

**Resource-based growth and eco-innovation in mining countries
The case of Australia and Chile**

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Abstract

In view of the collective effort to tackle climate change and achieve sustainable development worldwide, this dissertation addresses the question of what the emerging eco-innovation trends in resource-rich economies are and what drives them. It addresses this novel question by developing an analytical framework around rational choice institutionalism and the cases of Australia and Chile. Doing so the research follows the questions of (i) why Australia performs worse in reforming its policies and institutions in support of eco-innovation than Chile despite similar challenges and potentials and (ii) why mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia and (iii) to what extent international agreements and organisations, the domestic policy and institutional frameworks, the structure of collaboration between public institutions and the private sector, and finally, domestic veto players resistant to regime change play a role. The research finds that global climate change and trade and cooperation agreements have unfolded eco-innovation effects in terms of policy and practice in Chile, aligning international agreements with domestic goals of addressing energy security challenges and capitalising on its renewable energy potential to its economic advantage by facilitating access to finance and mobilising foreign investment, while the Australian case shows a high degree of lack of continuity and political will to transform its policies due to prevailing domestic vested interests pulling in one direction, hindering at the same time justified interests to cope with climate change impacts and develop innovations. Unlike Australia, Chile has effective horizontal coordination in place and an inclusive process has led to nation-wide renewable energy targets with bipartisan support. Such combination of foresight and horizontal coordination has been leading to continuity and certainty despite change in government. Australia, on the other hand, suffers from the “challenge of multi-jurisdiction cooperation”, which is particularly evident in the field of energy policy. The Australian case also shows that despite incumbents showing resistance for regime change can be overcome to some extent through an effective cooperation between public institutions and the private sector, aligning their preferences around common goals of reducing costs and enhancing competitiveness. Similarly, access

to finance and administrative support, facilitated by the Chilean government, to address economic risks and costs have unfolded a positive and encouraging effect on eco-innovation. The research design is based on mixed methods, including a coding scheme, for which this work benefitted from using NVivo, a data analysis software. In the context of eco-innovation in mining countries, this methodological approach is novel and provides useful insights on the two countries and mining sector's perception of sustainability, priorities and responses.

Impact statement

This research makes a valuable contribution to bridge a gap between extractivism and eco-innovation. Extractivism focuses on transparency and accountability; making the case that good governance in resource-rich developing economies can create real economic benefits. Yet, it does often not address the potential benefits of eco-innovation, such as reducing negative environmental externalities from resource-intensive economic activities, e.g. energy and emission savings, creating new business opportunities and markets for innovative technologies. The eco-innovation and ecological modernisation approaches were developed along cases of European demand-side countries with a large manufacturing base, thus, providing a comprehensive analysis of policies and practices of advanced European states. To the knowledge of the author, there is no comparative analysis of eco-innovation in resource-based economies. In times of rising prices and growing scarcities, import-dependent industrial countries focus on competitiveness, security of supply, recycling, resource efficiency, and clean production. Producer countries welcome rising prices and see them as a chance for prosperity and development – regardless of environmental implications, lower ore grades, more energy and water use. Therefore, this dissertation investigates to what extent mining countries and large mining companies adopt environmental innovation and if so, why. The academic aim is to contribute to the literature and policies on ecological modernisation as well as on resource governance and development. Both strands are not yet well aligned and are often treated separately from each other. Moreover, none of them would expect extractive industries particularly close to eco-innovation. Hence, the research is novel and original.

This thesis is also relevant because it investigates the eco-innovation efforts of Australia and Chile. Due to their benchmark function, resulting from their remarkable economic performance over the past two decades, any progress towards a greener economy supported by eco-innovation investments would set an important example for other mining countries, especially developing and emerging ones. Despite some limits of transferability due to unique local contexts, this research provides a discussion on possibilities of transferability. Furthermore, the dissertation provides a timely

contribution to existing policy and academic discussions, concerning the role of resource-rich countries in the global transition to a low carbon future. The question what these countries could do to in terms of eco-innovation, going beyond the predominant debate that they will play a strategic role as “suppliers” of metals and minerals and benefit economically from that, as well as the particular domestic interests and the role international organisation could play, are part of an emerging agenda to which this PhD contributes. The more such resource-rich countries consider eco-innovation in their strategic interest and be related to low carbon scenarios, the more they will become part of the global efforts for reducing greenhouse gas emissions and reaching sustainable development. Therefore, this research considers a discourse on their specific domestic policies for sustainability as important as discussing their strategic role as suppliers of critical resources for green technologies.

