (PIC). Coefficient *ab* represents the indirect effect upon innovativeness through risk perception of a change in the level of problem uncertainty from low to high moderated by irreversible consequence postponement.

Table 6.29: *H6b* within-respondent estimates for the PIC score range

The change in the value of both *b* and *ab* as a consequence of the change in the value of irreversible consequence postponement, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of a change in the level of risk perception associated with an increase in the level of irreversible consequence postponement. An identical but reverse effect can be shown to arise from a reduction from high to low in the level of irreversible consequence postponement. In regard to Figure 6.12, a change in the values of *b* and *ab*, moderated by the level of irreversible consequence postponement (PIC), is depicted in Figure 6.14. For both moderation cases considered, the value of coefficient *a* remained constant (0.691).

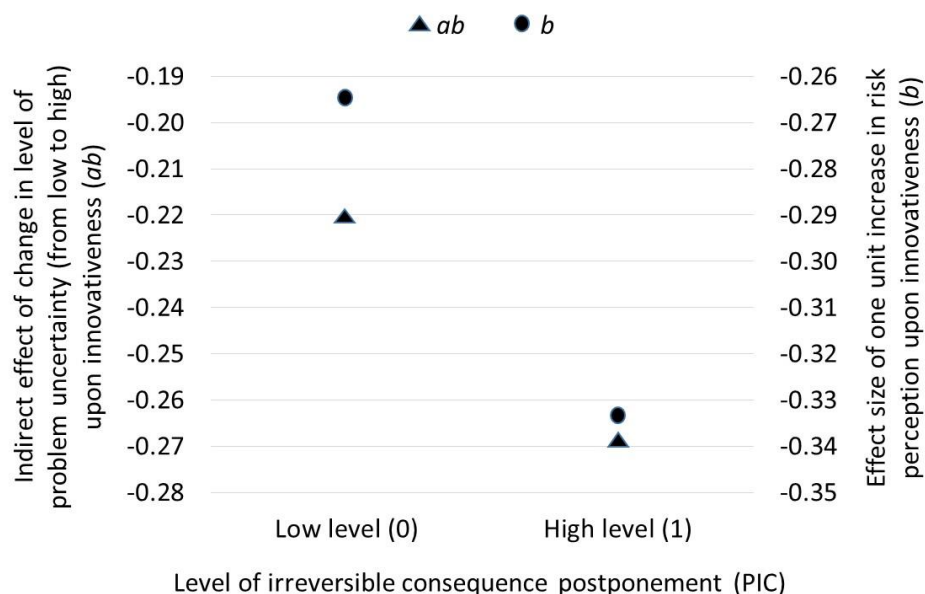


Figure 6.14: Moderation effect of PIC upon *b* and *ab* for hypothesis *H6b*



These results lead to rejection of the null hypothesis that irreversible consequence postponement, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between problem uncertainty and innovativeness. These results support hypothesis *H6b*.

#### **6.4.6.3 Analysis of moderated mediation: irreversible consequence failure**

The purpose of this section is to report the results from the testing of hypothesis *H6c*:

***H6c:** Where risk perception is shown to mediate the effect of irreversible consequence of failure upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.*

The results revealed that for the case involving random intercepts and fixed slopes, the Monte Carlo confidence interval for the index of moderated mediation did not contain zero within its range ( $ab_3 = -0.043$ ; MCLL =  $-0.076$ ; MCUL =  $-0.012$ ). This result was achieved using an irreversible consequence postponement value of zero (low case), demonstrating that the within-respondent indirect effect varies systematically as a function of irreversible consequence postponement. Based upon this result, the within-respondent indirect effect of solution uncertainty upon innovativeness through risk perception was expected to differ systematically for each unit change in value of irreversible consequence postponement.

A subsequent test of moderated mediation was conducted using an identical variable set with the value of irreversible consequence postponement again entered as zero, but in which the slopes of the regression equations were allowed to vary between respondents using an unstructured covariance matrix structure within the MLmed model. A likelihood ratio test was conducted, which determined that the random slopes model using the unstructured covariance matrix structure was a better fit based upon the inclusion of irreversible consequence postponement as a moderator within the indirect relationship pathway ( $\chi^2_{\text{change}} = 98.734$ ;  $df_{\text{change}} = 3$ ;  $p < .001$ ). The index of moderated mediation for the random intercepts and random slopes case revealed that zero was not contained within the range of its Monte Carlo confidence interval when using an irreversible consequence postponement value of zero ( $ab_3 = -0.034$ ; MCLL =  $-0.067$ ; MCUL =  $-0.003$ ). This result demonstrates that the within-respondent indirect effect varies systematically as a function of irreversible consequence

postponement when the slopes of the regression equations were allowed to vary between respondents.

To gain an understanding of the underlying moderating effect of irreversible consequence postponement within the random slopes case upon the indirect relationship involving the variables under examination within this section, the within-respondent indirect effect was probed using the high case (value = 1) for the irreversible consequence postponement variable. The results obtained from the probing of the interaction are contained in Table 6.30 and show that an incremental change in the value of both  $b$  and  $ab$  is associated with a change in the level of irreversible consequence postponement.

<b>PIC value</b>	<b><math>a</math></b>	<b><math>b</math></b>	<b>Within-respondent indirect effect (<math>ab</math>)</b>	<b>MCLL</b>	<b>MCUL</b>
0	0.571	-0.277	-0.198	-0.260	-0.145
1	0.571	-0.336	-0.232	-0.300	-0.174

Coefficient  $a$  represents the effect upon risk perception of a change in the state of irreversible consequence postponement from low to high. Coefficient  $b$  represents the effect upon innovativeness of a one-unit increase in risk perception moderated by irreversible consequence postponement (PIC). Coefficient  $ab$  represents the indirect effect upon innovativeness through risk perception of a change in the level of irreversible consequence postponement from low to high moderated by irreversible consequence postponement.

Table 6.30: *H6c* within-respondent estimates for the PIC score range

The change in the value of both  $b$  and  $ab$  as a consequence of the change in the value of irreversible consequence postponement, acting as a moderator of the relationship between risk perception and innovativeness, demonstrates the amplification of the effect upon innovativeness of change in the level of risk perception associated with an increase in the level of irreversible consequence postponement. An identical but reverse effect can be shown to arise from a reduction from high to low in the level of irreversible consequence postponement. In regard to Figure 6.12, change in the values of  $b$  and  $ab$ , moderated by the level of irreversible consequence postponement (PIC), is depicted in Figure 6.15. For both moderation cases considered, the value of coefficient  $a$  remained constant (0.571).

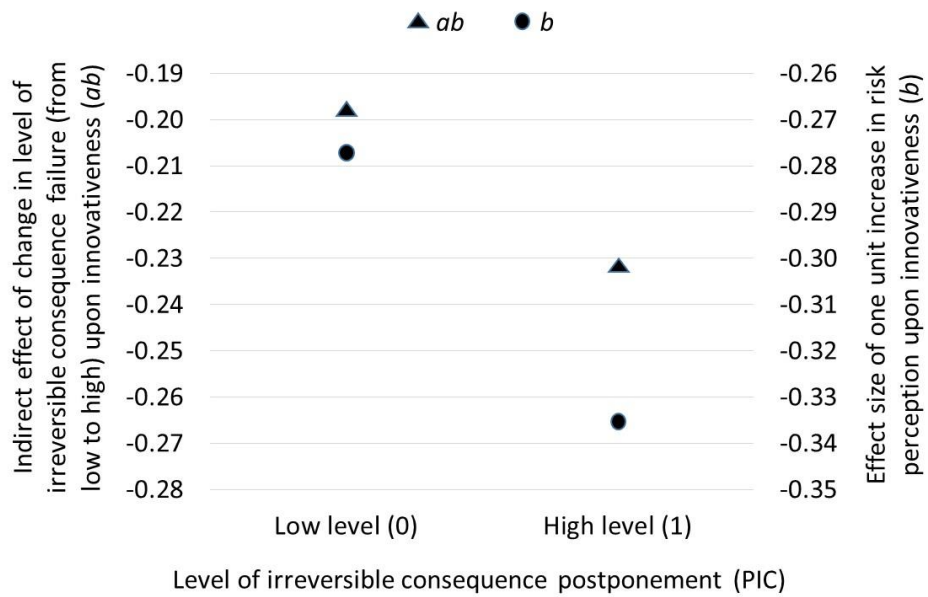


Figure 6.15: Moderation effect of PIC upon *b* and *ab* for hypothesis *H6c*

These results lead to rejection of the null hypothesis that irreversible consequence postponement, acting upon the relationship between risk perception and innovativeness, does not moderate the mediation effect of risk perception within the indirect relationship pathway between irreversible consequence failure and innovativeness. These results support hypothesis *H6c*.

### 6.5 Summary of hypothesis-testing outcomes

The results from the testing of the 21 hypotheses examined within this chapter are summarised in Table 6.31. From this table, it can be observed that, other than in the case of hypothesis *H2d*, all hypotheses were supported. A discussion concerning these outcomes is contained within the following chapter.

	<b>Hypothesis</b>	<b>Result</b>	<b>Effect</b>
<i>H1a</i>	Solution uncertainty is negatively associated with innovativeness.	✓	-0.620
<i>H1b</i>	Problem uncertainty is negatively associated with innovativeness.	✓	-0.495
<i>H1c</i>	Irreversible consequence failure is negatively associated with innovativeness.	✓	-0.420
<i>H1d</i>	Irreversible consequence postponement is positively associated with innovativeness.	✓	0.186
<i>H2a</i>	Solution uncertainty is positively associated with risk perception.	✓	0.758
<i>H2b</i>	Problem uncertainty is positively associated with risk perception.	✓	0.684
<i>H2c</i>	Irreversible consequence failure is positively associated with risk perception.	✓	0.570
<i>H2d</i>	Irreversible consequence postponement is positively associated with risk perception.	✗	-
<i>H2e</i>	Risk propensity is negatively associated with risk perception.	✓	-0.487
<i>H3a</i>	Risk perception is negatively associated with innovativeness.	✓	-0.352
<i>H3b</i>	Risk propensity is positively associated with innovativeness.	✓	0.456
<i>H4a</i>	Risk perception mediates the effect of solution uncertainty upon innovativeness.	✓	-0.250
<i>H4b</i>	Risk perception mediates the effect of problem uncertainty upon innovativeness.	✓	-0.244
<i>H4c</i>	Risk perception mediates the effect of irreversible consequence failure upon innovativeness.	✓	-0.218
<i>H4d</i>	Risk perception does not mediate the effect of irreversible consequence postponement upon innovativeness.	✓	-
<i>H5a</i>	Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.	✓ <sup>1</sup>	-0.026 <sup>2</sup>
<i>H5b</i>	Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.	✓ <sup>1</sup>	-0.024 <sup>2</sup>
<i>H5c</i>	Where risk perception is shown to mediate the effect of irreversible consequence failure upon innovativeness, risk propensity will moderate that mediating effect through the risk perception—innovativeness relationship.	✓ <sup>1</sup>	-0.020 <sup>2</sup>
<i>H6a</i>	Where risk perception is shown to mediate the effect of solution uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.	✓	-0.051 <sup>2</sup>
<i>H6b</i>	Where risk perception is shown to mediate the effect of problem uncertainty upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.	✓	-0.047 <sup>2</sup>
<i>H6c</i>	Where risk perception is shown to mediate the effect of irreversible consequence of failure upon innovativeness, irreversible consequence postponement will moderate that mediating effect through the risk perception—innovativeness relationship.	✓	-0.034 <sup>2</sup>

✓ Supported <sup>1</sup> Supported in fixed slopes case only, ✗ Not supported, <sup>2</sup> Index of moderated mediation value

Table 6.31: Results from hypothesis testing contained in Chapter 6

## **6.6 Conclusion**

This chapter has provided a description and analysis of the survey responses, including response rate considerations, a summation of the sample demographics and an analysis of non-response bias, which found that non-response bias is not a threat to this thesis. The sample size achieved was found to be acceptably large. Following this, the chapter summarised the results of an examination of common method bias and again found that this is not a threat to this thesis. The unidimensionality and internal consistency of both the risk propensity and risk perception measurement scales were tested using PCA and reliability analysis. In both instances, a single general factor emerged from the PCA, demonstrating the presence of a single attitudinal scale, and Cronbach's alpha reliability outcomes that, in all cases, exceeded the minimum thresholds of acceptability. All hypotheses developed in Chapter 4 were tested within this chapter, and all 21 hypotheses, except one, were supported. The results achieved through the testing of these 21 hypotheses provide the foundation for the discussion in Chapter 7 relative to the main research problem of this thesis, the development of the necessary conclusions, which flows from these results, and the implications that arise as a consequence for theory, practice and future research.

## 7. DISCUSSION OF RESULTS, CONCLUSIONS AND IMPLICATIONS

### 7.1 Introduction

The purpose of this thesis has been to examine to what extent predictions of investment decision-making behaviour may be made based upon how varying levels of uncertainty and irreversibility affect a decision-maker's risk perception, how this in turn may affect actual decision behaviour and how the strength of this effect may vary depending upon the decision-maker's risk propensity. From an analytic perspective, the purpose of this thesis was to examine to what extent predictions of investment decision-making behaviour may be made based upon indirect effect relationships between actual risky decision-making behaviour and variables concerning decision uncertainty and decision outcome irreversibility. This is done using decision-maker risk perception and risk propensity as psychographic mediator and moderator respectively. The genesis of this thesis stemmed from studies undertaken by Sitkin and Weingart (1995) concerning the determinants of risky decision behaviour involving both risk perception and risk propensity as the psychographic mediators of the indirect relationships examined by them. As such, the analytic model employed within this thesis has been represented in the form of a simple mediation model with consideration of the necessary moderated mediation relationships included as appropriate to satisfy the needs of the main research problem and the six research questions that flow from it.

A full-profile CVA online survey was employed to gather preference-based responses from the target survey population concerning ten conjoint tasks, with each task representing a differing combination of the attribute levels relevant to this thesis. The survey was informed by the case study 'Carter Racing', which was to be read before commencing the survey. The unit of analysis was a population of 400 executive managers employed by the global resources company BHP during the fourth quarter of 2018. Through this process, part-worth estimates and utility values were calculated, which provided the data necessary for subsequent analysis. For each conjoint task, each respondent was also required to state their perception of risk arising from the combination of attribute levels shown. For each completed online survey, the risk propensity of the respondent was measured using a five-item Likert measurement scale incorporated within the online survey. The adequacy of the survey response rate was evaluated and shown to be adequate. Rigorous steps were taken to assess survey non-response and common method bias, as well as the unidimensionality

and internal consistency of the psychographic variables. Given that the CVA survey design incorporated ten conjoint tasks per respondent, multi-level quantitative methods were required to be employed for hypothesis testing using simple regression, mediation analysis and moderated mediation analysis techniques to address the main research problem and the six research questions that arose from it. Within this context, the purpose of this final chapter is to discuss the results summarised within the previous chapter and to draw conclusions from these results to address the main research problem that has provided the focal point of this thesis. This chapter also addresses the theoretical and practical implications that arise from the results obtained. Finally, reflections and limitations arising from these reflections, as well as implications for future research, are discussed.

## **7.2 Conclusions about research questions based upon hypothesis testing**

Analysis undertaken concerning CVA survey responses from 103 executive managers employed by the global resources company BHP demonstrated that all of the hypotheses developed in Chapter 4, except for one, were supported. Of the 21 hypotheses listed in Table 6.31, only hypothesis *H2d* was not supported. It is important to note that hypotheses *H5a*, *H5b* and *H5c* concerning moderated mediation relationships involving risk propensity as the moderating variable were supported in the random intercepts and fixed slopes case only. This outcome does not suggest that these hypotheses were not supported, but that evidence was not found to support them once between-respondent variation was taken into account, as was the case when testing was conducted using random intercept and random slope conditions within the regression equations. Accordingly, support for these three hypotheses is conditional upon this limitation.

Before proceeding with a discussion of the results, it is important to restate the six research questions that arose from the main research problem that this thesis set out to address, as originally specified in Section 1.4, as these six research questions provide the framework for this current section. The six research questions are:

1. To what extent do respondents' decision choices demonstrate preferences that enable predictions of decision-making behaviour based upon variations in the level of the predictor variables of problem uncertainty, solution uncertainty, irreversible consequence failure and irreversible consequence postponement?

2. Can solution uncertainty, problem uncertainty, irreversible consequence failure, irreversible consequence postponement and risk propensity each be shown to be a predictor of risk perception?
3. Can risk perception and risk propensity each be shown to be a predictor of innovativeness?
4. Does risk perception mediate the effect of solution uncertainty, problem uncertainty, irreversible consequence failure and irreversible consequence postponement upon innovativeness?
5. Does risk propensity moderate the mediating effect of risk perception and the predictor variables of solution uncertainty, problem uncertainty, irreversible consequence failure and irreversible consequence postponement upon innovativeness?
6. Does irreversible consequence postponement moderate the mediation effect of risk perception and the predictor variables of solution uncertainty, problem uncertainty and irreversible consequence failure upon innovativeness?

The balance of this section is constructed to address each research question within individual sections, ordered in accordance with the abovementioned research questions.

### **7.2.1 Respondent preferences for conditions of uncertainty and irreversibility**

The purpose of this section is to address the first research question through the results obtained from testing hypotheses *H1a*, *H1b*, *H1c* and *H1d*. In each of the following subsections, the results are also contextualised in regard to the 'Carter Racing' case study. The corresponding data analysis and results are contained in Section 6.4.1.

#### **7.2.1.1 Respondent preferences: solution uncertainty and problem uncertainty**

The results of testing hypotheses *H1a* and *H1b* demonstrate a respondent decision-making preference, when faced with the prospect of choosing whether to engage in risky decision behaviour within an environment in which the probability of loss is not clear and the possible consequences from loss are material, for a lower rather than higher level of uncertainty in regard to the variables of solution uncertainty and problem uncertainty. That is, based upon



the responses from the 103 respondents to the ten conjoint tasks, a higher level of innovativeness was shown to be associated with both a lower level of solution uncertainty and a lower level of problem uncertainty. Contextualised in terms of the 'Carter Racing' case study, this translates to a decision-making preference in favour of more successful prior experiences with the new innovative gasket sealing arrangement and a higher percentage of successful prior engine performances within the 18–24° C ambient temperature range (see Table 6.19). These results are aligned with those previously described within this thesis concerning the relationship between uncertainty and innovativeness in that increased levels of uncertainty have been shown to be associated with reduced rates of innovation diffusion, such as those found by Ryan and Gross (1943) in their seminal study of the behaviour of farmers in the state of Iowa in regard to the adoption of hybrid corn seed (Griliches, 1957, Griliches, 1980, Rogers, 2003, Ryan and Gross, 1943).

The results also illustrate a preference, on average across the respondents, for the avoidance of loss in the future that can be associated with a heightened level of uncertainty in the present. This preference is aligned with the notion of loss aversion as described by Gilboa (2010), Kahneman (2012) and Kahneman and Tversky (1979) in that the prospect of loss gives rise to a proportionate aversion towards it by those to whom it is relevant. The pattern of respondent behaviour observed in response to varying levels of uncertainty in the present is also not misaligned with that described by Ahlbrecht and Weber (1997), Anderson and Stafford (2009), Blackburn and El-Deredy (2013), Grusec (1968), Hardisty and Pfeffer (2017) and Mischel and Grusec (1967) in regard to the effect of variation in the level of uncertainty in the present upon decision-making preferences. The results from the testing of hypotheses *H1a* and *H1b* do not reveal novel or controversial findings compared with those that have been shown previously. These results, being directionally consistent with the findings of others, set an important foundation upon which subsequent findings within this and the following sections build. Nonetheless, it is important to note that while these results may not be novel in and of themselves, no other use of CVA has been identified within the relevant literature for the purpose of examining relationships between innovativeness and conditions of uncertainty. This gives rise to a degree of uniqueness in this work from an applied methodological perspective.

### **7.2.1.2 Respondent preferences: irreversible consequence failure**

The result from the testing of hypothesis *H1c* demonstrated a respondent decision-making preference, when faced with the prospect of choosing whether to engage in risky decision behaviour within an environment in which the probability of loss is not clear and the possible consequences from loss are material, for a lower rather than higher level of decision outcome irreversibility in regard to the variable of irreversible consequence failure. Similar to what was applied above in the case of uncertainty, based upon the responses from the 103 respondents to the ten conjoint tasks, a higher level of innovativeness was shown to be associated with the lower level of the variable of irreversible consequence failure. That is, the choices made by the respondents demonstrated a preference for a lower level of irreversible consequence arising from risky decision behaviour. Innovativeness was, on average, shown to be higher when the irreversible loss was limited to the value of oil sponsorship only, as described within the ‘Carter Racing’ case study, rather than the loss of both existing oil and tyre sponsorships arrangements (see Table 6.19). Again, as in the case of uncertainty, decision-making preferences and behavioural patterns associated with the irreversible consequence failure exhibited a preference for the avoidance of loss in the future arising from decision choices made in the present—that is, through their behaviour, the respondents again demonstrated loss aversion.

This result is aligned with previous studies that have demonstrated a preference for greater levels of decision outcome reversibility (see Bullens et al., 2011, Bullens, 2013, Bullens et al., 2013, Bullens et al., 2014, Bullens and Harreveld, 2016, Gilbert and Ebert, 2002, Shiner, 2015), particularly in circumstances where the potential for improvement through iteration is considered an important situational attribute (Skinner, 1988). Given the consequence of losing both forms of sponsorship in the high irreversibility case, this result is also aligned with relevant theory that argues in favour of a delay to a point in time at which an irreversible decision is made so as to preserve, as far as possible, valuable decision options for the future unless the value of a strategic imperative dictates otherwise (Bernanke, 1983, Dixit and Pindyck, 1995). As was the case with the findings achieved through the testing of hypotheses *H1a* and *H1b*, while the result from the testing of hypothesis *H1c* does not yield novel or controversial results compared with that which has been shown previously by others, it further develops the foundation laid by the results from the testing of hypotheses *H1a* and *H1b*, upon which subsequent discussion will build. A similar degree of novelty applies to the testing of hypothesis *H1c*, as was mentioned previously regarding hypotheses *H1a* and *H1b*, from an applied methodological perspective.