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1. Introduction

In 2015, 196 states agreed to the Paris Agreement on climate change to tackle global warming and climate change. In the same year, 193 countries agreed on the Sustainable Development Goals, which are the continuation of the Millennium Development Goals, addressing the need for a sustainable development not only in the developing world but also across the globe.

There has been a lively discussion since then on the importance of raw materials in the transition to a decarbonised global economy and green growth. In June 2017, the World Bank published a report about the strategic materials needed for technologies for the shift towards clean energy, highlighting that those are more material intensive in their composition than fossil-fuel-based supply systems (World Bank, 2017). The report highlights resource-rich developing countries as being in a “strong position to become a supplier for the global climate friendly energy transition”, stressing the economic opportunity coming from increased productivity and turning “critical ore lodes” into economically profitable reserves. The same report highlights the need for higher recycling rates of metals to improve the future availability of those strategic metals. The World Economic Forum has published a similar report about the extractive industries’ contribution as an important supplier of minerals and materials for the global green transition (World Economic Forum et al. 2016).

Mining countries will continue to supply the metals and minerals needed to feed the “green transition”, along with a projection of increasing demand for metals and minerals (OECD, 2019). However, declining ore grades and deposits that are harder to access, will increase the environmental footprint of the mining sector, including higher energy and water consumption and increasing mine waste, which creates the necessity to align extractive-led development and economic growth objectives with environmental policies. Many mining companies still supply their own electricity with diesel generators because of unreliable grid infrastructure, contradictory policy signals or lack of political as well as financial support (CCSI, 2018). Mining represents more than 20% of installed diesel

generator capacity, making the sector the second-largest user after the electricity sector (World Bank, 2015). Mining countries should learn from past mistakes, which essentially means, internalising externalities, to mitigate social and environmental impact and reduce the water and carbon footprint of extractive projects, in order to reconcile climate, mining and economic growth/ development objectives. Thus, this research project addresses the question which has not been sufficiently addressed yet: have these global efforts translated themselves into strategies and policy change for cleaner and more sustainable growth in resource-rich economies, going beyond the predominant discussion of mining countries being “suppliers” of raw materials for green growth in the industrialised, high income world.

Chile and Australia are two traditional mining countries, which are often referred to as benchmarks for resource-based growth because of their successful economic and human development performance (Ville and Wicken, 2012; Schmidt-Hebbel, 2012; McMahon and Moreira, 2012). They have sound democratic institutions and low levels of corruption. Both are committed to the Paris Agreement, members of the OECD, have similar potentials for renewable energy production, particularly for solar energy in their large deserted areas (Mathews, 2014), and they are among the world’s driest places with high levels of water shortage (Soliman et al. 2017). The same three large mining companies operate or have economic stakes in both countries, namely BHP, Rio Tinto and Anglo American. In the case of Chile, the government plays an active role in energy policy with ambitious policy roadmaps, including binding renewable energy targets and attracting high levels of private investment. Furthermore, the state incentivises water efficiency and the use of alternative water sources, such as desalinated water, resulting in more eco-innovation investments in the mining sector. In contrast, surprisingly, Australia has given different responses to the Paris Agreement with lower levels of ambition; it has not continued important nation-wide initiatives to protect water resources; it does not sufficiently incentivise the use of desalinated water in mining or renewable electricity as part of a broader eco-innovation agenda. In fact, policy discontinuity, lack of coordination at the national level, and policy uncertainties undermine eco-innovation.

This dissertation aspires to unpack, investigate and explain that divergence which is a proposition within a comparative analysis.