### 7.2.1.3 Respondent preferences: irreversible consequence postponement

Hypothesis *H1c* was associated with the dichotomous attribute that described, through its levels, the consequences in each conjoint task that would arise from a decision to rely upon the new innovative gasket arrangement and race at Ponoco if engine failure was to be the outcome. Conversely, hypothesis *H1d* was associated with the dichotomous attribute that described, through its levels, the consequences in each conjoint task that would arise from a decision to not rely upon the new innovative gasket arrangement and defer the point in time at which the Carter Racing team would compete in their next race. The result from the testing of hypothesis *H1d* demonstrated a respondent decision-making preference for a higher rather than lower level of irreversible consequence of postponement. This means that, in regard to this variable, a higher level of innovativeness was associated with a higher level of decision outcome irreversibility, which is the inverse of what was found in regard to hypothesis *H1c* (see Table 6.19).

In the case of hypothesis *H1c*, the probability of irreversible loss of valuable sponsorship income arising from engine failure during the Ponoco race was dependent upon actual performance during the race, and until such time as failure occurred, if indeed it did, the probability of that loss was dependent upon the perceptions of the respondent decision maker. However, in the case of hypothesis *H1d*, the probability of the irreversible loss of valuable sponsorship income was near certain if the level of the attribute of irreversible consequence postponement was in its high state, this being retention of the oil sponsorship next season but the loss of the tyre sponsorship, and a decision to not race at Ponoco was to be the choice of the respondent. Similar to the arguments made by Kahneman (2012) and Kahneman and Tversky (1979) in regard to high-probability losses, it is argued that the high probability of loss unless action is taken is what gives rise to the reversal of the relationship between innovativeness and irreversible consequence postponement relative to the relationship between innovativeness and irreversible consequence failure. This is because a high probability of loss is very aversive (Kahneman, 2012).

While hypotheses *H1c* and *H1d*, as well as the attributes and attribute levels upon which they rely, both concern the loss of commercial sponsorship arrangements that are vital to the ongoing viability of the 'Carter Racing' team, what differs between them is the probability that loss will be incurred as a consequence of decisions made regarding them. Contextualised to the 'Carter Racing' case study, the results show innovativeness to be higher if the consequence from a decision to not race in the Ponoco event was the loss of a valuable oil

sponsorship than when no loss would be incurred from that decision choice. The result from the testing of hypothesis *H1d*, while demonstrating a reversal of the relationship between innovativeness and decision outcome irreversibility compared with that obtained through the testing of hypothesis *H1c*, nonetheless reflects loss aversion and the effect of variation in the probability of loss upon decision-making behaviour, as described by prospect theory (see Gilboa, 2010, Harbaugh et al., 2010, Kahneman, 2012, Kahneman and Tversky, 1979, Tversky and Kahneman, 1992). That is, when decision makers are faced with a selection of options—all of which are considered bad or grossly unfavourable—risk-seeking, as opposed to risk aversion, will prevail because the surety of loss is highly aversive (Kahneman, 2012). The risk-seeking preference identified through the testing of hypothesis *H1d*, as opposed to the risk-averse preference associated with each of the other three relationships examined within this section, reflects the vital trait that distinguishes prospect theory from the traditional expected utility-based theories as described by Gilboa (2009), Harbaugh et al. (2010), Kahneman and Tversky (1979), Levy (1992) and Schneider and Lopes (1986).

The result obtained through the testing of hypothesis *H1d* contradicts much of that which underpins the established theories concerning innovativeness that rely upon the premise of a risk-averse decision maker, with variation in the timing of innovation adoption decisions dependent upon factors such as accumulated knowledge, willingness to change, level of uncertainty and experience of others (see Goldsmith and Foxall, 2003, Goldsmith and Hofacker, 1991, Hurt et al., 1977, Midgley and Dowling, 1978, Rice and Rogers, 1980, Rogers and Havens, 1962, Rogers, 2003, Sundbo, 1998, Tarde, 1903). Established theories concerning innovativeness have not explicitly considered the effect of loss aversion upon decision-making behaviour, especially in regard to its relationship to both risk-averse and risk-seeking behaviours, these being behaviours that are fundamental to prospect theory as argued by Kahneman and Tversky (1979). The CVA survey design and the overall methodology employed within this thesis does not enable a more detailed examination of the relationship between innovativeness and the investment decision-maker behaviour within the domain of high-probability losses, nor does it enable an examination of the reflection point that defines the boundary region of transition between risk-averse and risk-seeking behaviours, as described by Levy (1992), Kahneman and Tversky (1979) and Kahneman (2012). Nevertheless, the outcome from the testing of hypothesis *H1d* points to the opportunity for future research efforts to be directed towards examining the relationships between innovativeness, prospect theory and the fourfold pattern of risk

attitudes in choice-making derived from that theory. This opportunity is discussed further in Section 7.7 of this chapter.

#### **7.2.1.4 Conclusions about respondent preferences**

It can be concluded that for each of the four predictor variables mentioned, predictions of decision-making behaviour can be made based upon variation in the attribute levels of those variables. Specifically, the results obtained through the testing of hypotheses *H1a*, *H1b*, *H1c* and *H1d* enable predictions to be made based upon the following principles derived from the results discussed within this section:

1. A higher level of innovativeness will be associated with a lower level of decision uncertainty, and a lower level of innovativeness will be associated with a higher level of decision uncertainty.
2. A higher level of innovativeness will be associated with a lower level of decision outcome irreversibility, and a lower level of innovativeness will be associated with a higher level of decision outcome irreversibility. Unless:
3. The decision context is representative of the domain of high-probability losses in that the probability of adverse irreversible consequences is high and imminent and that, through a decision to adopt and rely upon an innovation, the probability and consequence of loss is perceived to be reduced. Where this is so, a higher level of innovativeness will be associated with a higher level of decision outcome irreversibility.

These three conclusions form the foundation upon which the remainder of this chapter is founded. They also represent, in aggregate, an important contribution to knowledge concerning the processes of the adoption and diffusion of innovations.

#### **7.2.2 Predictors of risk perception**

This section addresses the second research question through the results obtained from the testing of hypotheses *H2a*, *H2b*, *H2c*, *H2d* and *H2e*, each of which concern bivariate

relationships involving risk perception. In each of the following subsections, the results are also contextualised in regard to the 'Carter Racing' case study as appropriate. The corresponding data analysis and results are contained in Section 6.4.2.

Prior to considering the relationships in each case, it is important to restate the meaning of the terms 'uncertainty', 'risk' and 'risk perception' that are applicable to this thesis, as well as the interrelationships that are said to exist between them. These terms are summarised as follows:

- (a) Uncertainty concerns the degree of confidence that can be assigned to estimates of values or criteria that are subject to evaluation, assessment or measurement (Duncan, 1972, Thompson, 2011).
- (b) Risk refers to the combination of uncertainty about future outcomes concerning events or possible future states of the world, uncertainty surrounding the consequences arising from those uncertain outcomes, and the severity of those consequences, in regard to something that is of human value or of value to humanity (Aven and Renn, 2009).
- (c) Risk perception refers to an individual's intuitive evaluation of the risk associated with a circumstance based upon predefined parameters and measurement scales, taking into consideration probabilistic estimations of the uncertainties surrounding the circumstance (Sitkin and Pablo, 1992), the level of confidence in those estimates and the degree to which uncertainties are believed to be controllable (see Baird and Thomas, 1985, Bettman, 1973, Duncan, 1972, Gough, 1990, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995, Vlek and Stallen, 1980).

### **7.2.2.1 Predictors of risk perception: solution and problem uncertainty**

Investigation into the relationships between risk perception and both solution uncertainty and problem uncertainty revealed a significant positive association for both relationships. An increase in the level of either solution uncertainty or problem uncertainty was shown to be associated with an increase in the level of risk perception (see Table 6.31; solution uncertainty:  $\gamma_{10} = 0.758$ ,  $p < 0.001$ ; problem uncertainty:  $\gamma_{10} = 0.684$ ,  $p < 0.001$ ). Contextualised to the 'Carter Racing' case study, the results show that risk perception is significantly higher, on average, when the number of successful prior experiences with the

new innovative gasket sealing arrangement was two rather than five, and when the percentage of successful prior engine performances within the 18–24° C ambient temperature range was 60% rather than 73%. This result suggests that an increase in the level of uncertainty in the present—whether solution uncertainty or problem uncertainty—gave rise to an increase in the level of uncertainty assigned to possible future states of engine reliability and racing car performance by respondents, which, by its nature in this case, relates to something of importance and value. The effect of an increase in the level of either solution uncertainty or problem uncertainty upon the level of perceived uncertainty surrounding possible future states of engine performance, and therefore the inherent risk arising from that increase, is argued to have been translated by the respondents into a higher level of risk perception through intuitive evaluations made by them via the relevant measurement scale provided within each conjoint task. Therefore, it can be said that in response to an increase in the level of uncertainty in the present, the respondents intuitively evaluated that change as causing an increase in the level of perceived risk attributable by them to that change. The logic of this explanatory argument concerning the relationship between risk perception, solution uncertainty and problem uncertainty is consistent with claims made by Aven and Renn (2009), Fischhoff et al. (1984), Rosa (1998) and Solberg and Njå (2012) concerning the conceptual nature of risk and the evaluation of risk perception, as summarised above.

#### **7.2.2.2 Predictors of risk perception: irreversible consequence failure**

An argument is made in favour of the variable of irreversible consequence failure similar to that made for both solution uncertainty and problem uncertainty in terms of the effect of possible future states upon perceptions of risk, as a positive relationship was found to exist between the variables of irreversible consequence failure and risk perception (see Table 6.31; irreversible consequence failure:  $\gamma_{10} = 0.570$ ,  $p < 0.001$ ). Relative to the ‘Carter Racing’ case study, a change in the level of irreversible consequence failure to its high state was shown to be associated with an increase in the level of risk perception. Based upon their survey responses, the respondents perceived the consequences arising from engine failure under this heightened level of decision outcome irreversibility as being more severe. As a consequence of this heightened level of irreversibility and the financial consequences that would flow from it in regard to the ongoing variability of the ‘Carter Racing’ team, it can be said that the respondents reacted by increasing the level of risk that they perceived to exist.

Based on the logic of this argument, the change in the level of decision outcome irreversibility drives the corresponding change in the level of risk perception because of the effect that this change in the level of decision outcome irreversibility has upon the magnitude of possible decision outcome consequences. Again, the logic of this explanatory argument concerning the relationship between risk perception and irreversible consequence failure is consistent with claims by Aven and Renn (2009), Fischhoff et al. (1984), Rosa (1998) and Solberg and Njå (2012) concerning the conceptual nature of risk and the evaluation of risk perception. The logic of this explanatory argument is also consistent with claims made by Bullens (2013), Bullens and Harreveld (2016), Dixit and Pindyck (1995) and Shiner (2015) in regard to decisions that give rise to higher levels of irreversibility and which, as a consequence, cause the sterilisation of valuable options.

### **7.2.2.3 Predictors of risk perception: irreversible consequence postponement**

Referring back to Section 7.2.1 and the preferences demonstrated through the results obtained from the testing of hypotheses *H1a*, *H1b* and *H1c*, the results obtained from the testing of hypotheses *H2a*, *H2b* and *H2c* directionally correspond with the risk-averse nature of those preferences. That is, in each case, a reduction in willingness to engage in risky decision-making behaviour was shown to be associated with a significant increase in the level of risk perception. However, in the case of hypothesis *H2d*, no significant relationship was found to exist between the variable of irreversible consequence postponement and risk perception based upon testing undertaken in regard to that hypothesis. The risk-seeking preference exhibited through the results obtained from the testing of hypothesis *H1d*—that is, the relationship between irreversible consequence postponement and innovativeness—did not correspond with a significant increase in the level of risk perception (see Table 6.31).

Contextualised to the ‘Carter Racing’ case study, the results show that risk perception did not vary significantly across the two possible consequence states arising from a decision not to race in the Ponoco event. It can be inferred from the results that while perceptions of risk may correspond with risk-averse decision-making preferences, this is not the case if the decision-making preference is risk-seeking. A possible explanation for this phenomenon is that the high probability of loss arising from the high-level condition of the variable of irreversible consequence of postponement—unless a decision to adopt and rely upon the new innovative gasket arrangement is made in the expectation that doing so will reduce the probability of that loss—causes variability across the respondent group that is sufficient to



nullify any relationship. Gaining a better understanding of the relationships involving perceptions of risk and decision-making preferences in the domain of high-probability losses is an opportunity for future research efforts; accordingly, this opportunity is again mentioned in Section 7.7.

Two important conclusions can be drawn from these results concerning the relevant population. When a decision choice cannot be described as being within the domain of high-probability losses in the present, then change in the level of either solution uncertainty, problem uncertainty or irreversible consequence failure will result in a corresponding and significant change in the level of risk perception. However, if a decision choice is representative of the domain of high-probability losses in the present, such as what occurs when the variable of irreversible consequence postponement is in its high state, no such significant relationship will be observed.

#### **7.2.2.4 Predictors of risk perception: risk propensity**

The final relationship addressed within this section concerns the relationship between risk propensity and risk perception. As was determined when this relationship was examined by Sitkin and Weingart (1995), a negative association between these two variables was found to exist within this study, indicating that the more a respondent self-reported that they were inclined to take risks, the less risky they were inclined to perceive each of the ten conjoint tasks within the online survey to be (see Table 6.31; risk propensity:  $\gamma_{10} = -0.487, p < 0.001$ ). It can be concluded from these results, based upon the measurement scales employed for both variables in question, that respondents who give greater salience to uncertainties and negative outcomes bias their attention towards downside risk and the chance of losses in comparison with those who do otherwise and give greater salience to upside possibilities and the potential for gains. These conclusions are in general alignment with arguments made by Brockhaus (1980), March and Shapira (1987), Schneider and Lopes (1986), Vlek and Stallen (1980), Sitkin and Weingart (1995).

It is important to note that the absence of a relationship between irreversible consequence postponement and risk perception also indicates the absence of a relationship between irreversible consequence postponement and risk propensity, which suggests that the latter may bear little relationship to decision-making behaviour when the decision context is representative of the domain of high-probability losses. For reasons such as this, it is

considered that the influence of risk propensity upon decision-making behaviour should be the subject of further empirical scrutiny and examination to better understand its effect. Possible future research opportunities concerning this variable are discussed in Section 7.7.

### **7.2.3 Predictors of innovativeness**

The purpose of this section is to address research question three through the results obtained from the testing of hypotheses *H3a* and *H3b*, which concern whether risk perception and risk propensity respectively can be shown to be a predictor of innovativeness. The corresponding data analysis and results are contained within Section 6.4.3.

#### **7.2.3.1 Predictors of innovativeness: risk perception**

The result obtained through the testing of hypothesis *H3a*—namely that risk perception is negatively associated with innovativeness—confirmed the argument postulated in Section 4.4.3 that a higher level of perceived situational risk would be associated with reduced willingness to engage in risky decision behaviour, and hence a reduced level of innovativeness (see Table 6.31; risk perception:  $\gamma_{10} = -0.352$ ,  $p < 0.001$ ). This result demonstrates an aversion to risk and is directionally aligned with the findings of Hamid et al. (2013), Huang et al. (2016), Sitkin and Weingart (1995) and Xia et al. (2017). That is, in response to changes in the level of uncertainty or irreversibility that cause the level of perceived risk to increase, the respondents' willingness to engage in risky decision behaviour was observed to reduce. This result illustrates the importance of perceptions of risk within the broad decision-making context, as well as the influence of these perceptions upon actual risk-taking behaviour, the implications of which will be discussed later within this chapter. The result is also logically congruent with, and a logical extension of, that found in regard to hypotheses *H2a*, *H2b* and *H2c*. The results from the testing of these hypotheses demonstrate that an increase in the level of either solution uncertainty, problem uncertainty or irreversible consequence failure causes a corresponding increase in the level of risk perception. Based upon the result obtained through the testing of hypothesis *H3a*, this leads to a reduction in the level of innovativeness. These cause-and-effect relationships serve as the centrepiece of discussion in Section 7.2.4, which follows the conclusion of this current section.

### **7.2.3.2 Predictors of innovativeness: risk propensity**

The result of testing the relationship between risk propensity and innovativeness demonstrated a positive association (see Table 6.31; risk propensity:  $\gamma_{10} = 0.456$ ,  $p < 0.001$ ), thereby providing support for hypothesis *H3b* and the assertions upon which this hypothesis relies (see Fagley and Miller, 1987, Huff et al., 1997, MacCrimmon and Wehrung, 1985, MacCrimmon and Wehrung, 1986b, Nicholson et al., 2001, Salminen and Heiskanen, 1997). The result in this case also provides support for the argument that an individual decision maker will be more inclined to make riskier decisions within decision-making domains for which they exhibit an increased level of risk propensity relative to others who exhibit a lesser degree of risk propensity within that same decision-making domain. The result does not conclusively address the question of whether risk propensity is a domain-specific trait or is instead a general disposition, as discussed in Section 3.7.3. Nevertheless, the result is aligned with arguments that this construct is a measure of the current tendency of an individual to take or avoid risks within a predefined domain (see Corsini and Osaki, 1984, Goldenson, 1984, Huff et al., 1997, MacCrimmon and Wehrung, 1985, Nicholson et al., 2001, Sitkin and Weingart, 1995, Sutherland, 1989).

Both Sitkin and Pablo (1992) and Sitkin and Weingart (1995) mentioned that the value of risk propensity as a construct had waned over time because of poor conceptualisation and measurement. Sitkin and Weingart (1995) stated that this argument is, based upon their findings, misplaced. The findings of this study support the statements of Sitkin and Weingart (1995) concerning the value of risk propensity as a construct, as well as the nature of the relationships between it and both risk perception, as discussed in the previous chapter, and risky decision-making behaviour. Attention will now transition from a discussion of bivariate relationships between the variables that have been under consideration to mediation effects that rely upon risk perception as a mediating variable within indirect relationships concerning innovativeness.

### **7.2.4 Mediation effects of risk perception**

The purpose of this section is to discuss the results obtained from the testing of hypotheses *H4a*, *H4b*, *H4c* and *H4d* that concern research question four—that is, whether risk perception is shown to mediate the relationship between innovativeness and each of the four variables of solution uncertainty, problem uncertainty, irreversible consequence failure and

irreversible consequence postponement. The corresponding data analysis and results are contained in Section 6.4.4.

#### **7.2.4.1 Mediation: risk perception and irreversible consequence postponement**

As discussed in Section 7.2.1.3, based upon the CVA survey results, a positive association was found to exist between the variables of irreversible consequence postponement and innovativeness, which demonstrates that the respondents displayed a risk-seeking preference in regard to this relationship. Given that the attribute level of the variable of irreversible consequence postponement in its high state is representative of the domain of high-probability losses, the demonstration of risk-seeking behaviour by the survey respondents is not surprising based upon prospect theory. According to the logic of prospect theory, when faced with high-probability losses, an otherwise risk-averse decision maker will, at some point as the probability of loss becomes more certain, transition towards and then exhibit a risk-seeking preference (Harbaugh et al., 2010, Kahneman, 2012, Kahneman and Tversky, 1979, Levy, 1992, Lewandowski, 2017). The result from the testing of hypothesis *H4d* revealed that, in accordance with what was hypothesised, risk perception did not mediate the effect of irreversible consequence postponement upon innovativeness (see Table 6.24).

Contextualised in terms of the ‘Carter Racing’ case study, the result demonstrates that the effect of change in the level of irreversible consequence postponement is not transferred into change at the level of decision-maker behaviour via perceptions of risk. This result, achieved through the testing of hypothesis *H4d*, corresponds with that found through the testing of hypothesis *H2d*—that is, that no significant relationship was shown to exist between irreversible consequence postponement and risk perception. In aggregate, these results demonstrate that, based upon the nature of the CVA survey and the decision-making behaviour of the 103 survey respondents, when faced with a circumstance isolated to the domain of high-probability losses—as is the case when the attribute level of irreversible consequence postponement was in its high state—perceptions of risk do not play a significant role as a mediator. Instead, decision makers act to reduce the perceived probability of loss, as discussed in Section 7.2.1.3.

#### **7.2.4.2 Mediation: risk perception and other predictor variables**

Unlike the relationship found to exist between the variables of irreversible consequence postponement and innovativeness, a negative relationship was found to exist between the variable of innovativeness and each of the three predictor variables of solution uncertainty, problem uncertainty and irreversible consequence failure. These outcomes were discussed in Section 7.2.1. The negative relationship in each case demonstrates a preference for risk aversion rather than risk-seeking, with risk aversion being associated with, according to prospect theory, domains that are typified as being of either low-probability losses or high-probability gains (Harbaugh et al., 2010, Kahneman, 2012). Whether respondents considered the conjoint tasks presented to them as low-probability losses or high-probability gains is not known. Nevertheless, the results arising from the testing of hypotheses *H4a*, *H4b* and *H4c* reveal that risk perception mediates the effect of solution uncertainty, problem uncertainty and irreversible consequence failure upon innovativeness (see Figure 6.5, Figure 6.6 and Figure 6.7 respectively). Contextualised in terms of the 'Carter Racing' case study, the results demonstrate that the effect of change in the levels of either solution uncertainty, problem uncertainty or irreversible consequence failure is transferred into change at the level of decision-maker behaviour via perceptions of risk. The effect of risk perception in these three cases is consistent with that found by Sitkin and Weingart (1995), Hamid et al. (2013) and Xia et al. (2017). The result in each case is also consistent with the results obtained throughout prior testing of bivariate relationships between risk perception and innovativeness and between risk perception and each of the three predictor variables of solution uncertainty, problem uncertainty and irreversible consequence failure. However, consistency with these significant bivariate relationships alone does not give rise to significant mediation effects.

The significance of a mediation effect is, as stated by Hayes (2018), determined by the significance of the combined effect of the bivariate relationships in question, and not their significance when considered separately. A change in the level of any of these three predictor variables was shown to have a significant and corresponding effect upon the level of respondent risk perception, with the effect of this change itself having a significant inverse effect upon the level of innovativeness demonstrated through respondent decision-making behaviour. As such, an increase in the level of any of these three variables from its low to high state was shown to cause an increase in the level of self-reported risk perception and a reduction in willingness to race, being the measure through which innovativeness is measured, via a mediation effect. The converse was also shown to apply.

#### **7.2.4.3 Conclusions: mediation effects of risk perception**

The findings summarised in Section 7.2.4 in regard to research question four address an important question that lies at the heart of the main research problem regarding to what extent predictions of decision-making behaviour can be made based upon risk perception acting as mediator between actual decision-making behaviour and measures of uncertainty and irreversibility. The findings demonstrate that where risk-averse direct effect relationships were shown to exist between innovativeness and measures of uncertainty and irreversibility, it could also be shown that risk perception acts as a mediator of these relationships. However, where a risk-seeking direct effect relationship was shown to exist, no such effect was observed. Contextualised in terms of the 'Carter Racing' case study, the results demonstrate that the effect of change in the levels of either solution uncertainty, problem uncertainty or irreversible consequence failure is transferred into change at the level of decision-maker behaviour, which concerns the probability of racing at the Ponoco event, via perceptions of risk. However, this is not the case in regard to the effect of change on the level of irreversible consequence postponement, where a risk-seeking direct effect relationship was observed between irreversible consequence postponement and innovativeness.

The significance of these findings in regard to the main research problem of this thesis will be discussed in Section 7.3. The findings regarding research question four also highlight what is believed to be a largely unexplored field concerning the interrelationships between prospect theory, the domains of losses and gains central to the framing of prospect theory, and how decision-maker perceptions of risk influence decision-making behaviours, including through mediation effects, across these domains. While exploration of these relationships was not addressed by the main research problem or the six research questions that flowed from it, the results of this thesis demonstrate that further exploration within this field may prove fruitful. This matter is returned to within the final section of this chapter, which discusses implications for further research.

#### **7.2.5 Moderated mediation effects of risk propensity**

The purpose of this section is to discuss the results obtained from the testing of hypotheses *H5a*, *H5b* and *H5c*. Each hypothesis concerns whether risk propensity moderates the mediating effect of risk perception. As was the case concerning risk perception in the

previous section, the findings discussed within this section address a question that lies at the heart of the main research problem within this thesis—namely the extent to which predictions can be made based upon findings related to risk propensity acting as moderator of actual decision-making behaviour. The results from the testing of hypotheses *H5a*, *H5b* and irreversible consequence postponement *H5c* revealed that risk propensity acts as a moderator of the relationship between risk perception and innovativeness in all cases examined. This moderating effect is similar to the finding of Hatfield and Fernandes (2009) in regard to risk propensity and a relationship between risk perception and risky automobile driving behaviour.

As a consequence of the moderating effect of risk propensity upon the relationship between risk perception and innovativeness, risk propensity also acts as a moderator of the indirect relationships between innovativeness and solution uncertainty, problem uncertainty and irreversible consequence failure respectively via risk perception. For this reason, a discussion of the results within this section will be done collectively based upon the results from the testing of the individual hypotheses. Contextualised in terms of the ‘Carter Racing’ case study, the results demonstrate that the strength of the effect of change in the levels of solution uncertainty, problem uncertainty and irreversible consequence failure, which have been shown to affect decision-maker behaviour via perceptions of risk, is governed by the risk propensity of the decision maker.

It is important to again note, as reported previously within this thesis, that a moderation effect was only observed when the slopes within the relevant regression equations were not permitted to vary across individual respondents. Nevertheless, this outcome does not diminish the fact that a moderating effect was observed to be attributable to risk propensity acting through the relationship between risk perception and innovativeness when the relevant regression models were constrained to fixed slopes only. The corresponding data analysis and results for this section are contained in Section 6.4.5.

#### **7.2.5.1 The moderating effect of risk propensity**

The results, limited to analyses of fixed slopes only, demonstrated moderation through the variable of risk propensity because for each of the three indirect relationships examined, a change in the level of risk propensity was shown to be associated with a significant and corresponding change in the magnitude of the inverse relationship between risk perception

and innovativeness. A change in the magnitude of the relationship between risk perception and innovativeness also caused a significant and corresponding change in the magnitude of the relationships between innovativeness and solution uncertainty, problem uncertainty or irreversible consequence failure via risk perception (see Figure 6.9, Figure 6.10 and Figure 6.11 respectively, together with Figure 6.8).

It was observed that incremental unit increases or decreases in the level of risk propensity led to corresponding increases or decreases in the value of coefficient  $b$  within the modelling, the magnitude of which is representative of the effect upon innovativeness of a one-unit change in the level of risk perception. That is, the results showed that increasing levels of risk propensity led to the progressive amplification of the effect of change in the level of risk perception upon innovativeness, while diminishing levels of risk propensity led to the progressive dampening of this relationship. It is important to note that this effect is consistent with the operational definition of risk propensity employed within this thesis—that is, it is an attitudinal measure of the current tendency of an individual to take or avoid risks within a predefined domain (Hatfield and Fernandes, 2009, Hurt et al., 1977, Sitkin and Pablo, 1992, Sitkin and Weingart, 1995).

#### **7.2.5.2 Conclusions: moderation by risk propensity**

It can therefore be said that the self-reported risk propensity of respondents who participated in this study is an important determinant and predictor of their actual decision-making behaviour. More broadly, because variation in this variable, acting as a moderator, has been shown to significantly influence respondents' willingness to engage in risky decision behaviour, these results suggest that individual risk propensity may play an important moderating role in risky decision-making behaviour generally. Given the apparent absence of research concerning the moderating effect of risk propensity upon actual decision-making behaviour, as was initially mentioned in Chapter 2, further examination of moderated relationships involving risk propensity—in particular, domain-specific risk propensity—may prove fruitful. This opportunity is discussed further in Section 7.7.

#### **7.2.6 Moderated mediation effects of irreversible consequence postponement**

The purpose of this section is to discuss the results pertaining to hypotheses  $H6a$ ,  $H6b$  and  $H6c$ , all of which concern research question six. The focus of research question six was to



address whether irreversible consequence postponement served to moderate the mediation effect of risk perception upon innovativeness. Therefore, it addresses the extent to which predictions of risky decision-making behaviour can be made based upon the moderating effect of the variable of irreversible consequence postponement. This research question serves to test the relationship and effect that this variable may have upon relationships between innovativeness and the three variables of solution uncertainty, problem uncertainty and irreversible consequence failure and, in doing so, test whether irreversible consequence postponement gives rise to an option value effect, as mentioned in Section 4.4.6. Contextualised in terms of the 'Carter Racing' case study, this translates to the extent to which decision choices about competing in the Ponoco event are, in an overall sense, influenced by whether the consequence of a decision to not race in the Ponoco event is the loss of a valuable oil sponsorship.

The results from the testing of hypotheses *H6a*, *H6b* and *H6c* revealed that the variable of irreversible consequence postponement acts as a moderator of the relationship between risk perception and innovativeness in all three cases. Consequently, irreversible consequence postponement also acts as a moderator of the indirect relationships between innovativeness and solution uncertainty, problem uncertainty and irreversible consequence failure respectively, via risk perception acting as mediating variable. For this reason, as was the case in Section 7.2.5, the discussion of the results within this section will be done collectively based upon the results from the testing of the individual hypotheses. However, unlike the discussion in Section 7.2.5, the analysis upon which this section relies was not found to be constrained to a moderation effect within the fixed slopes case only. The corresponding data analysis and results for this section are contained in Section 6.4.6.

#### **7.2.6.1 The moderating effect of irreversible consequence postponement**

The results revealed moderation through the variable of irreversible consequence postponement in that, for each of the three indirect relationships involving solution uncertainty, problem uncertainty and irreversible consequence failure, a change in the level of irreversible consequence postponement led to a corresponding change in the magnitude of the inverse relationship between risk perception and innovativeness. As with the moderation effect involving risk propensity, a change in the magnitude of the relationship between risk perception and innovativeness also caused a corresponding change in the magnitude of the indirect relationships between innovativeness and solution uncertainty,

problem uncertainty and irreversible consequence failure via risk perception (see Figure 6.13, Figure 6.14 and Figure 6.15 respectively, together with Figure 6.12).

It was observed that a change in the dichotomous state of the variable of irreversible consequence postponement, when acting in the role of a moderator as so described, led to significant and corresponding change in the value of coefficient  $b$  within the modelling, the magnitude of which is representative of the effect upon innovativeness of change in the level of risk perception. The results showed that when the variable of irreversible consequence postponement was in its high state, the effect upon innovativeness of a one-unit change in the level of risk perception was greater than when the variable of irreversible consequence postponement was in its low state. Thus, the effect of a change in the level of irreversible consequence postponement from its low to high state served to amplify the effect of change in the variable of risk perception, acting as a mediator of the indirect relationships, whereas the effect of a change in the level of irreversible consequence postponement from its high to low state served to dampen the effect of the change in the level of risk perception.

It is important to again state the high and low states of the dichotomous variable of irreversible consequence postponement. In its low state, both the valuable oil and tyre sponsorships were retained for next season if a decision was made to not race at the Ponoco event. That is, no loss would be incurred as a consequence of the decision to not race in the Ponoco event. However, if the variable was in its high state, electing not to race in the Ponoco event would result in the valuable oil sponsorship valued at \$500,000 being lost but the \$300,000 tyre sponsorship retained. The results in this case are similar to those observed in regard to hypothesis *H1d*—that is, the bivariate relationship between irreversible consequence postponement and innovativeness was shown to be associated with a preference for risk-seeking behaviour. That is, the respondents demonstrated higher levels of innovativeness when irreversible consequence postponement was in its high state, acting as a moderator of the relationship between risk perception and innovativeness, compared with when it was in its low state. The results show that:

- The effect of change in the level of risk perception upon innovativeness, when irreversible consequence postponement was in its high-level state, gave rise to a significantly greater change in the level of innovativeness than was the case when irreversible consequence postponement was in its low-level state. These outcomes correspond with the expectations of prospect theory when the decision context can

be characterised as being one of high-probability losses (see Harbaugh et al., 2010, Kahneman, 2012, Kahneman and Tversky, 1979, Levy, 1992, Lewandowski, 2017), as well as the basic theory of irreversible investment under uncertainty in regard to the preservation of valuable decision choice options (see Bernanke, 1983, Dixit, 1989, Hanemann, 1989, Dixit and Pindyck, 1995, Smit and Trigeorgis, 2004, Sunstein, 2010).

- A change in the state of either of the three dichotomous variables of solution uncertainty, problem uncertainty or irreversible consequence failure when irreversible consequence postponement was in its high-level state gave rise to a significant and larger change in the level of innovativeness compared with when irreversible consequence postponement was in its low-level state.

#### **7.2.6.2 Conclusions: moderation by irreversible consequence postponement**

The results align with the argument and logic that underpins hypotheses *H6a*, *H6b* and *H6c*, as stated in Section 4.4.6. That is, when the variable of irreversible consequence postponement was both acting as a moderator and was in its low state, the effect of change in the level of either risk perception or one of the three other relevant predictor variables upon innovativeness would be significantly less than if the variable had been in its high state. This reduction in effect when irreversible consequence postponement was in its low state suggests that, on average, based upon the nature of their decision-making behaviour, the respondents recognised value arising from the option to wait and defer a decision to race until a future time without penalty or loss. This logic is similar to that described by Arrow and Fisher (1974), Dixit (1992), Dixit and Pindyck (1995) and Henry (1974b) in terms of the existence and preservation of valuable options that could cease to exist at the point in time at which an irreversible decision is made. Conversely, actual respondent behaviour also suggests that when irreversible consequence postponement was in its high state, the respondents reacted to the high probability of loss under this condition by increasing their willingness to race—this being the measure of innovativeness—in the expectation that doing so would reduce the probability of loss.

The pattern of behaviour that emerged through the testing of hypotheses *H6a*, *H6b* and *H6c* is directionally consistent with that found in regard to hypothesis *H1d* in that, when faced with high probability or certain losses, a risk-seeking decision-making preference was observed. The design of the CVA online survey did not provide the option for each

respondent to describe why each decision-making choice was made, so claims within this thesis about the cause of decision-making behaviour in this particular case cannot be made with any certainty. Nevertheless, the results obtained through the testing of hypotheses *H6a*, *H6b* and *H6c* provide useful insights into what is believed to be a hitherto largely unexplored domain encompassing the dimensions of innovativeness, decision uncertainty and perceptions of risk, with decision outcome irreversibility acting as moderator of decision-making behaviour. For this reason, the opportunity represented by further exploration within this area is discussed in Section 7.7.

### **7.3 Conclusions about the main research problem**

The content of the preceding six sections forms the foundations from which to draw conclusions about the main research problem that this thesis set out to address. The purpose of this section is not to repeat the content of the previous sections, but to synthesise that content into an integrated whole and, in doing so, comprehensively address the main research problem. For clarity, the main research problem, which was originally stated in Section 1.4, is repeated below:

*To what extent may predictions of innovativeness be made determined from relationships between actual risky decision-making behaviour and measures of decision uncertainty and irreversibility, using risk perception and risk propensity as psychographic mediator and moderator respectively, based upon data generated from a full profile conjoint analysis survey and drawn from a population of 400 executives employed by the global resources company BHP?*

The analysis of the results undertaken within this and the prior chapter provides a rich environment that enables a comprehensive set of predictive capabilities that collectively serve to address the main research problem. Of paramount importance to this predictive capability concerning uncertainty and irreversibility is the finding that, unless a specific relationship involves measures that may give rise to a high probability of losses in the present, actual decision-making behaviour will demonstrate risk aversion. That is, when the

level of a predictor variable changes from its low to high state, willingness to engage in risky decision-making behaviour can be predicted to decrease. However, should the relationship in question involve a circumstance that may be conceived as being representative of a high probability of loss in the present, actual decision-making behaviour can instead be predicted to be risk-seeking because as the level of the predictor variable changes from its low to high state, the willingness of the respondent to engage in risky decision-making behaviour increases. This important difference in predicted behaviour, derived from the probability of loss within the decision-making context, is aligned with the central premise of prospect theory (see Kahneman, 2012, Kahneman and Tversky, 1979), and it forms the foundation upon which the suite of predictive capabilities derived through this thesis relies.

Unless one of the levels of a predictor variable is representative of a high probability of loss, predictions of innovativeness can be made based upon changes in the level of the attributes that reflect the underlying variables of uncertainty and irreversibility via a mediation effect through respondent self-reported risk perception. A change in the level of either solution uncertainty, problem uncertainty or irreversible consequence failure can be predicted to cause a corresponding change in the level of risk perception through a positive association with this change in the level of risk perception itself causing change, through an inverse relationship, in the level of innovativeness. For example, in response to a change in the level of any one of these three predictor variables to its high state, it can be predicted that this change will cause a corresponding increase in respondent self-reported risk perception. This increase in risk perception will have the effect of reducing innovativeness through reduced willingness to engage in risky decision-making behaviour. By following similar logical steps, it can also be predicted that a change in the level of any one of these three predictor variables from its high to its low state will cause both a corresponding reduction in respondent self-reported risk perception and an increase in the level of innovativeness. The relationships between each of these three predictor variables, together with respondent risk perception and actual decision-making behaviour, not only provide a predictive capability based upon the results of this thesis, but also serve to meaningfully explain how changes in the level of innovativeness, derived from actual decision-making behaviour, flow from changes in the measures of uncertainty and irreversibility.

For each of these three mediated relationships, explanatory and predictive capability can be further extended through the results of this thesis, demonstrating that respondent risk propensity plays an important moderating role within the decision-making process. It is important to stress that the measurement scale employed within this thesis, upon which the

variable of risk propensity relies, relates to a business-focused domain, as discussed in Section 3.7.3. Based upon the results of this thesis concerning the effect of risk propensity upon decision-making behaviour, three predictive capabilities arise. The first is that the variable of risk propensity, when acting as a moderator of the relationship between risk perception and actual decision-making behaviour, serves to both amplify and attenuate the magnitude of the relationship between risk perception and actual decision-making behaviour based upon variations in its level. The results demonstrate a predictive capability that can be illustrated through the following example. If it is presumed that there are two decision makers—named respondent *a* and respondent *b*—and each responds to an identical set of ten conjoint tasks within the online survey employed by this thesis, but they differ in terms of their level of self-reported risk propensity, differences in their respective decision-making behaviours may be predicted to manifest as follows. Respondent *a*, who self-reports a greater level of risk propensity than respondent *b*, will, for each relative difference in the level of risk perception reported for each of the ten conjoint tasks by *a* and *b*, display a greater magnitude of variation in the level of innovativeness through their decision-making behaviour than will respondent *b*, who reported a lower level of risk propensity. That is, the effect of a greater level of risk propensity reported by respondent *a* leads to the amplification of the relationship between the variables of risk perception and willingness to engage in risky decision-making behaviour, which is the means through which innovativeness is measured, relative to respondent *b*. Conversely, the effect of the lesser level of risk propensity reported by respondent *b* leads to the attenuation of the relationship between the variables of risk perception and innovativeness relative to respondent *a*.

As a consequence of this moderating effect, the range of variation in the level of innovativeness exhibited by respondents with higher levels of risk propensity may be predicted to be greater than what is exhibited by respondents with lower levels of risk propensity, as those with higher levels of risk propensity demonstrate, within their decision choices, greater behavioural responsiveness to change. This greater level of behavioural responsiveness to change also indicates, based upon the results obtained in regard to the moderation analysis, that respondent risk propensity bears a bivariate relationship to innovativeness, which was found to be supported through the analysis. This outcome enables the second predictive capability in regard to the variable of risk propensity. That is, as the level of risk propensity increases, so does the general level of innovativeness and, because of this, the likelihood of an innovation being adopted may increase. The third predictive capability that arises from this thesis in regard to the variable of risk propensity is

that increased levels of self-reported risk propensity are shown to be associated with lower levels of risk perception.

The final element to be discussed within this section in regard to conclusions about the main research problem of this thesis concerns the extent to which predictions of innovativeness may be made based upon the moderating effect of high probability or certain losses in the present within the overall decision context. The results show that irreversible consequence postponement—a dichotomous variable in which one level reflects high-probability losses while the other does not—gives rise to a moderation effect through the relationship between the variables of risk perception and innovativeness for all cases where risk aversion has been observed. The magnitude of the moderation effect was shown to be greater when irreversible consequence postponement was in its high state compared with when it was in its low state. That is, the high-state level of the moderating variable of irreversible consequence postponement—which reflects a high probability of loss in the present unless a decision was made to race at Ponoco in an attempt to reduce the probability of loss—was shown to have a greater effect upon the level of innovativeness than the low-state level, where this probability did not exist. This leads to the conclusion that the respondents displayed a greater level of innovativeness when faced with a high probability of loss in the present than when this was not so. From this, it can be predicted that when faced with a circumstance that represents, among other things, a high probability of loss in the present unless action is taken, decision makers will display a greater level of innovativeness than in circumstances where this probability is absent. Consistent with the principles of prospect theory (see Harbaugh et al., 2010, Kahneman, 2012, Kahneman and Tversky, 1979, Levy, 1992, Lewandowski, 2017), this moderated mediation effect, derived from the variable of irreversible consequence postponement, gives rise to risk-seeking behaviour when the immediate circumstance can be characterised as being within the domain of high-probability losses. When this is so, the results demonstrate that the survey respondents were significantly less inclined to preserve their decision choice options for the future.

These conclusions regarding the main research problem can be framed, in a synthesised form, based upon the analytic model developed in Chapter 4 and depicted in Figure 7.1. All significant relationships relevant to the main research problem are shown in Figure 7.1.