This research provides a comparative study on most similar cases with a nested case study on mining companies. The countries analysed and compared are Australia and Chile, which despite similarities, show significant divergence in their eco-innovation efforts. They are analysed through the lens of rational choice institutionalism, as it provides, compared to the historical and sociological institutionalisms, a robust analytical toolkit, seeking to explain change on the one hand and status quo on the other. Furthermore, it can also be applied to the nested case study on three large mining companies this research project focuses on, providing an explanation for their different corporate responses to eco-innovation in the two countries.

There are two puzzles resulting from the theoretical discussion, which drive this research. First, if norm diffusion through international regimes and so called “advocacy networks”, as sociological institutionalism suggests, would be decisive for the explanation of the divergence in outcome, why does Australia as an OECD member for over 40 years and party to the Paris Agreement show lower ambitions in eco-innovation than Chile? Second, why do mining companies, operating in both countries and facing similar environmental challenges, follow different investment strategies in Chile than in Australia? Certain environmental investment decisions could be the result of a calculation of transaction costs and risks, as rational choice institutions asserts, or of a socialisation process within an organisation that influences the perception of what is the “appropriate” decision to make. Norm diffusion and sociological institutionalism would suggest similar eco-innovative outcomes in Chile and Australia, if the company is the same and part of the same institutions or international initiatives, forming the corporate identity in a normative way. Yet, the analysis on the three companies shows clear differences between the same company’s investment decisions and performance in the two countries, which this research aims to explain. To understand the difference in outcome between the two countries and firms, we need to first understand past changes and the current state of institutions and policy in Australia and Chile supporting eco-innovation and address the

question of how the eco-innovation profile of mining companies operating in both countries looks like, what their priorities are and in which projects they invest, and why. To answer these questions, this thesis follows the propositions put forward by rational choice institutionalism, as these help explaining best the variance between the two case study countries and within the nested case study, while also considering alternative explanations, derived from institutionalist theories of domestic change. Addressing these questions will ultimately help us to answer the broader, overarching question of how eco-innovation in resource-rich countries may look like and what transition pathways could lead towards a cleaner and more sustainable growth model.

1.1. Research questions

Therefore, the research questions are the following:

- Why does Australia as an OECD member for over 40 years and party to the Paris Agreement perform worse in reforming its policies and institutions than Chile? What is the role of institutions and the policy framework? Do the existence of resource scarcity and climate change effects influence policy outcomes in both countries in a similar way?
- Why do mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia?
- How does eco-innovation in resource-rich countries look like and what transition pathways lead towards a cleaner and more sustainable growth model driven by institutions?
- To what extent are the result of the analysis on Chile and Australia transferable to resource-rich developing countries?

Based on the research questions above the dissertation is guided by the following objectives: it aims to unpack the divergence between policy and institutional decisions on eco-innovation in Chile and Australia despite various similarities; explore the scope and reasons behind eco-innovation investments and priorities of BHP, Rio Tinto and Anglo

American; understand how sustainability is defined by the three companies representative for the sector (environmental, social, economic sustainability or health and safety or human rights) and discuss implications; examine when and why states and companies implement international agreements and recommendations; and derive policy conclusions for the transition towards eco-innovation in mining countries based on discussion about the transferability of the research findings.

The research design is based on mixed methods, consisting of qualitative content analysis, process tracing, descriptive statistics and a coding scheme, for which this work benefitted from using NVivo, a data analysis software. In the context of eco-innovation in mining countries, this methodological approach is novel and provides useful insights on the mining sector's perception of sustainability, priorities and responses. Semi-structured interviews are seen as an additional validation exercise of document analysis.

1.2. Relevance

This thesis is relevant, as it investigates the eco-innovation efforts of Australia and Chile. Due to their benchmark function, resulting from their remarkable economic performance over the past two decades, any progress towards a greener economy supported by eco-innovation investments would set an important example for other mining countries, especially developing ones. Despite some limits of transferability due to unique local contexts, this research provides a discussion on possibilities of transferability. Furthermore, the dissertation provides a timely contribution to existing policy and academic discussions, concerning the role of resource-rich countries in the global transition to a low carbon future. The question what these countries could do to in terms of eco-innovation, going beyond the predominant debate that they will play a strategic role as “suppliers” of metals and minerals and benefit economically from that, as well as the particular domestic interests and the role international organisation could play, remain not sufficiently addressed. They are part of the global efforts for reducing greenhouse gas emissions and reaching sustainable development. Therefore, a discourse on their

domestic policies for sustainability needs to be as important as discussing their strategic role as suppliers of critical resources for green technologies.

1.3. Novelty

There is a significant potential for a valuable contribution to the literature. Extractivism focuses on transparency and accountability; making the case that good governance in resource-rich developing economies can create real economic benefits. Yet, it does not address the potential benefits of eco-innovation, such as reducing negative environmental externalities from resource-intensive economic activities, e.g. energy and emission savings, creating new business opportunities and markets for innovative technologies. The eco-innovation and ecological modernisation approaches were developed along cases of European demand-side countries with a large manufacturing base, thus, providing a comprehensive analysis of policies and practices of advanced European states. To the knowledge of the author, there is no comparative analysis of eco-innovation in resource-based economies. In times of rising prices and growing scarcities, import-dependent industrial countries like France, Germany, Italy or Japan focus on competitiveness, security of supply, recycling, resource efficiency, and clean production. Producer countries, such as Australia, Brazil, Canada, Russia, and South Africa welcome rising prices and see them as a chance for prosperity and development – regardless of environmental implications, lower ore grades, more energy and water use (Hilpert and Mildner, 2013). Therefore, this dissertation investigates to what extent mining countries and large mining companies adopt environmental innovation and if so, why. The academic aim is to contribute to the literature on ecological modernisation and resource governance and development. Both strands are not yet well aligned and are often treated separately from each other. Moreover, none of them would expect extractive industries particularly close to eco-innovation. Hence, the research question is novel and original.

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mining countries, this methodological approach is novel and provides useful insights on the mining sector's perception of sustainability, priorities and responses. Semi-structured interviews are seen as an additional validation exercise of document analysis. The use of rational choice institutionalism provides the analytical lens. Rational choice institutionalism expects actors making choices informed by institutions. Therefore, analysing actor perceptions and ways of decision-making matters.

1.4. Findings

The research findings show that international agreements, if they converge with domestic interests, and proactively, coordinating public institutions have an impact on eco-innovation efforts. While the Paris Agreement has resonated largely in both countries and Australia and Chile, its large-scale transformative effect remains modest – while other international initiatives are quite fragmented and show no effects on eco-innovation efforts. Eco-innovation is not only about cleaner production based on innovation but also about competitiveness, the exploration of niche markets and new business opportunities. These preferences in the case of Chile which shows higher levels of eco-innovation response than Australia are saving energy costs, ensuring energy security, using domestic resources, such as lithium (a by-product of copper), to its strategic advantage to diversify the economy through new value chains, achieve greater energy independence and competitiveness. After a bipartisan, inclusive process, Chile adopted an ambitious renewable energy target of 70 per cent by 2050 and energy efficiency policies including the mining sector. The country adopted a strategic approach to using its lithium reserves to fund low-carbon technology research and development, such as electro mobility, as one example of lithium-based value added products, solar energy and low emission mining. Building on its strategic resources and geographic conditions, in its two exploration contracts with international companies exploiting lithium Chile has included a clause to fund research and development over the next ten years, conducted by a consortium of universities, local firms and global companies. The aim is to move to an economic model with higher diversification and sophistication as well as environmental sustainability, locally and globally, by linking knowledge and technology transfer to

resource exploitation. The promotion of renewables in Chile for these rational reasons converges as a preference with the global agenda of reducing CO₂ emissions. Chile, as a newcomer to the OECD, shows also high levels of compliance with OECD recommendations. Since 2010, Chile strives to strengthen its environmental institutions and policies following explicit OECD recommendations, such as establishing the Ministry of Environment or launching a green growth strategy. During the Paris Conference, Chile committed to reducing GHG emission intensity by 30 per cent by 2030 compared to the 2007 level, and by up to 45 per cent if sufficient international support is provided. The NVivo analysis also shows that “energy efficiency” and “renewables” are mentioned together with “cost savings” and “energy security”, highlighting the strategic importance of achieving lower energy costs and higher energy security as part of the overall 2050 energy strategy. Regarding water efficiency and the promotion of the use of desalinated water, Chile has introduced a fast track procedure to evaluate and approve large infrastructure investments to address concerns over the high levels of water use of the mining sector and the expected water use increase over the next decades.