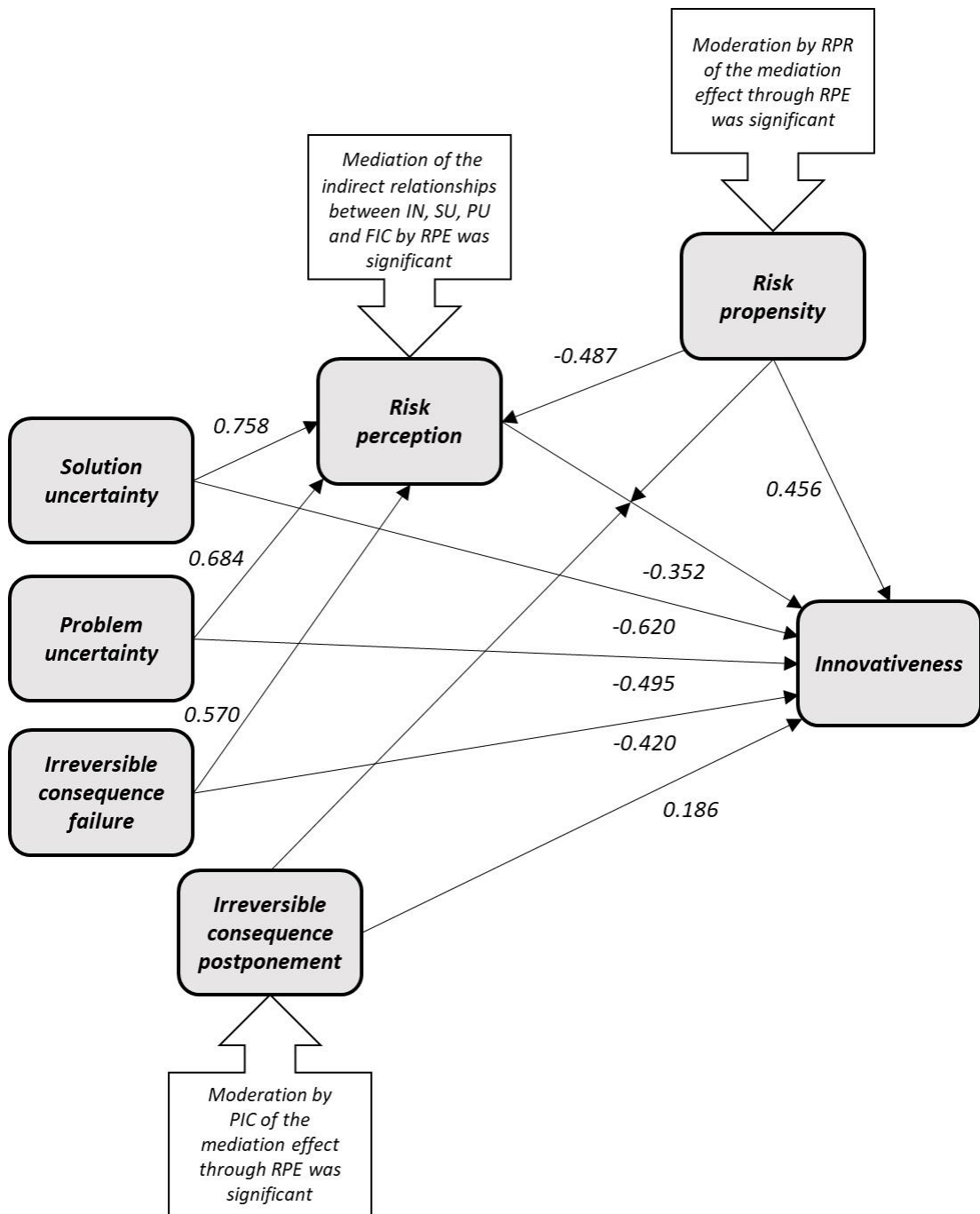


Figure 7.1: Conclusions drawn in response to the main research problem

Throughout this section, the question of the extent to which predictions of innovativeness may be made based upon the relationships between actual risky decision-making behaviour and measures of decision uncertainty and irreversibility, and using risk perception and risk propensity as psychographic mediator and moderator respectively, has been thoroughly addressed. A range of findings have been stated within this and the prior chapter that have enabled the predictive relationships identified and explained in this section. These findings



and predictive capabilities have closed the gaps identified within the literature, as discussed within Section 2.6. Accordingly, this thesis has made the following contributions to the body of knowledge:

1. Through the use of a CVA survey methodology, an empirically derived model of decision making has been formed that explains, for the circumstances described, the decision-making preferences of actual decision makers concerning the adoption of an innovation based upon variation in the levels of the variables of uncertainty and irreversibility.
2. The approach employed within the thesis has demonstrated how, for what is believed to be the first time, the separate quantitative methodologies of CVA and multi-level mediation and moderated mediation analysis can be integrated to create a novel analytical approach that enables both the analysis of decision-making preferences and the means through which factors such as survey respondent psychometric characteristics may influence, affect and limit actual decision-making behaviour within one overall process.
3. An empirically derived understanding of how decision-makers' perceptions of risk concerning the adoption of innovation affect innovativeness and innovation diffusion rates, and how they are affected by variations in the level of both decision uncertainty and decision outcome irreversibility.
4. An empirically derived understanding of how the risk propensity of decision makers influences their investment decision-making behaviour, innovativeness and innovation diffusion rates.
5. From the analysis undertaken concerning the effect of decision outcome irreversibility upon innovativeness, a hitherto unexplored yet important association has been identified between prospect theory and the body of knowledge that represents the theories of innovation in relation to the effect of high-probability losses upon innovation-related decision-making behaviour and innovativeness.
6. In its entirety, this thesis provides valuable insights into the processes through which executive-level leaders within the BHP organisation make decisions when faced with problems that can be characterised as being ambiguous in nature, their causes unclear and essential pieces of information required to solve them are somewhat contradictory or unavailable.

These contributions are discussed within the following two sections of this chapter in regard to their implications for both theory and practice.

#### **7.4 Implications for theory from conclusions about the main research problem**

Of the six contributions (summarised in Section 7.3) made by this thesis to the body of knowledge concerning processes of decision making and theories surrounding both innovation and prospect theory, all but the last one have direct implications for theory. Before advancing the discussion concerning the theoretical implications, it is important to address the fact that this thesis has relied upon a hypothetical circumstance, and the real-life behaviour of the survey respondents may differ from what they indicated through the survey methodology. While this circumstance was mentioned as a limitation of the study in Section 1.8, reliance upon hypothetical case studies and willingness-to-pay scenarios for the purpose of behavioural modelling has been criticised within the literature (see Meyerhoff, 2006). This criticism has typically been focused upon scepticism surrounding the reliability and validity of the relationships between behavioural intentions, attitudes towards behaviour and actual real-life behaviour, if this is indeed possible to measure (Ajzen et al., 2004, Kahneman et al., 1993, Meyerhoff, 2006).

Notwithstanding these criticisms, it is considered sufficient for the purposes of this study to recognise the possibility that the behavioural intentions expressed by the respondents within each conjoint task may not reflect their actual behaviour within a real-life environment, if it were in fact possible to measure it. In support of this position, and as a partial counterbalance against criticism of it from the perspective of reliance upon hypothetical case studies, the use of CVA for the purpose of identifying preferences associated with actual decision choices has been considered for some decades to be a well-established and reliable means of gaining insights into actual choice-making behaviour (Green and Srinivasan, 1978, Louviere, 1988, Orme, 2014, Rao, 2014, Steiner and Meißner, 2018). An opportunity nonetheless remains in related future research efforts to relax this limitation by examining real-life decision-making behaviour as well as testing, for example, whether an adjustment factor may be necessary to account for any effect resulting from the use of hypothetical descriptions, as was employed by Ajzen et al. (2004). This opportunity is again mentioned in the implications for further research in Section 7.7.

The implications for theory that flow from this thesis can be best illustrated through reference to that described in Section 2.2 concerning Schumpeter's theory of economic development (Schumpeter, 1951, Sweezy, 1943) and the structural model from the literature review chapters, which is repeated in Figure 7.2. As stated in Chapter 2, the diagram depicted in Figure 7.2 incorporates the three constructs that are widely considered the foundation elements of much of Schumpeter's theory (Becker et al., 2012, Croitoru, 2013, Godin, 2008a, Sundbo, 1998, Sweezy, 1943) and that comprise much of the parent and immediate discipline literature fields of this thesis. As mentioned in Chapter 2, these three constructs are:

1. the abstract notion of an economic system within which change, but not growth, is assumed to be absent (Hansen, 1938, Schumpeter, 1951, Sweezy, 1943)
2. the introduction of a new external force, arising through innovation, that is sufficiently large to influence and disturb the equilibrium of the abstracted economic system (Courvisanos and Verspagen, 2002, Hansen, 1938, Rogers, 2003, Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943)
3. the entrepreneur who is accountable for the introduction of innovation and thus the causative factors in change to a stable economic system in circular flow (Courvisanos and Verspagen, 2002, Hansen, 1938, Schumpeter, 1951, Sundbo, 1998, Sweezy, 1943).

Figure 7.2 also includes the two psychometric parameters of risk perception and risk propensity, which are vital to this thesis, as mentioned in Chapter 3, but which were not explicitly considered by Schumpeter in the theory of economic development (Schumpeter, 1951, Sweezy, 1943).

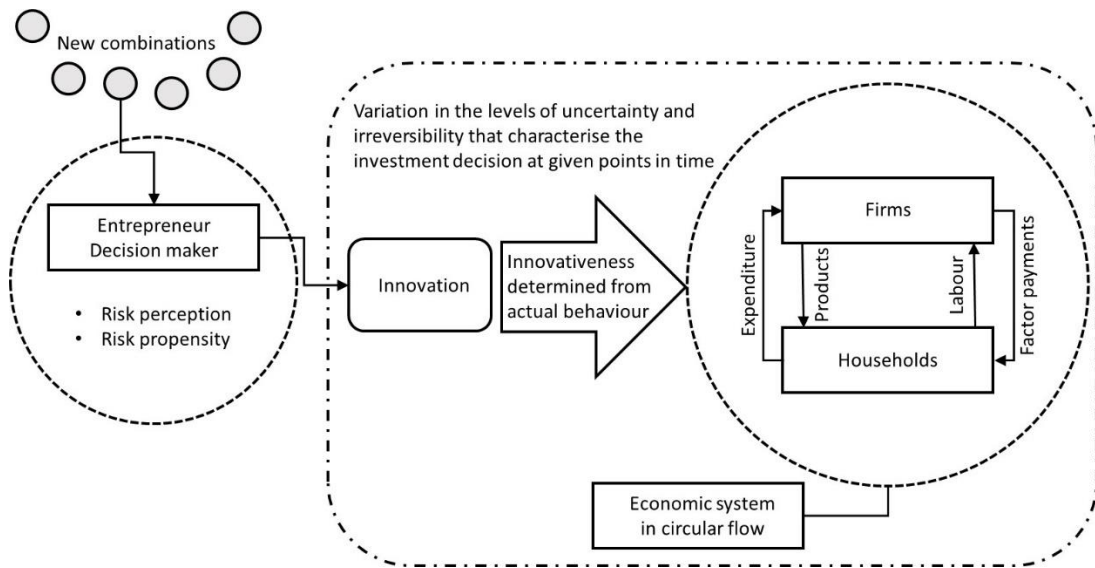


Figure 7.2: The structural model repeated from Figure 2.1

The three principal components of Schumpeter's theory of economic development (Schumpeter, 1951, Sweezy, 1943) and the theories of innovation generally, as illustrated, for example, by Godin (2008a) and Rogers (2003), have focused primarily upon the steps within the processes of innovation and the nature of those steps. To this point, the combined influence of uncertainty and irreversibility has largely been absent from analysis within the literature concerning the adoption and diffusion of innovations, as has the influence of risk-related psychographic characteristics associated with the decision maker. This is demonstrated by the gaps within the relevant literature, as discussed in Section 2.6. The focus of the literature has instead been upon issues such as:

- the definitions of innovation
- the environment within which the diffusion of innovation occurs
- the steps that comprise the innovation adoption process
- the nature of diffusion within a social system
- innovativeness as a conceptual construct
- the categorisation of individual adopters of innovation into adoption categories
- differences between consumer and organisational settings
- the consequences of innovation.

The output from this thesis materially contributes to and extends this body of knowledge in that it serves to explain how the two psychographic variables of risk perception and risk propensity give rise to variations in the level of innovativeness demonstrated by decision makers, as well as the mechanism through which these causes of variation have their effect. Similarly, the results have important theoretical implications in regard to the empirical appreciation of how differing levels of uncertainty surrounding an innovation adoption choice combine with differing levels of decision outcome irreversibility to cause variations in the level of decision-maker innovativeness.

The theoretical implications of this thesis are important, as the results generated through it provide insights into previously unexplored dimensions of innovation-based decision making, and through these insights, a new theoretical model is illuminated. The relationships depicted in Figure 7.2 can be amended to properly incorporate the findings of this study and, in doing so, better illustrate how the levels of decision uncertainty and decision outcome irreversibility associated with an innovation combine with the risk perceptions and risk propensity of decision makers to cause variations in innovativeness. The amended diagram is shown in Figure 7.3, which combines the original structure from Figure 7.2 with the synthesised results generated through this thesis as shown in Figure 7.1. That is, Figure 7.3 incorporates within a single diagram both the composition and arrangement of the three constructs that comprise Schumpeter's theory of economic development (Schumpeter, 1951, Sweezy, 1943), as well as the findings of this thesis in their entirety. Accordingly, Figure 7.3 also positions the findings from this thesis relative to the background and parent literature field upon which this thesis relies.

It is important to note that Figure 7.3 shows only the sign of the significant relationships and not the strength. This is to focus attention upon the nature of the significant relationships and the implications of them.

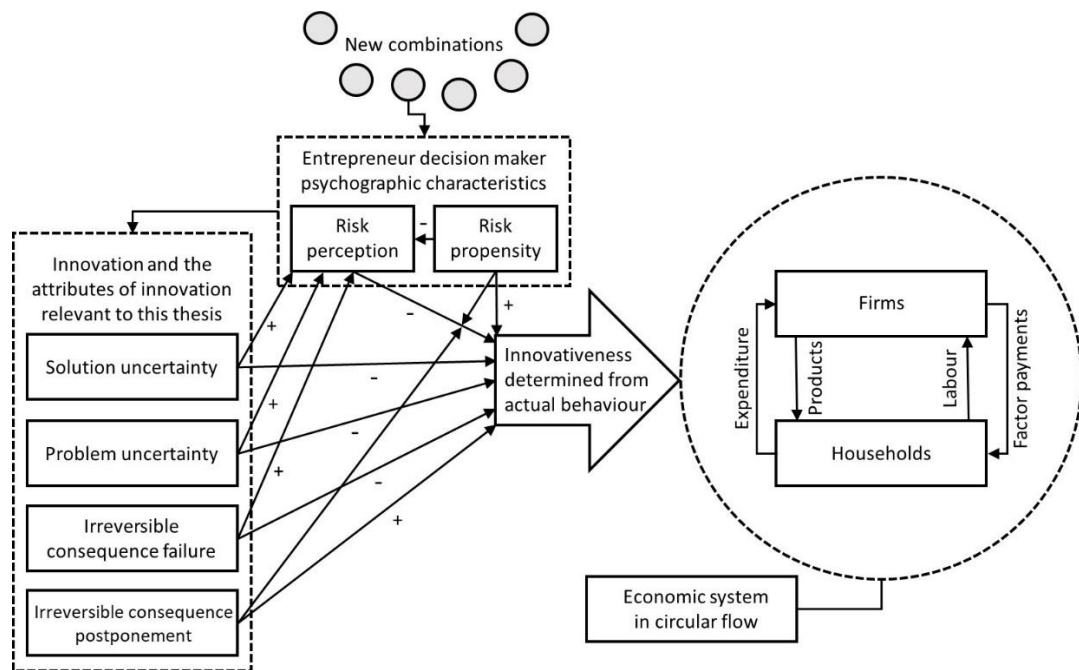


Figure 7.3: The results from this thesis integrated with the structural model

Through the new theoretical model depicted in Figure 7.3, and considering the six contributions to knowledge made by this thesis, which are summarised at the conclusion of the prior section within this chapter, three themes can be abstracted that capture the essence of the implications for theory arising from the conclusions made about the main research problem. These three themes are discussed below.

#### 7.4.1 Mediation of risk-averse relationships by risk perception

The first abstracted theme of theoretical importance concerns the mediating effect of risk perception upon the indirect relationships between innovativeness and the three predictor variables that were shown to exhibit risk-averse direct effect relationships with innovativeness. There are three principal reasons why this theme has important implications for theory:

- The first implication is that the risk perception of the decision maker has been shown within the unit of analysis for this thesis to be an important determinant and predictor of innovativeness. The analysis has demonstrated, as shown in Figure 7.3, that through the measurement of perceptions of risk, important explanatory insights

concerning both the nature and strength of the relationships within the decision-making context may be understood, which influence the adoption of innovation. This finding is significant because within the relevant literature concerning theories of innovation, nothing similar has been found concerning risk perception and its relationship with either innovativeness or the diffusion of innovation through a mediation effect. Therefore, it is argued that, from this perspective alone, a significant and original contribution to knowledge can be claimed.

- The second implication is that the significance of perceptions of risk was only apparent when decision makers exhibited risk-averse preferences in regard to direct effect relationships between the predictor variables of interest and innovativeness. Where risk-seeking preferences were exhibited, risk perception did not exhibit a mediating effect within the relationship. This finding is significant because it demonstrates that, as a minimum, within the context of this thesis, different decision-making influences are at play depending upon whether the decision context can be considered within the domain of high-probability losses. While this thesis does not enable further examination of the decision-making mechanisms in regard to this, it nevertheless indicates that a phenomenon that is of considerable interest and worthy of further exploration exists in terms of the mediating effect of risk perception across the domains of gains and losses as defined by prospect theory (Kahneman and Tversky, 1979).
- The third implication is that the analysis undertaken within this thesis in regard to the measurement scale employed for the evaluation of risk perception demonstrates this risk perception scale to be reliable and unidimensional in nature, which lends support to arguments in favour of its validity and hence use within future studies where it may prove suitable. Given the scope and nature of the implications for future research that arise from this thesis, as summarised in Section 7.7, the performance of the measurement scale in this instance may prove to be of value.

#### **7.4.2 Moderation of the mediation effect by risk propensity**

The second abstracted theme of theoretical importance concerns the moderating effect of risk propensity upon the indirect relationships that was found to exist between each of the predictor variables that exhibited risk-averse direct effect relationships with innovativeness and that was, through the indirect relationship via risk perception, shown to be mediated by

that variable. As explained in Section 2.6, no prior research could be identified that examined the moderating effect of risk propensity upon innovativeness. Indeed, when the scope of investigation was widened further, only Hatfield and Fernandes (2009) were found to have addressed the question of the moderating relationship between risk propensity and any form of risky decision behaviour. While the findings within this thesis in regard to risk propensity are limited to the fixed slope regression case only, as explained in Section 7.2.5, the findings are nevertheless significant in regard to the theories of innovation because they enable a greater level of understanding about the decision processes that lead to the adoption of innovation.

These findings provide both an explanation of actual behaviour and the potential—given the scarce amount of prior research concerning the moderating effect of this variable upon actual decision-making behaviour and innovativeness—to spark further interest concerning how and through what means self-reported risk propensity may be used to predict risky decision behaviour in a more general sense. Lastly, and similar to that stated in regard to the measurement scale employed for the evaluation of risk perception, the measurement scale for risk propensity proved to be reliable and unidimensional within this study, which lends support for its application within future research provided that proper consideration is given to its domain-specific nature.

### **7.4.3 Innovativeness and the domain of high-probability losses**

The third abstracted theme of theoretical importance is the effect of high-probability losses in the present upon innovativeness. Within this thesis, in the absence of high-probability losses in the present, respondent decision-making behaviour exhibited a preference for risk aversion measured through relationships between the relevant predictor variables and innovativeness both directly and indirectly, with risk perception acting as a mediator of the relationships. However, it has been found within this thesis that where the probability of loss in the present was very high or certain, decision-making behaviour exhibited a risk-seeking preference. It has also been shown within this thesis that the presence of high-probability losses in the present can give rise to a moderating effect upon the indirect relationships between the predictor variables and innovativeness via risk perception and the recognition of option value in the absence of such a condition. This distinction between risk aversion and risk-seeking within the context of innovation and innovativeness, based upon the probability of loss in the present, is significant because it provides an insight into an important and



hitherto unexamined association between the processes of innovation (Rogers, 2003) and prospect theory (Kahneman and Tversky, 1979) and is of theoretical relevance.

This novel association provides an important theoretical linkage between that which can be described as comprising the body of knowledge surrounding innovativeness and the processes of innovation (Godin, 2017, Rogers, 2003, Sundbo, 1998, Tarde, 1903) and the two domains of losses and gains described by prospect theory—each categorised into high- and low-probability groups—together with the attendant behavioural implications (Harbaugh et al., 2010, Kahneman and Tversky, 1979). This third abstracted theme is considered to have important theoretical implications because it represents the creation of an opening that is thought to enable access into an unexplored field that is believed to exist between these two well-established theoretical realms. Hence, it is argued that these findings provide valuable insights into possible future research opportunities. It is anticipated that future research efforts directed towards this intersection between prospect theory (Kahneman and Tversky, 1979) and the theory of innovation diffusion (Rogers, 2003) may give rise to valuable knowledge that will help to better explain the uptake of innovation within differing decision-making domains.

### **7.5 Implications for practice from conclusions about the main research problem**

From a practical perspective, the primary contribution of this thesis is that it provides insights into the means through which executive-level leaders within the BHP organisation make decisions when they are faced with decision problems that are ambiguous in nature, unclear in regard to cause-and-effect relationships, and for which essential pieces of information required to solve them are contradictory or unavailable. Importantly, this contribution is aligned with comments made by the Nobel Prize–winning Professor Daniel Kahneman during an interview (Schrage, 2002, p. 6), when he said that:

*If I had one wish, it is to see organisations dedicating some effort to study their own decision processes and their own mistakes, and to keep track so as to learn from those mistakes.*

As such, the practical implications of this thesis principally pertain to the possibility that organisational leaders and decision makers may learn through the work that has been undertaken and, from this, possess a greater understanding and appreciation of the manner through which individual decision makers arrive at different decision outcomes concerning the same decision context. These learning opportunities may be categorised into three groups. The first is the process employed within this thesis for the examination of relationships, the second is the influence of the two psychometrics variables of risk perception and risk propensity upon innovativeness and risky decision-making behaviours generally, and the third is the effect of perceived high-probability losses in the present upon innovativeness. Each opportunity is discussed separately below, and each has a different focus compared with the attributes of the Post Investment Review process that currently exists within BHP. The purpose of this process is to examine the extent to which an investment meets expectations and to verify actual performance outcomes against the plan. In a similar way to how organisations, leadership teams and teams generally may use Myers–Briggs Type Indicator tests to gain a better understanding of the psychological types and cognitive preferences of the individuals that complete them (see Cunningham, 2000), an opportunity arising from this thesis is for teams and organisations to explore their decision-making processes. The research methodology employed within this thesis, which combines CVA with multi-level mediation and moderated mediation analysis, as well as the analysis subsequently undertaken, can be readily adapted to suit the needs of organisations and teams of various sizes and circumstances to enable them to gain a better understanding of their decision-making behaviours and, through that, to learn and improve. For example, the number of conjoint tasks could be reduced to match the needs of the circumstances, and the number of attributes in question could be similarly reduced to correspond to the reduced number of conjoint tasks. The nature of the attributes could be changed to reflect specific needs other than measures of uncertainty or irreversibility.

The methodology employed within this thesis may also be adapted to dovetail with the processes of actual decision making within organisations for real-time investment decisions. This could enable leadership teams to better understand how and for what reason individual decision makers adopt differing positions in regard to investment decisions based upon variations in the level of certain parameters of interest and their own perceptions of risk and risk propensities. Independent of how it may be adapted, the practical implications of this thesis arise from the opportunity for organisations and teams to use the knowledge created through its development to gain insights into how the characteristics of a circumstance,

perceptions of risk that arise based upon that circumstance and decision-maker risk propensity combine to affect their risky decision choices. Through this, organisations, teams and individuals may learn, and this may lead to development in capability and improvement in the quality of future risky decision-making processes and behaviour.

Further implications for practice arise from the predictive strength of the mediator variable of risk perception within this thesis, and its effect upon decision-making behaviour. On the assumption that risk perception shows similar levels of predictive power when coupled with other predictor variables within differing contexts, the simple method of evaluating an individual's perceptions of risk within differing contexts could in itself be a parsimonious means through which to better understand the preferences and decision-making traits of individuals within teams and organisations. Seeking to better understand the range of risk perceptions among team members could prove to be a valuable capability for the purpose of increasing the level of diversity within teams.

A significant body of evidence demonstrates a strong connection between greater levels of diversity within teams and superior levels of performance (Hunt et al., 2014, Hunt et al., 2018, Phillips et al., 2008). In a comprehensive study of the relationships between team performance and diversity, Phillips et al. (2008) established that heterogeneity within teams may boost team performance and improve decision outcomes. Greater heterogeneity was shown by Phillips et al. (2008) to encourage a more careful examination of assumptions, information and information processing mechanisms. Phillips et al. (2008) also argued that an improvement in the effectiveness of problem solving and decision outcomes is a consequence of an increase in the exchange of different ideas, the presence of a greater range of conflicting opinions and more disagreement based upon opposing points of view. Similar claims to those of Phillips et al. (2008) regarding the beneficial effects of diversity upon team performance were made by McKinsey and Company based upon the outcomes of separate studies (Hunt et al., 2018). Both Phillips et al. (2008) and Hunt et al. (2018) identified a myriad of different forms through which diversity can be considered. Given the nature of the relationships identified through this thesis, the conscious shaping of teams in regard to differing perceptions of risk held by prospective team members may prove to be a valuable enabler of business performance within contexts where innovation and innovativeness is paramount. It is anticipated that this will be especially applicable in instances where teams are formed and reformed to meet the changing demands of businesses operating within dynamic environments.

Further, based upon the nature of the relationship observed between decision-maker risk propensity and perceptions of risk within this thesis, a similar argument can be made regarding risk propensity. It was shown that a significant negative correlation exists between self-reported levels of risk propensity and risk perception, and that the self-reported risk propensity of individuals has a significant positive correlation to the probability of them engaging in risky decision-making behaviour. Given this, and given that the level of self-reported risk propensity varied significantly across the survey respondents, it is argued that self-reported risk propensity may also be an insightful and easily measured dimension of diversity that warrants consideration when contemplating the composition of teams. This claim is based upon the findings of Hunt et al. (2018) and Phillips et al. (2008), as mentioned previously, and it is considered applicable both within the workplace and within other contexts where the evaluation of risk is materially important to performance.

The third and final implication for practice to be discussed within this section is the effect of perceived high-probability losses within the present upon innovativeness. Within the relevant literature, a comprehensive body of evidence supports the arguments advanced by Kahneman and Tversky (1979) regarding the influence and effect of high-probability losses upon decision-making behaviour and how this may cause an otherwise risk-averse decision maker to demonstrate risk-seeking behaviours. There is also a body of evidence that disputes these effects (see Sitkin and Weingart, 1995). Regardless of the contradiction within the literature, a developmental opportunity arises from the results of this thesis for BHP executives, business managers and other decision makers to learn from actual behaviour so they may become more conscious of how their risk-seeking tendencies may be exhibited in response to framing effects that emphasise the possibility of high-probability losses in the present. Through conscious awareness of this effect and behaviour tendency, and as a consequence of greater attention being placed upon issue definition to improve the understanding of decision framing and how this may affect behavioural responses, it is possible that this knowledge may lead to better and more informed decisions being made in the future.

## **7.6 Reflections and limitations arising from these reflections**

Beyond the limitations discussed in Section 1.8, several reflections have arisen throughout the course of this thesis that are worthy of mention prior to addressing the implications for further research. This thesis has addressed only a small part of an overall picture that

concerns the processes of risky decision-making behaviour; indeed, it is considered upon reflection that little more could be included within this thesis to capture some of what has been excluded from it. Nevertheless, the small part that has been addressed herein is believed to represent something that is both novel and valuable and that has not, until this point, been explored to the level done so within this thesis. The enormity of the variables that are at play within the context under examination, as well as the relationships that exist between them, provides a fertile environment for further research, and it is hoped that this thesis may provide a launching place for future work of this nature. It is perhaps the conscious recognition of the relationships that may exist between the variables that could be at play within the context of risky decision-making behaviour that provides the starkest lesson upon reflection, as does the importance of adopting a systems perspective when considering matters such as this.

### **7.7 Implications for further research**

The product of this thesis is a comprehensive appreciation of a range of relationships that have been identified as existing among the variables under consideration based upon and limited by the unit of analysis specified within this thesis. These relationships are depicted in Figure 7.3. As stated in Section 7.6, this thesis has examined only a small subset of the variables that may contribute to risky decision-making behaviour and the relationships that may exist between those variables. The results of this thesis suggest that a broad range of related research opportunities exist upon which future research may be focused. Accordingly, the implications for future research that arise from this thesis can be categorised into nine groups:

1. testing of the relationships examined through this thesis using the same analytic model but within different contexts of analysis and using a different case study for the purpose of expanding the generalisability of the work
2. substitution of predictor variables and attribute levels within the analytic model structure to test the repeatability of the key relationships
3. inclusion of additional variables within the analytic model to test the effect upon model performance

4. accommodation of variation in the value of the initial investment amount to test its influence upon decision-making behaviour
5. testing of the analytic model using an actual decision circumstance rather than a hypothetical case to verify whether the findings from this thesis hold true within that environment
6. further examination of the manner through which risk perception may act as a mediator of relationships between predictor variables of interest and risky decision behaviour across the frames of losses and gains while ranging the probabilities of loss and gain
7. further examination of the domain-specific nature of risk propensity to better understand and appreciate both its nature and limitations
8. testing of the moderating effect of risk propensity upon other indirect decision-making relationships to examine the generalisability of the effect
9. refinement of the measurement scales for the self-evaluation of both risk propensity and risk perception.

In each category, the implications for further research stem from relaxation, to some extent, of the limitations that applied to this thesis, which are expressed in Section 1.8. The literature concerning innovativeness since the time of Tarde (1903) has typically focused upon the processes of innovation, the nature of the steps that comprise these processes and how diffusion occurs within social systems (see Rogers, 2003, Sundbo, 1998, Tarde, 1903). Within the literature, scant evidence exists to link the theories of innovation with prospect theory using quantitative approaches and empirical analysis. This thesis has shown that innovativeness is dependent upon both the risk perceptions and risk propensity of the individual who is contemplating a decision to adopt an innovation within a given context. This thesis has also shown that the adoption decision is affected by both uncertainties surrounding the investment decision and the irreversibility of the decision choice options. The potential for high-probability losses in the present has been shown in this thesis to cause otherwise risk-averse behavioural preferences to switch to risk-seeking, thus providing evidence to associate the behavioural patterns described by prospect theory to those that represent the theories of innovation. The analytic model of this thesis and the relationships that comprise it, drawn from the results achieved through this study—when holistically combined with this apparent linkage between these two theoretical realms—provide a

selection of interesting research opportunities towards which future investigative efforts could be directed.

## **APPENDIX A - Literature review gap verification**



For the purposes of verifying the existence of gaps within the salient literature, a series of searches using the Scopus<sup>1</sup> literature review search engine was systematically conducted using the following 13 sets of search logic term combinations. These 13 search term combinations were selected based upon the overall nature of the six research questions contained in Section 1.4 to validate and enable the claims made in Section 2.6 regarding research gaps within the literature. The 13 searches were undertaken progressively over time to check whether any changes within the body of relevant literature was materially relevant to this thesis. No material changes within the literature relevant to this thesis were noted between 17 June 2017 and 14 July 2019. All results mentioned within this appendix are those from the searches conducted on 14 July 2019. The 13 searches have been categorised below to match the four research gaps mentioned in Section 2.6.

### **Research gap 1**

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY (uncertainty))*

This keyword combination focused on innovativeness and uncertainty using the search parameter fields of title, abstract and keywords. This search provided 174 hits, of which 169 were written in the English language. The English language-based documents included articles (110), conference papers (37), conference review papers (8), book chapters (7), review papers (4) and undefined (3).

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY (uncertain))*

This keyword combination focused on innovativeness and the term ‘uncertain’ using the search parameter fields of title, abstract and keywords. This was undertaken to check whether the term ‘uncertain’ yielded more results than the term ‘uncertainty’. This search provided 34 hits, of which 33 were written in the English language. The English language-based documents included articles (22), conference papers (7), book chapters (2), conference review papers (1) and undefined (1).

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY (irreversibility))*

This keyword combination focused on innovativeness and irreversibility using the search parameter fields of title, abstract and keywords. This search provided no results.

<sup>1</sup> <https://www-scopus-com.libproxy.ucl.ac.uk>

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY (irreversible))*

This keyword combination focused on innovativeness and irreversible using the search parameter fields of title, abstract and keywords. This was undertaken to check whether the term 'irreversible' yielded more results than the term 'irreversibility'. This search provided one hit that was written in the English language. This English language-based document was an article.

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY (irreversibility) AND TITLE-ABS-KEY (uncertainty))*

This keyword combination focused on innovativeness, irreversibility and uncertainty using the search parameter fields of title, abstract and keywords. This search provided no results.

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY (uncertainty))*

This keyword combination focused on innovation, adoption and uncertainty using the search parameter fields of title, abstract and keywords. This search provided 486 hits, of which 477 were written in the English language. The English language-based documents included articles (317), conference papers (95), book chapters (24), review papers (22) conference review papers (15), notes (2), short survey (1) and undefined (1).

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY (irreversibility))*

This keyword combination focused on innovation, adoption and irreversibility using the search parameter fields of title, abstract and keywords. This search provided 11 hits, all of which were written in the English language. The English language-based documents included articles (8), review papers (2) and conference review papers (1).

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY (uncertainty) AND TITLE-ABS-KEY (irreversibility))*

This keyword combination focused on innovation, adoption, uncertainty and irreversibility using the search parameter fields of title, abstract and keywords. This search provided 8 hits, all of which were written in the English language. The English language-based documents included articles (6), conference papers (1) and review papers (1).

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY (uncertainty) AND TITLE-ABS-KEY (irreversibility) AND TITLE-ABS-KEY (conjoint) OR TITLE-ABS-KEY (regression))*

This keyword combination focused on innovation, adoption, uncertainty, irreversibility and either conjoint or regression using the search parameter fields of title, abstract and keywords. This search provided no results.

### **Research gap 2**

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY ('risk perception') AND TITLE-ABS-KEY (mediate))*

This keyword combination focused on innovativeness, 'risk perception' and mediate using the search parameter fields of title, abstract and keywords. This search provided one hit, which was written in the English language. This English language-based document was an article.

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY ('risk perception') AND TITLE-ABS-KEY (mediation))*

This keyword combination focused on the innovativeness, 'risk perception' and mediate using the search parameter fields of title, abstract and keywords. This search provided no results.

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY ("risk perception") AND TITLE-ABS-KEY (mediate))*

This keyword combination focused on innovation, adoption, 'risk perception' and mediation using the search parameter fields of title, abstract and keywords. This search provided one hit, which was written in the English language. This English language-based document was an article.

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY ('risk perception') AND TITLE-ABS-KEY (mediation))*

This keyword combination focused on innovation, adoption, 'risk perception' and mediation using the search parameter fields of title, abstract and keywords. This search provided one hit, which was written in the English language. This English language-based document was an article.

### **Research gap 3**

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY ("risk propensity") AND TITLE-ABS-KEY (moderate))*

This keyword combination focused on innovativeness, 'risk propensity' and moderate using the search parameter fields of title, abstract and keywords. This search provided no results.

*(TITLE-ABS-KEY (innovativeness) AND TITLE-ABS-KEY ('risk propensity') AND TITLE-ABS-KEY (moderation))*

This keyword combination focused on innovativeness, 'risk propensity' and moderation using the search parameter fields of title, abstract and keywords. This search provided no results.

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY ('risk perception') AND TITLE-ABS-KEY (moderate))*

This keyword combination focused on innovation, adoption, 'risk propensity' and moderate using the search parameter fields of title, abstract and keywords. This search provided no results.

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY ('risk perception') AND TITLE-ABS-KEY (moderation))*

This keyword combination focused on innovation, adoption, 'risk propensity' and moderate using the search parameter fields of title, abstract and keywords. This search provided no results.

### **Research gap 4**

*(TITLE-ABS-KEY (innovation) AND TITLE-ABS-KEY (adoption) AND TITLE-ABS-KEY (irreversibility) AND TITLE-ABS-KEY (option))*

This keyword combination focused on innovation, adoption, irreversibility and option using the search parameter fields of title, abstract and keywords. This search provided 8 hits, all of which were written in the English language. The English language-based documents included articles (6), conference papers (1) and review papers (1).

## **APPENDIX B - Carter Racing case study**

## **Carter Racing Car Team**

'What should we do?'

It was now 9am and Pat Carter had only one hour to make a final decision if they were to be ready to race in time for the 11am start of the Ponoco race, and Pat was not sure what to do. But Carter's brother and partner, Fred, was on the phone and needed a decision. Should they run in the race or not? It had been a successful season so far, but the Ponoco race was important because of the prize money and publicity it promised. This first year had been hard because the team was trying to make a name for itself. They had run a lot of small races to get this shot at the bigtime. A successful outing could mean more sponsors, a chance to start making some profits for a change, and the luxury of racing only the major events. But what if they suffered another engine failure on national television?

Just thinking about the team's engine problems made Pat wince. They had blown the engine seven times in 24 outings this season with varying degrees of damage to the engine and race car. No one could figure out why. It took a lot of sponsor money to replace a \$20,000 racing engine, and the wasted entry fees were no small matter either. Pat and Fred had everything riding on Carter Racing. This season had to be a success.

Paul Edwards, the engine mechanic, was guessing the engine problem was related to ambient air temperature. He argued that when it was cold the different expansion rates for the cylinder head and engine block were damaging the head gasket and causing the engine failures. It was below freezing last night, which meant a cold morning for the race.

Tom Burns, the chief mechanic, did not agree with Paul's 'gut feeling'. He pointed out that the gasket failures had occurred across a range of temperatures, which meant temperature was not an issue. Tom had been racing for twenty years and believed that luck was an important element in success. He had argued this view when he and Pat discussed the problem last week: 'In racing, you are pushing the limits of what is known. You cannot expect to have everything under control. If you want to win, you have to take risks. Everybody in racing knows it. The drivers have their lives on the line, I have a career that hangs on every race, and you guys have got every last dollar tied up in the business. That's the thrill, beating the odds and winning'. Last night he added to this argument by stating forcefully 'Nobody ever won a race sitting in the pits'.

Pat, Fred and Tom discussed Carter Racing's situation the previous evening. This first season was a success from a racing standpoint. Just the other day, Tom had said: 'In comparison

with some other teams, we have done extremely well this season'. Tom proudly reeled off their impressive record for the season. 'Out of the 30 race season, we finished fifteen of the twenty four we raced. When we finished, we were in the top five 67% of the time (10 of the 15 races). We blew our engine in seven races, so our rate of blowing engines is 29%. But we are running fast, so we have to expect some difficulties. I'm not happy with the engine problems, but I will take the four first-place finishes and our success in finishing in the top five over seven blown engines any day. If we continue to run like this, we could have our pick of sponsors. If we win today, we will also get the \$75,000 first place prize. Finishing second through fifth wouldn't be bad either, with an average prize of \$24,000'.

Because of their previous success, sponsorship offers critical to the team's business success were starting to come in. A big break had come recently after the Slippery Rock race, where the team scored its fourth first place finish using a new innovative gasket seating arrangement, the purpose of which it was to reduce the likelihood of engine failure. Goodstone Tyre had finally decided Carter Racing deserved its sponsorship at Ponoco and guaranteed a full season contract for next year if the team's car finished in the top five in this race. The Goodstone sponsorship would be \$300,000 a year, plus incentives. Pat and Fred had received a favourable response from Goodstone's Racing Program Director last week when they presented their plans for next season, but it was clear that his support depended upon the visibility they generated in this race.

'Pat, we only have an hour to decide' Fred said over the phone. 'After paying the Ponoco entry fee, we are \$32,500 in the red, so the prize money, even without the sponsors, could keep us out of debt at the end of the season. But, if we withdraw now, we could recoup some of our losses next season, but we will most likely lose Goodstone for next year. If we run and finish in the top five, we will have Goodstone in our pockets and can add another car next season. You know as well as I do, however, that if we run and lose another engine, we are back at square one next season. We will probably lose the tire sponsorship and a blown engine is surely going to lose us the Dynaco Oil contract. No oil company would want a national TV audience to see a smoker being dragged off the track with their name all over it. The oil sponsorship is \$500,000 that we cannot live without. Think about it, call Paul and Tom if you want, but I need a decision in an hour'.

Pat hung up the phone and looked out the window at the crisp autumn sky. The temperature sign across the street flashed '5 DEGREES CELSIUS 9:23AM'. 'Get Paul Edwards for me', Pat barked into the phone. Pat was in a hurry to find out more about the engine mechanic's

opinion on whether they should race. Although Tom believed temperature was not the problem, Pat wanted to get Paul's direct assessment.

Paul Edwards was a classic 'auto mechanic'. His fingernails were permanently blackened by grease and his clothes never stayed clean for more than two minutes on Saturday mornings. He had been knocking around the professional circuit for ten years after dropping out of school to follow drag racing. He lacked the sophisticated engineering training that was becoming common in racing, but he did know racing engines.

Pat had discussed the gasket problem with Paul two days ago. While waiting for Paul to come to the phone, Pat reflected on their previous conversation. Paul was a man of few words and not given to overstatement. 'The way I see it, the turbo pressure during warm up, in conjunction with the different expansion rates for the head and block, has been causing our problems' was the extent of what he had to say on the situation. It was his personal opinion on the cause of the engine failures and he would never represent it as anything else.

It was the same story Pat had heard twenty times, but it did not match Tom's data. 'Paul, we have discussed this before. How do you know this is the problem? When we ran at Riverside the temperature was 24C and we still lost the gasket and the engine'.

'I'm not sure what happened at Riverside' Paul had replied. 'I am not sure that the temperature is the problem but it is the only thing I can figure out. It is definitely the gaskets that are blowing out and causing the engine to fail'.

Part of Carter Racing's success was due to an innovative turbo-charging system that Tom and Pat had developed. They had come up with a new head design that allowed them to get more turbo pressure to the engine while maintaining fuel consumption at a fairly constant level. By casting the head and turbo bodies in a high-strength aircraft alloy, they had saved almost 25 kilograms of weight. The alloy they were using was not as temperature sensitive as the material in the engine block, but the head gasket should be able to handle the different expansion rates.

Pat could hear the sounds of race day in the background as Paul approached the phone. 'Hello Pat' he said, obviously excited. 'The Goodstone coveralls just got here. We are talking some fine threads, and no sew on patches for these guys. The logo on the back and our names are stitched right into the material. I guess this means we get to keep them. I got some grease on mine already, so they probably won't want them back anyway!'



'I'm glad you like them' Pat said. 'I need to get some information from you. What are we doing about the gasket failures?'

'The car is set to go. We have been using the new gasket seating procedure since Slippery Rock, and have had no problems since then. Tom says the Goodstone deal is set as long as we finish in the top five today. The guys in the shop want this badly. Goodstone is a class act. They can make us the number one team on the circuit if they decide to take us on'.

Pat had only ten minutes and he decided to call Tom. 'Give me the ambient temperatures for the races where we did not have any gasket problems'. Tom said, 'Let's see, we have run 24 races this year, with temperatures ranging from 12C to 29C'. Pat said, 'what about where we did not have problems?' Tom was organised, which counted for a lot at times like this, he said 'ok, they range from 18 to 29C, we've blown gaskets between 12 and 24C. Since the Slippery Rock race, the temperatures been between 23 and 26C'.

Pat plotted the ambient temperature ranges on paper as Tom read them off.

It was now time to call Fred.

**Now you must put yourself in the place of Pat Carter**

**Your Decision:** you now face a tough decision that involves trade-offs, uncertainties and the question of how successful the new innovative gasket seating arrangement has been preventing engine failures. Based on the season so far you have a 42% chance of finishing in the top 5 and securing the \$300,000 tyre sponsorship on top of the current \$500,000 oil sponsorship deal. If you do not race at Ponoco, risk and uncertainty surround your ability to maintain and secure vital sponsorship for next season that is critical for the ongoing financial viability of your racing team.

When ready, please click upon the survey link within the email to which this document is attached to commence the survey. This survey will examine your willingness to race at Ponoco based solely upon the content provided in this case and the additional scenario-based information contained within the survey.

## **APPENDIX C - CVA survey questionnaire specification**

This Appendix contains the specifications necessary for programming of the Sawtooth full-profile CVA software to enable execution of the online survey. The structure of content for the attributes and levels corresponds with the data entry format of the software.

### ***Opening page***

This survey forms the methodology of a study being conducted by Michael Bailey, Dr Ady James and Dr Michael Emes at University College London (UCL) for the purpose of completing the requirements for degree of Doctor of Philosophy.

The study is titled:

Advancing the determinants of risky decision-making behaviour using conjoint and moderated multi-level mediation analysis

Your contribution to this study through the completion of this survey is greatly appreciated.

Please click on the arrow below to advance to the informed consent section of the survey.