Australia also has significant deposits of lithium, especially in South Australia, but lacks a strategy, going beyond extraction, and coordinating public institutions. The country is a long-standing member of the OECD and party to the Paris Agreement. However, it shows rather modest levels of ambition. Australia agreed to implement an economy-wide target to reduce GHG emissions by 26-28 per cent below 2005 levels by 2030. Yet, meeting the Paris goals will require an enormous reduction of Australia’s emissions and a much steeper trajectory (Wood et al. 2017). It is one of the world’s major fossil fuel exporters, wherefore the domestic agenda of economic growth and jobs shows less convergence with the international green transition agenda, compared to Chile. Yet, the creation of the Australian Renewable Energy Agency in 2012 has supported the acceleration of the integration of renewable energy in some mines through knowledge sharing and co-financing of economically viable projects. The agency played an important role in providing loan-based financial assistance for the integration of renewables in mining operations, beyond technical assistance to close knowledge gaps in the sector. While veto players in the Australian energy sector remain influential, the mining sector shows some

efforts in diversifying and divesting their portfolios. In the Australian context, the NVivo study was a helpful tool in understanding the importance of the coal sector for the Australian economy while analysing the government documents on energy. “Coal” appeared in conjunction with “affordable” and “cost competitive” illustrating the economic benefit of coal for the broader Australian economy. In its water policies, this study shows the lack of coordination between the states and territories and the Commonwealth government hinder substantial reforms. The mining sector is considered a high value user of water, putting it in a better position than, for example, the agricultural sector. Therefore, mining is not as much criticised as the agricultural sector for its water use. From a rational choice perspective, there might be a first mover problem, which is why the existence of inter-institutional coordination, the moderation of different interests facilitated by institutions and a strong long-term policy framework contributing to overcoming uncertainties, creating a level playing field for all relevant rational actors are relevant. The existence of resource scarcity alone does not qualify itself as a sufficient reason for eco-innovation, as the case of Australia shows. It is among the most carbon intensive and the worst environmental performer in the OECD despite being the driest continent in the world with high levels of water scarcity and areas directly affected by climate change (OECD, 2016).

At a sectoral level, the Paris Agreement has created stakeholder pressure, in the three mining companies analysed, to revise the asset portfolios and invest in assets that could be viable in a carbon restricted global economy. BHP was the first company to report to investors on climate scenario analysis in 2015, avoiding a shareholder resolution. It has spun off high emitting coal assets to a company named South32 to focus on iron ore, copper and energy (fossil fuel) production. Rio Tinto decided to sell its last major thermal coal assets to be better positioned for a low-carbon transition. In total, it sources a third of its energy from renewable sources, helping to reduce its emissions intensity. Anglo American announced far-reaching plans in 2016 to focus on three commodities: copper, platinum and diamonds – however, the company’s coal business accounts for a quarter of earnings, higher than any other single commodity. Yet, recently the company announced the sale of some coal assets. While all three companies have revised their investments

and portfolios, the immediate decarbonisation effect of the Paris Agreement on the mining operations have been marginal.

The NVivo analysis helped understanding the strategies of the world's three largest mining companies through automatised, systemised document search and word frequency analysis. The query results show the preferred areas of eco-innovation, perception of costs and how they define sustainability in general. The major finding is that health and safety, human rights and community issues occupy almost half of the topics covered in their corporate sustainability reporting. This is to some extent the result of the broad focus of international initiatives geared towards the mining sector, covering all three dimensions of sustainable development, namely economic, social and environmental. There is no clear-cut initiative supporting environmental sustainability and eco-innovation practices alone. Though, a targeted environmental initiative might have been more effective, as the targeted transparency initiatives show. The strong emphasis on human rights as well as health and safety suggest that environmental sustainability is mostly restricted to the performance at the local level. Yet, the analysis also shows that despite the focus on local environmental effects, after the conclusion of the Paris Agreement in 2015, climate change and emission reduction have become a strong area of concern for the three companies analysed, proving the importance of global environmental decisions as drivers of eco-innovation. This, of course, is also due to the Agreement's anticipated long-term impact on demand in the commodity markets, affecting the core business interests of the mining companies.