### ***Informed consent decision page***

INFORMED CONSENT PRIOR TO PARTICIPATION IN THE ONLINE SURVEY

Title of the research project: Advancing the determinants of risky decision-making behaviour using conjoint and moderated multi-level mediation analysis

Thank you for your interest in taking part in this research. Before you agree to take part, the person undertaking the research must adequately explain the project to you. The Participant Information Sheet included as an attachment to the email from which you accessed this survey performs this purpose. If you have not yet reviewed it, please do so now.

This study has been approved by the UCL Research Ethics Committee (Project ID Number): Z6364106/2017/01/67

### Participant's Statement

I have read the Participant Information Sheet provided, I understand what this project involves and any questions I have asked were answered to my satisfaction. I agree to participate in this activity and acknowledge that I may withdraw at any time without reason or prejudice.

I understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researcher involved and withdraw immediately.

I consent to the processing of information that I provide for the purposes of this research study.

I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998 (UK).

I agree that any information I provide may be shared with other researchers and published provided my name or other identifying information is not used.

Please indicate your decision whether to participate using the voting buttons.

1. Left button text – I agree to participate in the survey
2. Right button text - I do not wish to participate in the survey

Please click on the right arrow below to advance to the next step based on your decision.

### ***Instructions page***

#### SURVEY INSTRUCTIONS

You will be guided through the survey as you click upon the arrows.

To advance to the next page click the right arrow, to return to the previous page click the left arrow.

The survey is structured as follows:

One page for you to make a set of selections that best represent your age group, gender and employment history.

Following this are 10 decision scenarios, each based upon the Carter Racing case, and when completing the survey you must put yourself in the place of Pat Carter.

For each scenario you will be asked to (1) indicate the probability that you would decide to race at Ponoco based upon the additional information contained within the scenario (2) decide whether you would race or not and then (3) make selections that best characterise the decision you face in that particular scenario.

After the ten scenarios, then follows one more page containing five questions concerning decision choice preferences.

The survey requires that all questions must be answered for it to be successfully completed.

Please click on the right arrow below to commence the survey.

***Personal details page***

1. Age

For each of the following, please select which best represents you.

Age group

1. 18 to 35
2. 36 to 45
3. 46 to 55
4. >55

2. Years

Years working for BHP is closest to

1. less than 5
2. 5 to 10
3. 11 to 20
4. >20

### 3. Time

Time in current role (years) is closest to

1. less than 5
2. 5 to 10
3. 11 to 20
4. >20

### 4. Career

Duration of working career to date (years)

1. less than 5
2. 5 to 10
3. 11 to 20
4. >20

### 5. Duration of working career to date (years)

5. less than 5
6. 5 to 10
7. 11 to 20
8. >20

### 6. Level

Grade of current role

1. 14 or less
2. 15 to 16
3. 17 to 18
4. 19 or greater

### 7. Gender

Gender

1. Male
2. Female

**Conjoint task pages**

Scenario #: considering both the additional engine reliability and sponsor funding decision outcomes shown below, what is the probability you would decide to race at Ponoco?

*Scenario (there are 10 scenarios, each with identical text other than the numerals 1, 2, 3.....10).*

Willingness attributes and levels

1. # races completed using new gasket since last failure using old gasket

1. 5

2. 2

2. % of finished races with air temp in 18° C to 24° C range

1. 73%

2. 60%

3. Sponsor funding outcomes if you decide to race and blow up engine

1. Lose oil sponsorship but retain option to negotiate tyre sponsorship

2. Lose both oil and tyre sponsorships

4. Sponsor funding outcomes if you decide not to race

1. Retain options to negotiate both oil and tyre sponsorships next season

2. Retain option to negotiate oil sponsorship next season but lose tyre sponsorship

Dichotomous forced choice question

To ask the question another way for this scenario, would you decide to race or not?

1. In this situation I would race

2. In this situation I would not race

***Risk perception semantic measurement scale***

Slide each button so it best reflects how you characterise the decision you face in this scenario

Semantic scale item descriptor: left hand side

1. Significant opportunity
2. High potential for loss
3. A positive situation
4. Very unlikely to succeed at Ponoco Race

Semantic scale item descriptor: right hand side

1. Significant threat
2. High potential for gain
3. A negative situation
4. Very likely to succeed at Ponoco Race



The visual structure of each conjoint task page presented to the respondent is as follows.

Scenario *n*: considering both the additional engine reliability and sponsor funding decision outcomes shown below, what is the probability you would decide to race at Pocono?

- # races completed using new gasket since last failure using old gasket
- % of finished races with air temp in 18C to 24C range
- Sponsor funding outcomes if you decide to race and blow up engine
- Sponsor funding outcomes if you decide not to race

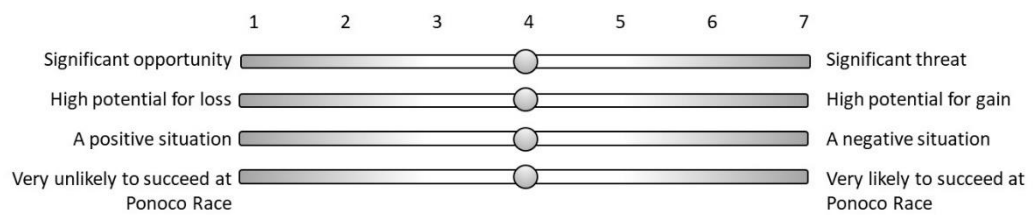
For each conjoint task a discrete set of four attribute levels shown here



To ask the question another way for this scenario, would you decide to race or not?

- In this situation I would race    In this situation I would not race

Slide each button so it best reflects how you characterise the decision you face in this scenario



***Risk propensity measurement scale page***

For each question below, how would you rate your own personal tendency to:

1. Choose more or less risky alternatives based on the assessment of others on whom you must rely
2. Choose more or less risky alternatives which rely upon analyses high in technical complexity
3. Choose more or less risky alternatives which could have a major impact on the strategic direction of your organisation
4. Initiate a strategic corporate action which has the potential to backfire
5. Support a decision when I was aware that relevant analyses were done while missing several pieces of information

Scale of each Likert item

1. Strong tendency to avoid risks
2. 2
3. 3
4. 4
5. 5
6. 6
7. Strong tendency to take risks

The visual structure of the risk propensity measurement scale page is as follows.

For each question below, how would you rate your own personal tendency to:

	Strong tendency to avoid risks	2	3	4	5	6	Strong tendency to take risks
Choose more or less risky alternatives based on the assessment of others on whom you must rely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choose more or less risky alternatives which rely upon analyses high in technical complexity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choose more or less risky alternatives which could have a major impact on the strategic direction of your organisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Initiate a strategic corporate action which has the potential to backfire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Support a decision when I was aware that relevant analyses were done while missing several pieces of information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

***Submit page***

You have now completed the survey.

Please click the right arrow to submit your completed survey.

Alternatively use the left arrow should you wish to adjust any responses prior to doing this.

***Termination page for survey completed selection from submit page***

Thank you for taking the time to completing this survey.

Your time and effort in doing so very much appreciated.

***Termination page for selection from informed consent decision page to not participate***

Your decision not to participate is acknowledged. Thank you.

## **APPENDIX D - Participant information sheet**



## PARTICIPANT INFORMATION SHEET FOR SURVEY

### **Research project title**

Advancing the determinants of risky decision-making behaviour using conjoint and moderated multi-level mediation analysis.

### **Invitation to participate**

We would like to invite you to participate in a project conducted by researchers at University College London (UCL). Before making your decision to participate, it is important for you to understand why the research is being done and what your participation will involve. Please read the following information carefully and discuss it with others if you wish. Do ask if there is anything that is not clear or if you would like more information for it is your decision alone whether you participate.

### **Purpose of the project**

The purpose of this study is to create and test a model of investment decision-making behaviour under conditions of uncertainty and irreversibility. Testing will examine how decision choices are influenced by the combined effect of the level of uncertainty and irreversibility associated with such decisions and the risk appetite of a decision maker measured in terms of individual risk propensity, risk perception and the outcome history from previous decisions in similar circumstances. To this end, an online survey is being used, the purpose of which is to measure the degree to which you are willing to either advance or defer decisions based solely upon a specific standardised case that is provided combined with ten differing uncertainty and irreversibility scenarios. The survey also seeks responses to sets of risk propensity and perception questions from you to understand how individual differences may influence decision choices. This project is being undertaken to fulfil the requirements of a Doctor of Philosophy (Ph.D.) degree.

**Who is undertaking the project?**

The project is being led by Dr. Ady James of UCL. Other members of the research team include Michael Bailey (the Ph.D. student); and, Dr. Michael Emes of UCL.

**Background to the Ph.D. student**

The student is the General Manager of Rail within the Iron Ore Asset of BHP and his previous role was the General Manager of Port within the same asset. He possesses a deep professional and personal interest in decision-making processes, as well as the subject of decision science, and this has manifest itself in a desire to undertake academic research in this field on a part time basis.

**Why are you being invited to participate?**

You have been invited to participate in this project because your organisational level and role within the BHP business is one well suited to the nature of the research due to the requisite decision-making requirements inherent to it. You are one of approximately 400 similar leaders within the BHP business being invited to participate.

**Do I have to take part?**

It is entirely your choice to take part in this survey and you may withdraw from it at any time without reason or explanation.

**What will happen and what do I have to do?**

Your participation will involve reading the case study provided and then complete the online survey accessible via an email link. Completion of the online survey, including reading of the associated case study prior to the survey, should take less than 30 minutes of your time.

**What are the potential disadvantages of taking part?**

There are no foreseeable disadvantages arising from your participation however should you have concerns we encourage you to discuss them with us.

**What are the potential benefits of taking part?**

While there are no immediate benefits from your participation, you will be given the opportunity to access a research paper, to which you have contributed, from which you may learn more about aspects of decision making under conditions of uncertainty and irreversibility. It is thought that this is a modest but valuable benefit that may arise from your participation.

A secondary benefit is the knowledge that through your participation you will have made a meaningful contribution towards the development of one of your colleagues.

**What if something goes wrong?**

This study has been approved by the UCL Research Ethics Committee (Project ID Number: Z6364106/2017/01/67). However, if you have questions or concerns relating to your participation, or you wish to raise a concern or complaint about the project, please contact Dr. Ady James in the first instance. Contact details are shown at the end of this document.

If you wish to speak to an independent person regarding your concerns, understand UCL's policy on research involving human participants, or your rights as a participant, please refer to <https://ethics.grad.ucl.ac.uk/> or contact [ethics@ucl.ac.uk](mailto:ethics@ucl.ac.uk).

**Will my taking part in this research project be kept confidential?**

All information that we collect during this research project will be kept strictly confidential. Data will always be reported in an anonymous manner and no personal information will be divulged. All data will be collected and stored in accordance with the Data Protection Act 1998 (UK).

**What will happen to the results of the research project?**

Completed surveys will be subject to analysis for the purposes of producing a Ph.D. thesis. The data may also be presented within published journals, other reports and other forums including conferences. At no time will you be able to be identified within any ensuing report or publication. You will be given the opportunity to receive a summary of the analysis and results once it is completed.

**Who is organising and funding the research?**

This research project is being organised solely by the student and UCL and the funding source for the project is provided solely through student fees and the student's own funds. Thank you for taking the time to read this briefing note and participating in this research project.

**Contacts for further information**

Dr. Ady James:

Michael Bailey:

Dr. Michael Emes:

## REFERENCE LIST



- Abrams, M. H. 1953. *The mirror and the lamp: romantic theory and the critical tradition*, New York, Oxford University Press.
- Ahlbrecht, M. & Weber, M. 1997. An empirical study on intertemporal decision making under risk. *Management Science*, 43, 813-826.
- Ajzen, I., Brown, T. C. & Carvajal, F. 2004. Explaining the discrepancy between intentions and actions: the case of hypothetical bias in contingent valuation. *Personality and Social Psychology Bulletin*, 30, 1108-1121.
- Althaus, C. E. 2005. A disciplinary perspective on the epistemological status of risk. *Risk Analysis*, 25, 567-588.
- Amundrud, Ø. & Aven, T. 2015. On how to understand and acknowledge risk. *Reliability Engineering and System Safety*, 142, 42-47.
- Anderson, L. & Stafford, S. 2009. Individual decision-making experiments with risk and intertemporal choice. *Journal of Risk and Uncertainty*, 38, 51-72.
- Armstrong, J. S. & Overton, T. S. 1977. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, 14, 396-402.
- Arrow, K. J. & Fisher, A. C. 1974. Environmental preservation, uncertainty, and irreversibility. *The Quarterly Journal of Economics*, 88, 312-319.
- Aslaksen, I. & Synnøstvedt, T. 2004. *Are the Dixit–Pindyck and the Arrow–Fisher–Henry–Hanemann option values equivalent?*, Statistics Norway, Research Department.
- Atif, A., Richards, D. & Bilgin, A. 2012. Estimating non-response bias in a web-based survey of technology acceptance: a case study of unit guide information systems. *23rd Australasian Conference on Information Systems*. Geelong: ACIS.
- Australian National Audit Office 2009. *Innovation in the public sector*, Canberra, Commonwealth of Australia.
- Aven, T. 2010a. A holistic framework for conceptualising and describing risk. *Summer Safety and Reliability Seminars*. Gdańsk-Sopot, Poland.
- Aven, T. 2010b. *Misconceptions of risk*, Padstow, John Wiley & Sons Ltd.
- Aven, T. 2010c. On how to define, understand and describe risk. *Reliability Engineering and System Safety*, 95, 623-631.
- Aven, T. 2011. On the new ISO guide on risk management terminology. *Reliability Engineering and System Safety*, 96, 719-726.
- Aven, T. 2012. The risk concept - historical and recent development trends. *Reliability Engineering and System Safety*, 99, 33-44.
- Aven, T. & Renn, O. 2009. On risk defined as an event where the outcome is uncertain. *Journal of Risk Research*, 12, 1-11.
- Aven, T., Renn, O. & Rosa, E. A. 2011. On the ontological status of the concept of risk. *Safety Science*, 49, 1074-1079.
- Baird, I. S. & Thomas, H. 1985. Toward a contingency model of strategic risk taking. *The Academy of Management Review*, 10, 230-243.
- Baldwin, C. Y. & Meyer, R. F. 1979. Liquidity preference under uncertainty. *Journal of Financial Economics*, 7, 347-374.
- Barnett, H. G. 1953. *Innovation: the basis of cultural change*, New York, McGraw-Hill.
- Baron, R. M. & Kenny, D. A. 1986. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51, 1173-1182.
- Bartlett, M. S. 1954. A note on the multiplying factors for various  $\chi^2$  approximations. *Journal of the Royal Statistical Society: Series B (Methodological)*, 16, 296-298.
- Bauer, D. J., Preacher, K. J. & Gil, K. M. 2006. Conceptualizing and testing random indirect effects and moderated mediation in multilevel models: new procedures and recommendations. *Psychological Methods*, 11, 142-163.
- Bazerman, M. H. 2013. *Judgment in managerial decision making*, New Jersey, Wiley.

- Beck, U. 1992. *Risk society: toward a new modernity*, London, Sage Publications.
- Becker, M. C. & Knudsen, T. 2003. The entrepreneur at a critical juncture in Schumpeter's work: Schumpeter's 1928 handbook entry entrepreneur. *Austrian Economics and Entrepreneurial Studies*.
- Becker, M. C., Knudsen, T. & Swedberg, R. 2012. Schumpeter's theory of economic development: 100 years of development. *Journal of Evolutionary Economics*, 22, 917-933.
- Ben-Akiva, M., McFadden, D., Train, K. & McFadden, D. 2019. Foundations of stated preference elicitation: consumer behavior and choice-based conjoint analysis. *Foundations and Trends in Econometrics*, 10, 1-144.
- Benhamou, R. 1991. Imitation in the decorative arts of the eighteenth century. *Journal of Design History*, 4, 1-13.
- Berenson, M. L. & Levine, D. M. 1999. *Basic business statistics: concepts and applications*, Upper Saddle River, Prentice Hall.
- Berg, M. 1999. New commodities, luxuries and their consumers in eighteenth-century England. In: Clifford, H. (ed.) *Consumers and luxury: consumer culture in Europe, 1650-1850*. Manchester: Manchester University Press.
- Berg, M. 2002. From imitation to invention: creating commodities in eighteenth-century Britain. *Economic History Review*, 55, 1-30.
- Bernanke, B. S. 1983. Irreversibility, uncertainty and cyclical investment. *The Quarterly Journal of Economics*, 98, 85-106.
- Bernstein, P. 1998. *Against the gods: the remarkable story of risk*, New York, John Wiley & Sons.
- Bettman, J. 1973. Perceived risk and its components: a model and empirical test. *Journal of Marketing Research (pre-1986)*, 10, 184-190.
- Bickel, R. 2007. *Multilevel analysis for applied research*, New York, Guilford Press.
- Bishop, R. C. 1982. Option value: an exposition and extension. *Land Economics*, 58, 1-15.
- BITRE 2019. Electric vehicle uptake: modelling a global phenomenon. *Research Report 151*. Canberra: Bureau of Infrastructure, Transport and Regional Economics.
- Blackburn, M. & El-Deredy, W. 2013. The future is risky: discounting of delayed and uncertain outcomes. *Behavioural Processes*, 94, 9-18.
- Bledow, R., Frese, M., Anderson, N., Erez, M. & Farr, J. 2009. A dialectic perspective on innovation: conflicting demands, multiple pathways, and ambidexterity. *Industrial and Organizational Psychology*, 2, 305-337.
- Bollen, K. A. 1989. *Structural equations with latent variables*, New York, John Wiley & Sons.
- Bratvold, R. B. & Begg, S. 2010. *Making good decisions*, Richardson, Society of Petroleum Engineers.
- Brittain, J. & Sitkin, S. B. 1990. Facts, figures, and organizational decisions: Carter racing and quantitative analysis in the organizational behavior classroom. *Organizational Behavior Teaching Review*, 14, 62-81.
- Brockhaus, R. H. 1980. Risk taking propensity of entrepreneurs. *The Academy of Management Journal*, 23, 509-520.
- Bronfenbrenner, M. 1945. Some fundamentals in liquidity theory. *The Quarterly Journal of Economics*, 59, 405-426.
- Bullens, L. 2013. *Having second thoughts: consequences of decision reversibility*, Amsterdam, Universiteit van Amsterdam.
- Bullens, L. & Harreveld, F. 2016. Second thoughts about decision reversibility: an empirical overview. *Social and Personality Psychology Compass*, 10, 550-560.
- Bullens, L., van Harreveld, F. & Förster, J. 2011. Keeping one's options open: the detrimental consequences of decision reversibility. *Journal of Experimental Social Psychology*, 47, 800-805.

- Bullens, L., Van Harreveld, F., Förster, J. & Higgins, T. E. 2014. How decision reversibility affects motivation. *Journal of Experimental Psychology*, 143, 835-849.
- Bullens, L., van Harreveld, F., Förster, J. & van Der Pligt, J. 2013. Reversible decisions: the grass isn't merely greener on the other side; it's also very brown over here. *Journal of Experimental Social Psychology*, 49, 1093-1099.
- Bury, J. E. 1932. *The idea of progress*, New York, Macmillan.
- Campbell, S. 2005. Determining overall risk. *Journal of Risk Research*, 8, 569-581.
- Campbell, S. & Currie, G. 2006. Against Beck: in defence of risk analysis. *Philosophy of the Social Sciences*, 36, 149-172.
- Carifio, J. & Perla, R. 2008. Resolving the 50-year debate around using and misusing Likert scales. *Medical Education*, 42, 1150-1152.
- Cattell, R. B. 1966. The scree test for the number of factors. *Multivariate Behavioral Research*, 1, 245-276.
- Cattin, P. & Punj, G. 1984. Factors influencing the selection of preference model form for continuous utility functions in conjoint analysis. *Marketing Science*, 3, 73-82.
- Cerin, E. & MacKinnon, D. P. 2009. A commentary on current practice in mediating variable analyses in behavioural nutrition and physical activity. *Public Health Nutrition*, 12, 1182-1188.
- Churchill Jr, G. A. 1979. A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research*, 16, 64-73.
- Cicchetti, C. J. & Freeman, A. M. 1971. Option demand and consumer surplus: further comment. *The Quarterly Journal of Economics*, 85, 528-539.
- Clark, D. L. 1951. Imitation: theory and practice in Roman rhetoric. *Quarterly Journal of Speech*, 37, 11-22.
- Clifford, H. 1999. Concepts of invention, identity and imitation in the London and provincial metal-working trades, 1750-1800. *Journal of Design History*, 12, 241-255.
- Cole, A. H. 1949. Entrepreneurship and entrepreneurial history: the institutional setting. In: Cole, A. H. (ed.) *Change and the entrepreneur: postulates and patterns for entrepreneurial history*. Cambridge: Harvard University Press.
- Coltman, T., Devinney, T. M., Midgley, D. F. & Venaik, S. 2008. Formative versus reflective measurement models: two applications of formative measurement. *Journal of Business Research*, 61, 1250-1262.
- Condor, F. R. 1983. *The men who built railways*, London, Thomas Telford.
- Corsini, R. J. & Osaki, B. D. (eds.) 1984. *Encyclopedia of psychology*, New York, Wiley.
- Coulson, R. 1992. Development of an instrument for measuring attitudes of early childhood educators towards science. *Research in Science Education*, 22, 101-105.
- Courvisanos, J. & Verspagen, B. 2002. Innovation and investment in capitalist economies 1870-2000: Kaleckian dynamics and evolutionary life cycles. *Investigación Económica*, 62, 33-80.
- Croitoru, A. 2013. Digging among the roots of entrepreneurship. *Journal of Community Positive Practices*, 13, 92-111.
- Crombie, A. C. 1975. Some attitudes to scientific progress: ancient, medieval and early modern. *History of Science*, 13, 213-230.
- Cropley, D. H. 2015. *Creativity in engineering: novel solutions to complex problems*, London, Academic Press.
- Crowe, R. M. & Horn, R. C. 1967. The meaning of risk. *The Journal of Risk and Insurance*, 34, 459-474.
- Cui, D. & Curry, D. 2005. Prediction in marketing using the support vector machine. *Marketing Science*, 24, 595-615.