In addition, the findings show that the policy and institutional framework is the main determining factor for eco-innovation. The case of Chile proves that a long-term roadmap with clear objectives create confidence and certainty for investors. The Bachelet government introduced a carbon tax and a renewable energy target of 60% by 2035 and 70% by 2050. The new centre-right government under Piñera remains committed to these policies. In fact, the International Energy Agency highlights in its country review on Chile (IEA, 2018) that the energy roadmap for 2050 has been a major achievement of the Chilean government, in which the public and different parties were consulted on a broad

basis for the first time. The entire policy-making process has “become an internationally outstanding example for public consultations on energy policy” (ibid.). A high-ranking Chilean public servant who was interviewed confirmed that the energy roadmap has achieved cross-party support, ensuring continuity even after change in government due to the inclusive process in the policy-making process, while in areas of education or tax reforms failed. On the other hand, the Australian case shows a clear policy gap, creating several challenges for the national electricity market. The renewable energy target was introduced, abolished and then reintroduced with the change of governments. A carbon-pricing scheme in Australia was introduced in 2011 and was abolished three years later by the following government. Even though the current federal renewable energy target has supported investment in renewable energy, the 2020 target is because of its short-term focus a source of concern and uncertainty. Investors do not know how each state will support renewable energy in the future and how this might affect investment in the national energy market in a broader sense. Such “policy consistency and continuity gaps” contributes to the weakening of price signals and uncoordinated government policies make it very difficult to tell whether or not the market can deliver. Government policies create uncertainties. There is general consensus that the federal climate change policies are insufficient to meet Australia's 2030 emission reduction targets. Different states have different targets with different time frames, disintegrating the market further and adding up to uncertainties in the national electricity market (Wood et al. 2017). Not only in the energy policy field the lack of coordination leads to policy uncertainties but also in the field of water policies. States and territories are responsible for water resource management within their jurisdictions. Nationally consistent water policy was strengthened in 2007 with the Water Act, one objective of which is to protect the environmental and economic value of surface waters and groundwater in the Murray-Darling-Basin via the 2012 Basin Plan for surface waters and groundwater. Progress has been made under the National Water Initiative. However, scope for improvement remains on water access entitlements and planning, on water pricing, and Indigenous Community engagement (OECD, 2019). Almost all jurisdictions have created statutory-based, clear and secure long-term water rights for consumptive uses. In some areas, major water uses, e.g. by extractive industries, are not yet part of the allocation framework. Arrangements

allow water to be traded to higher-value users, putting the mining sector in an advantageous position because of their higher value economic output than, e.g. the agricultural sector (ibid.).

Moreover, coordination and joint efforts between public institutions and the private sector for knowledge generation play an important role. The Chilean case shows that for instance the state copper commission Cochilco, working closely with the sector, develops and facilitates the implementation of policies, strategies and operations for promoting the mining industry's sustainable development within a globalised and competitive world through the generation of knowledge based on studies about the environmental performance of the sector, i.e. energy or water use. In its reporting, Cochilco underlined that Chile's mining industry accounted for around 5% of fresh water consumed in the country (Cochilco, 2014). As a result of the commission's recommendations, over the last six years Chile's mining industry has employed new technology to reduce water consumption and increase recycling rates. In Chile, the mining sector is the country's largest energy consumer, accounting for a third of total electricity generation. According to predictions of the Chilean Copper Commission Cochilco, the amount of electricity required by Chile's copper mining industry is predicted to grow by 80% by 2025 (Cochilco, 2015). Energy is one of the industry's major source of costs and seen by many as a major threat to competitiveness compared to its Latin American peers, particularly neighbouring Peru. This has informed policymakers and the sector about the need to eco-innovate and develop renewable energy capacities for competitiveness and long-term cost savings. In the Australian case, The Australian Renewable Energy Agency (ARENA) has proven to be an important information and financial assistance provider in overcoming information deficits in the mining sector. It is a commercially oriented agency providing co-funding and pursues the goal to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy in Australia. The agency organises seminars and meeting involving the country's most important mining companies, including BHP, Rio Tinto and Anglo America, to make an economic case for investing in renewables. The example of ARENA in Australia makes again clear, how important it is to create a platform for information exchange, assistance and technical

cooperation to promote eco-innovation. As a result of ARENA, Rio Tinto asked for financial assistance for a joint project with First Solar to develop a 1.7-megawatt solar capacity for the mining project in Weipa. First Solar constructed and operated 18000 solar panels, while ARENA provided A\$ 3.5 million for a 15-year purchase agreement.