- Cunningham, P. B. 2000. Improved communication and teamwork through use of Myers-Briggs type indicator. *Proceedings 1st Austin Workshop on Engineering Management in Technology-Based Organizations*.
- Currim, I. S., Weinberg, C. B. & Wittink, D. R. 1981. Design of subscription programs for a performing arts series. *Journal of Consumer Research*, 8, 67-75.
- Damanpour, F. 1988. Innovation type, radicalness, and the adoption process. *Communication Research*, 15, 545-567.
- Damanpour, F. & Schneider, M. 2008. Characteristics of innovation and innovation adoption in public organizations: assessing the role of managers. *Journal of Public Administration Research and Theory*, 19, 495-522.
- Damanpour, F. & Wischnevsky, J. D. 2006. Research on innovation in organizations: distinguishing innovation-generating from innovation-adopting organizations. *Journal of Engineering and Technology Management*, 23, 269-291.
- Darlington, R. B. & Hayes, A. F. 2017. *Regression analysis and linear models*, New York, Guilford Press.
- De Vries, H., Bekkers, V. & Tummers, L. 2014. Innovation in the public sector: a systematic review and future research agenda. *Ottawa IRSPM Conference*. Ottawa.
- Debreu, G. 1959. Topological methods in cardinal utility theory. *No. 76, Cowles Foundation Discussion Papers*. Yale University: Cowles Foundation for Research in Economics.
- Dewar, R. D. & Dutton, J. E. 1986. The adoption of radical and incremental innovations: an empirical analysis. *Management Science*, 32, 1422-1433.
- Diamond Jr., A. M. 2003. Edwin Mansfield's contributions to the economics of technology. *Research Policy*, 32, 1607-1617.
- Dixit, A. K. 1989. Entry and exit decisions under uncertainty. *The Journal of Political Economy*, 97, 620-638.
- Dixit, A. K. 1992. Investment and hysteresis. *Journal of Economic Perspectives*, 6, 107-132.
- Dixit, A. K. & Pindyck, R. S. 1994. *Investment under uncertainty*, Princeton, Princeton University Press.
- Dixit, A. K. & Pindyck, R. S. 1995. The options approach to capital investment. *Harvard Business Review*, May-June, 105-115.
- Doraszelski, U. 2001. The net present value method versus the option value of waiting: a note on Farzin, Huisman and Kort (1998). *Journal of Economic Dynamics and Control*, 25, 1109-1115.
- Dosi, G. 1982. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research Policy*, 11, 147-162.
- Doszyń, M. 2018. Propensity to risk and the prospect theory: computational methods in experimental economics (CMEE) 2017 Conference. In: Nermend, K. & Łatuszyńska, M. (eds.) *Problems, methods and tools in experimental and behavioral economics*. Cham: Springer Nature Switzerland AG.
- Duncan, R. B. 1972. Characteristics of organizational environments and perceived environmental uncertainty. *Administrative Science Quarterly*, 17, 313-327.
- Dutton, J. & Jackson, S. 1987. Categorizing strategic issues: links to organizational action. *Academy of Management. The academy of management review*, 12, 76-90.
- Easton, M. D. 2015. *Gender-pay inequality and organizational culture: a multi-organizational analysis of job-evaluation data*, Ann Arbor, University of Toronto.
- Erickson, K. H. 2013. *Choice theory: a simple introduction*, Middleton, Createspace Independent Publishers.
- Evers, A. & Ewert, B. 2015. Social innovation for social cohesion. In: Nicholls, A., Simon, J. & Gabriel, M. (eds.) *New frontiers in social innovation research*. London: Palgrave Macmillan.

- Fagley, N. S. & Miller, P. M. 1987. The effects of framing on choice of risky vs certain options. *Organizational Behavior and Human Decision Processes*, 39, 264-277.
- Farzin, Y. H., Huisman, K. J. M. & Kort, P. M. 1998. Optimal timing of technology adoption. *Journal of Economic Dynamics and Control*, 22, 779-799.
- Ferrant, G. & Thim, A. 2019. Measuring women's economic empowerment: time use data and gender inequality. *OECD Development Policy Papers, No. 16*. Paris: OECD Publishing.
- Fichman, R. 2004. Real options and IT platform adoption: implications for theory and practice. *Information Systems Research*, 15, 132-154.
- Field, A. 2009. *Discovering statistics using SPSS*, London, Sage Publications.
- Fischhoff, B., Watson, S. R. & Hope, C. 1984. Defining risk. *Policy Sciences*, 17, 123-139.
- Fisher, A. 2005. Investment under uncertainty and option value in environmental economics: reply. *Resource and Energy Economics*, 27, 89.
- Flin, R. & Fruhen, L. 2015. Managing safety: ambiguous information and chronic unease. *Journal of Contingencies and Crisis Management*, 23, 84-89.
- Foucault, M. 1972. *The archaeology of knowledge*, New York, Pantheon Books.
- Frambach, R. T. & Schillewaert, N. 2002. Organizational innovation adoption: a multi-level framework of determinants and opportunities for future research. *Journal of Business Research*, 55, 163-176.
- Freeman, A. M. 1984. The quasi-option value of irreversible development. *Journal of Environmental Economics and Management*, 11, 292-295.
- Freudenberg, W. R. 1988. Perceived risk, real risk: social science and the art of probabilistic risk assessment. *Science*, 242, 44-49.
- Fritz, M. S. & Mackinnon, D. P. 2007. Required sample size to detect the mediated effect. *Psychological Science*, 18, 233-239.
- Fruhen, L. S. & Flin, R. 2016. 'Chronic unease' for safety in senior managers: an interview study of its components, behaviours and consequences. *Journal of Risk Research*, 19, 645-663.
- Fruhen, L. S., Flin, R. H. & McLeod, R. 2014. Chronic unease for safety in managers: a conceptualisation. *Journal of Risk Research*, 17, 969-979.
- Fujii, T. & Ishikawa, R. 2013. Arrow–Fisher–Hanemann–Henry and Dixit–Pindyck option values under strategic interactions. *Strategic Behaviour and the Environment*, 3, 169-183.
- Gardner, P., L. 1995. Measuring attitudes to science: unidimensionality and internal consistency revisited. *Research in Science Education*, 25, 283-289.
- Garvey, J. 2010. An investigation into risk propensity in bull and bear markets. *Journal of Risk Research*, 13, 789-804.
- Gerrans, P., Faff, R. & Hartnett, N. 2015. Individual financial risk tolerance and the global financial crisis. *Accounting & Finance*, 55, 165-185.
- Gilbert, D. T. & Ebert, J. E. J. 2002. Decisions and revisions: the affective forecasting of changeable outcomes. *Journal of Personality and Social Psychology*, 82, 503-514.
- Gilboa, I. 2009. *Theory of decision under uncertainty*, Cambridge, Cambridge University Press.
- Gilboa, I. 2010. *Rational choice*, Cambridge, MIT Press.
- Godin, B. 2008a. In the shadow of Schumpeter: W. Rupert Maclaurin and the study of technological innovation. *Minerva*, 46, 343-360.
- Godin, B. 2008b. *Innovation: the history of a category, working paper No. 1, project on the intellectual history of innovation*, Warsaw, Polish Academy of Sciences, Committee for the Science.

- Godin, B. 2015a. Meddle not with them that are given to change. *In: Godin, B. (ed.) Innovation contested: the idea of innovation over the centuries.* New York: Routledge.
- Godin, B. 2015b. The vocabulary of innovation: a lexicon, project on the intellectual history of innovation. *In: Godin, B. (ed.) Innovation contested: the idea of innovation over the centuries.* New York: Routledge.
- Godin, B. 2017. *Models of innovation: the history of an idea,* Cambridge, MIT Press.
- Goldenson, R. M. (ed.) 1984. *Longman dictionary of psychology and psychiatry,* New York, Longman.
- Goldsmith, R. E. & Foxall, G. R. 2003. The measurement of innovativeness *In: Shavinina, L. V. (ed.) The international handbook on innovation.* Oxford: Pergamon.
- Goldsmith, R. E. & Hofacker, C. F. 1991. Measuring consumer innovativeness. *Journal of the Academy of Marketing Science,* 19, 209-221.
- Gomulko, S. 1971. *Inventive activity, diffusion and stages of growth,* Denmark, Institute of Economics Aarhus University.
- Gopalakrishnan, S. & Damanpour, F. 1997. A review of innovation research in economics, sociology and technology management. *Omega International Journal of Management Science,* 25, 15-28.
- Gordon, R. A. 1952. *Business fluctuations,* New York, Harper & Brothers.
- Gough, J. D. 1990. *A review of the literature pertaining to 'perceived' risk and 'acceptable' risk and the methods used to estimate them,* Canterbury, Centre for Resource Management, University of Canterbury and Lincoln University.
- Green, P. & Wind, J. 1975. New way to measure consumers' judgments. *Harvard Business Review,* July, 107-117.
- Green, P. E., Krieger, A. M. & Wind, Y. 2001. Thirty years of conjoint analysis: reflections and prospects. *Interfaces,* 31, S56-S73.
- Green, P. E. & Rao, V. R. 1971. Conjoint measurement for quantifying judgmental data. *Journal of Marketing Research,* 8, 355-363.
- Green, P. E. & Srinivasan, V. 1978. Conjoint analysis in consumer research: issues and outlook. *Journal of Consumer Research* 5, 103-123.
- Green, P. E. & Srinivasan, V. 1990. Conjoint analysis in marketing: new developments with implications for research and practice. *Journal of Marketing,* 54, 3-19.
- Griliches, Z. 1957. Hybrid corn: an exploration in the economics of technological change. *Econometrica,* 25, 501-522.
- Griliches, Z. 1980. Hybrid corn revisited: a reply. *Econometrica,* 48, 1463-1465.
- Grusec, J. E. 1968. Waiting for rewards and punishments: effects of time and probability on choice. *Journal of Personality and Social Psychology,* 9, 85-89.
- Gustafsson, A., Herrmann, A. & Huber, F. 2007. Conjoint analysis as an instrument of market research practice. *In: Gustafsson, A., Herrmann, A. & Huber, F. (eds.) Conjoint measurement methods and applications.* Berlin: Springer-Verlag.
- Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. 2006. *Multivariate data analysis,* Upper Saddle River, Prentice Hall.
- Hamid, F. S., Rangel, G. J., Taib, F., M & Thurasamy, R. 2013. The relationship between risk propensity, risk perception and risk-taking behaviour in an emerging market. *International Journal of Banking and Finance,* 10, 134-146.
- Hanemann, W. M. 1989. Information and the concept of option value. *Journal of environmental economics and management,* 16, 23-37.
- Hansen, A. H. 1938. *Full recovery or stagnation?,* New York, W. W. Norton & Company.
- Harbaugh, W. T., Krause, K. & Vesterlund, L. 2010. The fourfold pattern of risk attitudes in choice and pricing tasks. *Economic Journal,* 120, 595-611.

- Hardisty, D. J. & Pfeffer, J. 2017. Intertemporal uncertainty avoidance: when the future is uncertain, people prefer the present, and when the present is uncertain, people prefer the future. *Management Science*, 63, 519-527.
- Hatfield, J. & Fernandes, R. 2009. The role of risk-propensity in the risky driving of younger drivers. *Accident Analysis and Prevention*, 41, 25-35.
- Hathaway, N. 1989. Compilatio: from plagiarism to compiling. *Viator*, 20, 19-44.
- Hayes, A. F. 2006. A primer on multilevel modeling. *Human Communication Research*, 32, 385-410.
- Hayes, A. F. 2009. Beyond Baron and Kenny: statistical mediation analysis in the new millennium. *Communication Monographs*, 76, 408-420.
- Hayes, A. F. 2015. An index and test of linear moderated mediation. *Multivariate Behavioral Research*, 50, 1-22.
- Hayes, A. F. 2018. *Introduction to mediation, moderation, and conditional process analysis*, New York, Guilford Press.
- Hayes, A. F. n.d. *The PROCESS macro for SPSS, SAS, and R* [Online]. Available: <http://processmacro.org/download.html> [Accessed 29 December 2017].
- Hayes, A. F., Montoya, A. K. & Rockwood, N. J. 2017. The analysis of mechanisms and their contingencies: PROCESS versus structural equation modeling. *Australasian Marketing Journal*, 25, 76-81.
- Hayes, A. F. & Rockwood, N. J. 2019. Conditional process analysis: concepts, computation, and advances in the modeling of the contingencies of mechanisms. *American Behavioral Scientist*, July, 1-36.
- Hayes, A. F. & Scharkow, M. 2013. The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: does method really matter? *Psychological Science*, 24, 1918-1927.
- Heck, R. H., Thomas, S. L. & Lynn, N. T. 2014. *Multilevel and longitudinal modeling with IBM SPSS*, New York, Routledge.
- Henry, C. 1974a. Investment decisions under uncertainty: the "irreversibility effect". *The American Economic Review*, 64, 1006-1012.
- Henry, C. 1974b. Option values in the economics of irreplaceable assets. *The Review of Economic Studies*, 41, 89-104.
- Hillson, D. 2002. What is risk? Towards a common definition. *InfoRM Journal of the Institute of Risk Management*, April, 11-12.
- Hillson, D. 2007. When is a risk not a risk? *Project Manager Today*, January, 15-16.
- Holton, G. 2004. Defining risk. *Financial Analysts Journal*, 60, 19-25.
- Huang, Y. P., Wang, X. Q., Ding, R. X. & Xia, N. N. 2016. Risk perception, risk propensity, and unsafe behavior: an empirical study of workers in Chinese construction industry. *2016 IEEE International Conference on Industrial Engineering and Engineering Management*. Nusa Dua: IEEE Conference Publications.
- Huff, R. A., Keil, M., Kappelman, L. & Prybutok, V. 1997. Validation of the Sitkin-Weingart business risk propensity scale. *Management Research News*, 20, 39-48.
- Hunt, V., Layton, D. & Prince, S. 2014. *Diversity matters*, McKinsey and Company.
- Hunt, V., Prince, S., Dixon-Fyle, S. & Yee, L. 2018. *Delivering through diversity*, McKinsey and Company.
- Hurt, H. T., Joseph, K. & Cook, C. D. 1977. Scales for the measurement of innovativeness. *Human Communication Research*, 4, 58-65.
- Iacobucci, D., Saldanha, N. & Deng, X. 2007. A meditation on mediation: evidence that structural equations models perform better than regressions. *Journal of Consumer Psychology*, 17, 139-153.
- Jackson, S. A. & Brashers, D. E. 1994. *Random factors in ANOVA*, Thousand Oaks, Sage Publications.

- Jackson, S. E. & Dutton, J. E. 1988. Discerning threats and opportunities. *Administrative Science Quarterly*, 33, 370-387.
- James, L. R. & Brett, J. M. 1984. Mediators, moderators, and tests for mediation. *Journal of Applied Psychology*, 69, 307-321.
- Jamieson, S. 2004. Likert scales: how to (ab)use them. *Medical Education*, 38, 1217-1218.
- Jasanoff, S. 1999. The songlines of risk. *Environmental Values*, 8, 135-152.
- Judd, C. M. & Kenny, D. A. 1981. Process analysis: estimating mediation in treatment evaluations. *Evaluation Review*, 5, 602-619.
- Kahneman, D. 2003. Maps of bounded rationality: psychology for behavioral economics. *The American Economic Review*, 93, 1449-1475.
- Kahneman, D. 2012. *Thinking, fast and slow*, London, Penguin Books.
- Kahneman, D. & Lovallo, D. 1993. Timid choices and bold forecasts: a cognitive perspective on risk taking. *Management Science*, 39, 17-31.
- Kahneman, D., Ritov, I., Jacowitz, K. E. & Grant, P. 1993. Stated willingness to pay for public goods: a psychological perspective. *Psychological Science*, 4, 310-315.
- Kahneman, D. & Tversky, A. 1979. Prospect theory: an analysis of decision under risk. *Econometrica*, 47, 263-291.
- Kaiser, H. 1970. A second generation little jiffy. *Psychometrika*, 35, 401-415.
- Kaiser, H. 1974. An index of factorial simplicity. *Psychometrika*, 39, 31-36.
- Kanigel, R. 1997. *The one best way: Frederick Winslow Taylor and the enigma of efficiency*, London, Little, Brown and Company.
- Kenny, D. A., Korchmaros, J. D. & Bolger, N. 2003. Lower level mediation in multilevel models. *Psychological Methods*, 8, 115-128.
- Kinnunen, J. 1996. Gabriel Tarde as a founding father of innovation diffusion research. *Acta Sociologica*, 431-442.
- Kline, M. 1985. *Mathematics and the search for knowledge*, New York, Oxford University Press.
- Kline, S. & Rosenberg, N. 1986. An overview of innovation. In: Landau, R. & Rosenberg, N. (eds.) *The positive sum strategy: harnessing technology for economic growth*. Washington, DC: National Academy Press.
- Kneale, W. C. 1955. *The idea of invention*, London, Oxford University Press.
- Knight, F. H. 1921. *Risk, uncertainty and profit*, New York, Houghton Mifflin Company.
- Kondratieff, N. D. & Stolper, W. F. 1935. The long waves in economic life. *The Review of Economics and Statistics*, 17, 105-115.
- Krause, R. M., Serlin, C. R., Ward, E. S., Rony, Z. Y., Ezenwa, O. M. & Naab, O. F. 2010. Testing mediation in nursing research: beyond Baron and Kenny. *Nursing Research*, 59, 288-294.
- Kreft, I. & de Leeuw, J. 2007. *Introducing multilevel modeling*, Northampton, Sage Publications.
- Kuhfeld, W. F., Tobias, R. D. & Garratt, M. 1994. Efficient experimental design with marketing research applications. *Journal of Marketing Research*, 31, 545-557.
- Kushner, E. 1980. The concept of invention and its role in renaissance literary theory. *Neohelicon*, 8, 135-146.
- Kuznets, S. 1940. Schumpeter's business cycles. *The American Economic Review*, 30, 257-271.
- Lancaster, K. 1971. *Consumer demand: a new approach*, New York, Columbia University Press.
- Lancaster, K. J. 1966. A new approach to consumer theory. *Journal of Political Economy*, 74, 132-157.
- Langlois, R. N. & Cosgel, M. M. 1993. Frank Knight on risk, uncertainty, and the firm: a new interpretation. *Economic Inquiry*, 31, 456-465.



- Lawrence, P. R. & Lorsch, J. W. 1967. *Organization and environment : managing differentiation and integration*, Homewood, Irwin.
- LeBreton, J. M., Wu, J. & Bing, M. N. 2009. The truth(s) on testing for mediation in the social and organizational sciences. In: Lance, C. E. & Vandenberg, R. J. (eds.) *Statistical and methodological myths and urban legends*. New York: Routledge.
- LeRoy, S. F. & Singell Jr., L. D. 1987. Knight on risk and uncertainty. *Journal of Political Economy*, 95, 394-406.
- Levitt, B. & March, J. G. 1988. Organizational learning. *Annual Review of Sociology*, 14, 319-340.
- Levitt, T. 1966. Innovative imitation. *Harvard Business Review*, September, 63-70.
- Levy, J. S. 1992. An introduction to prospect theory. *Political Psychology*, 13, 171-186.
- Lewandowski, M. 2017. Prospect theory versus expected utility theory: assumptions, predictions, intuition and modelling of risk attitudes. *Central European Journal of Economic Modelling and Econometrics*, January, 275-321.
- Libby, R. & Fishburn, P. C. 1977. Behavioral models of risk taking in business decisions: a survey and evaluation. *Journal of Accounting Research*, 15, 272-292.
- Linder, J. R., Murphy, T. H. & Briers, G. E. 2001. Handling nonresponse bias in social science research. *Journal of Agricultural Education*, 42, 43-53.
- Linton, R. 1936. *The study of man*, New York, Appleton Century Crofts.
- Louviere, J. 1988. Conjoint analysis modelling of stated preferences: a review of theory, methods, recent developments and external validity. *Journal of Transport Economics and Policy*, 22, 93-119.
- Luce, R. D. & Raiffa, H. 1958. *Games and decisions*, New York, John Wiley & Sons.
- Luce, R. D. & Tukey, J. W. 1964. Simultaneous conjoint measurement: a new type of fundamental measurement. *Journal of Mathematical Psychology*, 1, 1-27.
- Luecke, R. & Katz, R. 2003. *Managing creativity and innovation*, Boston, Harvard Business School Press.
- Luke, D. A. 2004. *Multilevel modeling*, Thousand Oaks, Sage Publications.
- MacCrimmon, K. R. & Wehrung, D. A. 1985. A portfolio of risk measures. *Theory and Decision*, 19, 1-29.
- MacCrimmon, K. R. & Wehrung, D. A. 1986a. Assessing risk propensity. In: Daboni, L., Montesano, A. & Lines, M. (eds.) *Recent developments in the foundations of utility and risk theory*. Dordrecht: Springer.
- MacCrimmon, K. R. & Wehrung, D. A. 1986b. *Taking risks: the management of uncertainty*, New York, Free Press.
- MacCrimmon, K. R. & Wehrung, D. A. 1990. Characteristics of risk taking executives. *Management Science*, 36, 422-435.
- MacKinnon, D. P. 2008. *Introduction to statistical mediation analysis*, New York, Lawrence Erlbaum Associates.
- Mackinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G. & Sheets, V. 2002. A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, 7, 83-104.
- MacLaurin, W. R. 1949. *Invention and innovation in the radio industry*, New York, Macmillan.
- Madsen, T. K. 1989. Successful export marketing management: some empirical evidence. *International Marketing Review*, 6, 41-57.
- Mansfield, E. 1961. Technical change and the rate of imitation. *Econometrica*, 29, 741-766.
- March, J. 1978. Bounded rationality, ambiguity, and the engineering of choice. *Bell Journal of Economics*, 9, 587-608.
- March, J. G. & Shapira, Z. 1987. Managerial perspectives on risk and risk taking. *Management Science*, 33, 1404-1418.

- Marschak, J. 1949. Role of liquidity under complete and incomplete information. *The American Economic Review*, 39, 182-195.
- Marx, L. 1987. Does improved technology mean progress? *Technology Review*, January, 33-42.
- Maurer, T. J. & Andrews, K. D. 2000. Traditional, Likert, and simplified measures of self-efficacy. *Educational and Psychological Measurement*, 60, 965-973.
- McClelland, D. 1961. *The achieving society*, New York, Van Nostrand.
- McDonald, A. J. & Hansen, J. R. 2009. *Truth, lies, and o-rings: inside the space shuttle Challenger disaster*, Gainesville, University Press of Florida.
- McKeon, R. 1936. Literary criticism and the concept of imitation in antiquity. *Modern Philology*, 34, 1-35.
- Meade, A. W., Watson, A. M. & Kroustalis, C. M. 2007. Assessing common methods bias in organizational research. *22nd Annual Meeting of the Society for Industrial and Organizational Psychology*. New York.
- Mensink, P. & Requate, T. 2005. The Dixit–Pindyck and the Arrow–Fisher–Hanemann–Henry option values are not equivalent: a note on Fisher (2000). *Resource and Energy Economics*, 27, 83-88.
- Meyerhoff, J. 2006. Stated willingness to pay as hypothetical behaviour: can attitudes tell us more? *Journal of Environmental Planning and Management*, 49, 209-226.
- Midgley, D. F. & Dowling, G. R. 1978. Innovativeness: the concept and its measurement. *Journal of Consumer Research*, 4, 229-242.
- Mill, J. S. 1885. *Principles of political economy*, London, D. Appleton and Company.
- Milliken, F. J. 1987. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *The Academy of Management Review*, 12, 133-143.
- Miltgen, C. L., Henseler, J., Gelhard, C. & Popovič, A. 2016. Introducing new products that affect consumer privacy: a mediation model. *Journal of Business Research*, 69, 4659-4666.
- Mischel, W. & Grusec, J. 1967. Waiting for rewards and punishments: effects of time and probability on choice. *Journal of Personality and Social Psychology*, 5, 24-31.
- Monroe, K. B. 1976. The influence of price differences and brand familiarity on brand preferences. *Journal of Consumer Research*, 3, 42-49.
- Morris, W. T. 1972. *The analysis of management decisions*, Homewood, Irwin.
- Mulgary, G. & Albury, D. 2003. *Innovation in the public sector*, London, Strategy Unit, Cabinet Office.
- Mythen, G. 2004. *Ulrich Beck : a critical introduction to the risk society*, London, Pluto Press.
- Nahm, M. C. 1947. The theological background of the theory of the artist as creator. *Journal of the History of Ideas*, 8, 363-372.
- Nahm, M. C. 1956. *The artist as creator: an essay of human freedom*, Baltimore, Johns Hopkins University Press.
- National Audit Office 2009. *Innovation across central government*, London, The Stationery Office.
- Nelson, D. L. & Quick, J. C. 2006. *Organisational behavior: foundations, reality and challenges*, Nashville, South-Western.
- Nelson, R. & Winter, S. 1982. *An evolutionary theory of economic change*, Cambridge, Harvard University Press.
- Nelson, R. R., Peck, M. J. & Kalachek, E. D. 1967. *Technology, economic growth, and public policy; a Rand Corporation and Brookings Institution study*, Washington, DC, Brookings Institution.
- NESTA 2012. *Plan 1: the case for innovation led growth*, London, NESTA.

- Nicholson, N., Fenton-O'Creevy, M., Soane, E. & Willman, P. 2001. *Risk propensity and personality*, London, Centre for Organisational Research London Business School.
- Nisbet, R. A. 1970. Developmentalism: a critical analysis. In: Kinney, J. C. & Tiyrakian, E. A. (eds.) *Theoretical sociology: perspectives and developments*. New York: Appleton Century-Crofts.
- Norman, G. 2010. Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education*, 15, 625-632.
- OECD/Eurostat 2005. *The Oslo manual*, Paris, OECD Publishing.
- OECD/Eurostat 2018. *Oslo manual 2018: guidelines for collecting, reporting and using data on innovation, 4th edition*, Paris, OECD Publishing.
- Ogburn, W. F. 1936. Stationary and changing societies. *American Journal of Sociology*, 42, 16-31.
- Okamoto, G. 2020. Nightmare uncertainty. *Finance & Development*, 57, 10-11.
- Oppenheim, A. N. 1992. *Questionnaire design, interviewing and attitude measurement*, London, Continuum.
- Orme, B. K. 2009. *Which conjoint method should I use?* [Online]. Available: <https://www.sawtoothsoftware.com/support/technical-papers/hierarchical-bayes-estimation/168-support/technical-papers/general-conjoint-analysis/1077-which-conjoint-method-should-i-use-2013> [Accessed 11 June 2016].
- Orme, B. K. 2014. *Getting started with conjoint analysis: strategies for product design and pricing research third edition*, Glendale, Research Publishers LLC.
- Orme, B. K. & Chrzan, K. 2017. *Becoming an expert in conjoint analysis: choice modeling for pros*, Orem, Sawtooth Software.
- Osborn, R. N. & Jackson, D. H. 1988. Leaders, riverboat gamblers, or purposeful unintended consequences in the management of complex, dangerous technologies. *The Academy of Management Journal*, 31, 924-947.
- Pablo, A. L. 1997. Reconciling predictions of decision making under risk. *Journal of Managerial Psychology*, 12, 4-20.
- Pablo, A. L. & Javidan, M. 2002. Thinking of a merger ... do you know their risk propensity profile. *Organizational Dynamics*, 30, 206-222.
- Pallant, J. 2016. *SPSS Survival Manual: a step by step guide to data analysis using SPSS*, Maidenhead, McGraw Hill.
- Perry, C. 1998. A structured approach for presenting theses. *Australasian Marketing Journal*, 6, 63-85.
- Phillips, K. W., Liljenquist, K. A. & Neale, M. A. 2008. Is the pain worth the gain? The advantages and liabilities of agreeing with socially distinct newcomers. *Personality & Social Psychology Bulletin*, 35, 336-350.
- Pindyck, R. S. 1991. Irreversibility, uncertainty, and investment. *Journal of Economic Literature*, 29, 1110-1148.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y. & Podsakoff, N. P. 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88, 879-903.
- Podsakoff, P. M., MacKenzie, S. B. & Podsakoff, N. P. 2012. Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, 63, 539-569.
- Podsakoff, P. M. & Organ, D. W. 1986. Self-reports in organizational research: problems and prospects. *Journal of Management*, 12, 531-544.
- Pollack, J. M., Vanepps, E. M. & Hayes, A. F. 2012. The moderating role of social ties on entrepreneurs' depressed affect and withdrawal intentions in response to economic stress. *Journal of Organizational Behavior*, 33, 789-810.

- Preacher, K. J., Rucker, D. D. & Hayes, A. F. 2007. Addressing moderated mediation hypotheses: theory, methods, and prescriptions. *Multivariate Behavioral Research*, 42, 185-227.
- Rankine, W. J. M. 1861. *A manual of the steam engine and other prime movers*, London, Griffin, Bohn, and Company.
- Rao, A. R. & Monroe, K. B. 1988. The moderating effect of prior knowledge on cue utilization. *Journal of Consumer Research*, 15, 253-264.
- Rao, V. R. 2014. *Applied conjoint analysis*, Heidelberg, Springer.
- Renn, O. 1985. Risk perception: a systematic review of the concept and results. *Meeting on Risk and Policy Analysis*. Laxenburg: International Institute of Applied Systems Analysis.
- Requate, T. 2003. *The Dixit–Pindyck and the Arrow–Fisher–Hanemann–Henry option values are not equivalent*, Christian-Albrechts-University of Kiel, Department of Economics.
- Rice, R. E. & Rogers, E. M. 1980. Reinvention in the innovation process. *Science Communication*, 1, 499-514.
- Richards, R. M., Prybutok, V. R. & Kappelman, L. A. 1996. Influence of computer user training on decision-making risk preferences. *Management Research News*, 19, 26-41.
- Robson, K. & Pevalin, D. 2016. *Multilevel modeling in plain language*, Thousand Oaks, Sage Publications.
- Rockwood, N. J. 2017. *Advancing the formulation and testing of multilevel mediation and moderated mediation models*. Master of Arts, The Ohio State University.
- Rockwood, N. J. n.d. *MLmed MACRO multilevel mediation in SPSS* [Online]. Available: <https://njrockwood.com/mlmed> [Accessed 12 June 2018].
- Rogers, E. M. 1962. *Diffusion of innovations*, New York, The Free Press.
- Rogers, E. M. 1976. New product adoption and diffusion. *Journal of Consumer Research*, 2, 290-301.
- Rogers, E. M. 2003. *Diffusion of innovations*, New York, The Free Press.
- Rogers, E. M. 2004. A prospective and retrospective look at the diffusion model. *Journal of Health Communication*, 9, 13-19.
- Rogers, E. M. & Havens, A. E. 1962. Predicting innovativeness. *Sociological Inquiry*, 32, 34-42.
- Roll, R. 1986. The hubris hypothesis of corporate takeovers. *The Journal of Business*, 59, 197-216.
- Romeo, A. 1975. Interindustry and interfirm differences in the rate of diffusion of an innovation. *The Review of Economics and Statistics*, 57, 311-319.
- Rosa, E. A. 1998. Metatheoretical foundations for post-normal risk. *Journal of Risk Research*, 1, 15-44.
- Rosa, E. A. 2010. The logical status of risk - to burnish or to dull. *Journal of Risk Research*, 13, 239-253.
- Rothwell, R. 1986. Innovation and re-innovation: a role for the user. *Journal of Marketing Management*, 2, 109-123.
- Rouibah, K., Lowry, P. B. & Hwang, Y. 2016. The effects of perceived enjoyment and perceived risks on trust formation and intentions to use online payment systems: new perspectives from an Arab country. *Electronic Commerce Research and Applications*, 19, 33-43.
- Rowe, W. D. 1997. *Anatomy of risk*, New York, Wiley.
- Rucker, D. D., Preacher, K. J., Tormala, Z. L. & Petty, R. E. 2011. Mediation analysis in social psychology: current practices and new recommendations. *Social and Personality Psychology Compass*, 5, 359-371.

- Runde, J. 1998. Clarifying Frank Knight's discussion of the meaning of risk and uncertainty. *Cambridge Journal of Economics*, 22, 539-546.
- Ryan, B. & Gross, N. C. 1943. The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology*, 8, 15-24.
- Salminen, S. & Heiskanen, M. 1997. Correlations between traffic, occupational, sports, and home accidents. *Accident Analysis and Prevention*, 29, 33-36.
- Samuelson, P. A. 1948. *Economics: an introductory analysis*, New York, McGraw-Hill.
- Sarton, G. 1962. The quest for truth: scientific progress during the renaissance. In: Ferguson, W. F. (ed.) *The renaissance: six essays*. New York: Harper.
- Saunders, M., Lewis, P. & Thornbill, A. 2003. *Research methods for business students*, Rotolito Lombardarda, Pittman.
- Savage, C. I. 1959. *An economic history of transport*, London, Hutchinson of London.
- Sawtooth Software. n.d. *Conjoint value analysis (CVA) version 3.0* [Online]. Available: <https://www.sawtoothsoftware.com/download/techpap/cva3tech.pdf> [Accessed February 26 2017].
- Say, J. B. 1855. *A treatise on political economy*, Philadelphia, Claxton, Remsen & Haffelfinger.
- Schaefer, R. E. 1978. *What are we talking about when we talk about "risk"? A critical survey of risk and risk preference theories*, Laxenburg, International Institute for Applied Systems Analysis.
- Schertzer, C. B. & Kernan, J. B. 1985. More on the robustness of response scales. *Journal of the Marketing Research Society*, 27, 261-281.
- Schmookler, J. 1966. *Invention and economic growth*, Cambridge, Harvard University Press.
- Schneider, S. & Lopes, L. 1986. Reflection in preferences under risk: who and when may suggest why. *Journal of Experimental Psychology: Human Perception and Performance*, 12, 535-548.
- Schön, D. A. 1967. *Technology and change: the new Heraclitus*, New York, Delacorte Press.
- Schrage, M. 2002. Daniel Kahneman: the thought leader interview. *Strategy + Business*, 6.
- Schumpeter, J. A. 1935. The analysis of economic change. *The Review of Economics and Statistics*, 17, 2-10.
- Schumpeter, J. A. 1939. *Business cycles: a theoretical, historical and statistical analysis of the capitalist process*, New York, The Free Press.
- Schumpeter, J. A. 1951. *The theory of economic development*, Cambridge, Harvard University Press.
- Shiner, R. L. 2015. Maximizers, satisficers, and their satisfaction with and preferences for reversible versus irreversible decisions. *Social Psychological and Personality Science*, 6, 896-903.
- Shrout, P. E. & Bolger, N. 2002. Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychological Methods*, 7, 422-445.
- Simon-Vandenberg, A. M. 2008. Almost certainly and most definitely: degree modifiers and epistemic stance. *Journal of Pragmatics*, 40, 1521-1542.
- Simon, H. 2000. Bounded rationality in social science: today and tomorrow. *Mind & Society*, 1, 25-39.
- Singpurwalla, N. D. 2006. *Reliability and risk: a Bayesian perspective*, New York, Wiley.
- Sitkin, S. B. & Pablo, A. L. 1992. Reconceptualizing the determinants of risk behavior. *The Academy of Management Review*, 17, 9-38.
- Sitkin, S. B. & Weingart, L. W. 1995. Determinants of risky decision-making behavior: a test of the mediating role of risk perceptions and propensity. *The Academy of Management Journal*, 38, 1573-1592.
- Skinner, Q. 1988. Language and social change. In: Tully, J. (ed.) *Meaning and context : Quentin Skinner and his critics*. Princeton: Princeton University Press.

- Slovic, P. 1972. Information processing, situation specificity, and the generality of risk-taking behavior. *Journal of Personality and Social Psychology*, 22, 128-134.
- Slovic, P. 1987. Perception of risk. *Science*, 236, 280-285.
- Slovic, P. 1992. Perceptions of risk: reflections on the psychometric paradigm. In: Krinsky, S. & Golding, D. (eds.) *Social theories of risk*. New York: Praeger.
- Slovic, P., Fischhoff, B. & Lichtenstein, S. 1982a. *Facts versus fears: understanding perceived risk*, Cambridge, Cambridge University Press.
- Slovic, P., Fischhoff, B. & Lichtenstein, S. 1982b. Judgment under uncertainty: heuristics and biases. In: Kahneman, D., Slovic, P. & Tversky, A. (eds.) *Judgment under uncertainty: heuristics and biases*. Cambridge: Cambridge University Press.
- Smit, H. T. J. & Trigeorgis, L. 2004. *Strategic investment: real options and games*, New Jersey, Princeton University Press.
- Smith, L. P. 1925. *Words and idioms: studies in English language*, London, Constable.
- Smith, V. K. 1983. Option value: a conceptual overview. *Southern Economic Journal*, 49, 654-668.
- Snijders, T. A. B. & Bosker, R. J. 2004. *Multilevel analysis*, London, Sage Publications.
- Solberg, Ø. & Njå, O. 2012. Reflections on the ontological status of risk. *Journal of Risk Research*, 15, 1201-1215.
- Song, H. 2018. A primer on multilevel mediation models for egocentric social network data. *Communication Methods and Measures*, 12, 1-24.
- Spadafora, D. 1990. *The idea of progress in eighteenth-century Britain*, New Haven, Yale University Press.
- Spector, P. E. 1992. *Summated rating scale construction: an introduction*, Thousand Oaks, Sage Publications.
- Spector, P. E. 2006. Method variance in organizational research: truth or urban legend? *Organizational Research Methods*, 9, 221-232.
- Standards Australia 2009. AS/NZS ISO 31000:2009 risk management—principles and guidelines. Sydney: Standards Australia.
- Standards Australia 2018. AS/NZS ISO 31000:2018 risk management—principles and guidelines. Sydney: Standards Australia.
- Steiner, M. & Meißner, M. 2018. A user's guide to the galaxy of conjoint analysis and compositional preference measurement. *Marketing ZFP – Journal of Research and Management*, 40, 3-25.
- Sundbo, J. 1998. *The theory of innovation: entrepreneurs, technology and strategy*, Cheltenham, Edward Elgar.
- Sunstein, C. R. 2005. The precautionary principle as a basis for decision making. *The Economists' Voice*, 2, 1-9.
- Sunstein, C. R. 2010. Irreversibility. *Law, Probability & Risk*, 9, 227-245.
- Sutherland, S. (ed.) 1989. *International dictionary of psychology*, New York, Continuum.
- Sweezy, P. 2004. Why stagnation? *Monthly Review*, 56, 69-77.
- Sweezy, P. M. 1943. Professor Schumpeter's theory of innovation. *The Review of Economics and Statistics*, 25, 93-96.
- Tabachnick, B. G. & Fidell, L. S. 2013. *Using multivariate statistics*, Boston, Pearson Education.
- Tarde, G. 1903. *The laws of imitation*, New York, Henry Holt and Company.
- Taylor, S. P. 2017. What is innovation? A study of the definitions, academic models and applicability of innovation to an example of social housing in England. *Open Journal in Social Housing*, 5, 128-146.
- Tehseen, S., Ramayah, T. & Sajilan, S. 2017. Testing and controlling for common method variance: a review of available methods. *Journal of Management Sciences*, 4, 146-175.

- Thaler, R. H. & Johnson, E. J. 1990. Gambling with the house money and trying to break even: the effects of prior outcomes on risky choice. *Management Science*, 36, 643-660.
- Thompson, M. 2011. What *exactly* is uncertainty? *Accreditation and Quality Assurance*, 17, 93-94.
- Traeger, C. P. 2014. On option values in environmental and resource economics. *Resource and Energy Economics*, 37, 242-252.
- Trimpop, R. M. 1994. *The psychology of risk taking behavior*, Amsterdam, North-Holland.
- Tversky, A. & Fox, C. R. 1995. Weighing risk and uncertainty. *Psychological Review*, 102, 269-283.
- Tversky, A. & Kahneman, D. 1974. Judgment under uncertainty: heuristics and biases. *Science*, 185, 1124-1131.
- Tversky, A. & Kahneman, D. 1986. Rational choice and the framing of decisions. *The Journal of Business*, 59, S251-S278.
- Tversky, A. & Kahneman, D. 1992. Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk & Uncertainty*, 5, 297-323.
- Vlek, C. & Stallen, P. J. 1980. Rational and personal aspects of risk. *Acta Psychologica*, 45, 273-300.
- Weaver, R. D. & Wessler, J. 2004. Monopolistic pricing power for transgenic crops when technology adopters face irreversible benefits and costs. *Applied Economics Letters*, 11, 969-973.
- Wehrung, D. 1989. Risk taking over gains and losses: a study of oil executives. *Annals of Operations Research*, 19, 115-139.
- Wehrung, D. A., Kam-Hon, L., Tse, D. K. & Vertinsky, I. B. 1989. Adjusting risky situations: a theoretical framework and empirical test. *Journal of Risk & Uncertainty*, 2, 189-212.
- Weinstein, E. & Martin, J. 1969. Generality of willingness to take risks. *Psychological Reports*, 24, 499-501.
- Weisbrod, B. A. 1964. Collective-consumption services of individual-consumption goods. *The Quarterly Journal of Economics*, 78, 471-477.
- White, H. O. 1935. *Plagiarism and imitation during the English Renaissance: a study in critical distinctions*, Cambridge, Cambridge University Press.
- Whitehead, A. N. 1926. *Science and the modern world: Lowell lectures 1925 by Alfred North Whitehead*, Cambridge, Cambridge University Press.
- Whitehead, J. C., Groothuis, P. A. & Blomquist, G. C. 1993. Testing for non-response and sample selection bias in contingent valuation: analysis of a combination phone/mail survey. *Economics Letters*, 41, 215-220.
- Williams, J. B. & Lawrey, R. 2000. *new economics for the Asia-Pacific an issues-based modular approach*, Sydney, McGraw-Hill Book Company Australia Pty Ltd.
- Willits, F., Theodori, G. & Luloff, A. E. 2016. Another look at Likert scales. *Journal of Rural Social Sciences*, 31, 126-139.
- Wittkower, R. 1965. *Imitation, eclecticism, and genius*, Baltimore, Johns Hopkins Press.
- Wolman, B. B. (ed.) 1989. *Dictionary of behavioural science*, San Diego, Academic Press.
- Wonglimpiyarat, J. & Yuberk, N. 2005. In support of innovation management and Roger's innovation diffusion theory. *Government Information Quarterly*, 22, 411-422.
- Wrree, P. & Sauer, J. 2016. High-yielding genetically modified wheat in Germany: economic impact assessment of its potential. *Agricultural Economics Review*, 17, 80-96.
- Xia, N., Wang, X., Griffin, M. A., Wu, C. & Liu, B. 2017. Do we see how they perceive risk? An integrated analysis of risk perception and its effect on workplace safety behavior. *Accident Analysis and Prevention*, 106, 234-242.
- Yu, C.-S. & Tao, Y.-H. 2009. Understanding business level innovation technology adoption. *Technovation*, 29, 92-109.

- Zaichkowsky, J. L. 1985. Measuring the involvement construct. *Journal of Consumer Research*, 12, 341-352.
- Zhao, X., Lynch, J. G. & Chen, Q. 2010. Reconsidering Baron and Kenny: myths and truths about mediation analysis. *Journal of Consumer Research*, 37, 197-206.
- Zilsel, E. 1945. The genesis of the concept of scientific progress. *Journal of the History of Ideas*, 6, 325-349.
- Zivin, J. & Neidell, M. 2010. Medical technology adoption, uncertainty, and irreversibilities: is a bird in the hand really worth more than in the bush? *Health Economics*, 19, 142-153.
- Zwillinger, D., Krantz, S. G. & Rosen, K. H. (eds.) 2003. *CRC standard mathematical tables and formulae*, Boca Raton, Chapman & Hall/CRC.