Finally, the absence of major veto players in the case of Chile supported the joint goal of promoting renewable energy, enhancing also the competitiveness of the mining sector in the world. Thus, the goal of the ministries of energy and environment converged with those of ministries of economy and trade. The country is energy dependent and does not have any fossil fuel suppliers, which could have been losers of such an eco-innovation process. In the case of Australia, there is one major veto player, which are the coal producers. Abundant coal and gas deposits and substantial carbon exports strengthened the power of the fossil fuel energy lobby, affecting the perceptions of the economic costs of reducing emissions. The large share in exports and overall economic weight slow down eco-innovation in the country's energy sector. During the negotiations of the Kyoto Protocol, the trade minister was responsible for the oversight of the negotiations and for understanding the potential trade implications of the outcome. The priority was to ensure that the national economic interest took precedence in any development-environment dispute, which resulted in an ideological resistance to climate policy, emphasising the primacy of economic goals, favouring the coal sector. Nevertheless, the Australian case also shows that despite incumbents resistant to wider regime change, cooperation between public institutions and the private sector can make an incremental, smaller scale contribution towards eco-innovation in the sector as the focused analysis on the integration of renewable energy demonstrates.

1.5. Transferability and how the findings advance the study of the subject

The findings show clearly, and confirm propositions in the literature – especially with regard to rational choice institutionalism, that a strong policy framework and coordination is key to eco-innovation. Surprisingly, Chile is less developed than Australia but introduced more progressive policies in terms of eco-innovation and environmental

sustainability. Due to the robust policy framework, supported by output legitimacy based on an inclusive and bipartisan policymaking process, also the mining sector responds to policy certainty and confidence in the markets, supporting investments decisions. Rational choice institutionalism would argue that the cooperation between public institutions and the private sector gathering around the goal to address energy security and competitiveness challenges supported such an evolution by policies. What exactly is transferable from the case study analysis? Especially resource-rich developing countries, particularly those at a similar stage of development as Chile, and with a lack of energy and water supplies should consider revising their policy and institutional framework, setting ambitious and clear goals as the outcome of a collective effort between the public, private sector and all state institutions involved. Such a process would facilitate the definition of common goals and lead most likely to a convergence of preferences or workable compromises. Especially national platforms, agencies or other institutions providing knowledge for informed decision-making play a crucial role. These could be set up to understand better the environmental performance of the mining sector, their vulnerabilities stemming from price developments or resource scarcities, and ultimately, make eco-innovation decisions, minimising risks, securing competitiveness and supporting cost-saving. As the cases of Australia and Chile show, the promotion of eco-innovation does not have to be at the cost of the state budget. Also countries with limited budget could introduce enabling instruments in support of eco-innovation such as co-financing (loans) for commercial projects or subsidies for feasibility studies on eco-innovation investments. Finally, the findings show that there is room for eco-innovation within the broader academic debate on resource-based growth and development and a meaningful case for the integration of such an important topic. Resource-rich countries are not only important suppliers of strategic materials for green technologies needed for the global transition towards a low carbon future, they are part of the sustainable development agenda and the efforts to tackle climate change. They are often the most vulnerable ones to climate change effects and thus resource scarcities (water, land or food in particular). Therefore, further studies are needed to understand the potential and stage of eco-innovation in other resource-rich countries and how they could catalyse the process of catching up on eco-innovation with the rest of the world. Nevertheless, it

needs to be noted that there are limits to transferability and caution is required in generalising the findings. The aim of this research is to test the analytical framework in regions with data availability. Developing a blueprint for green development in resource-rich countries is beyond the scope of the analysis. Fragile state and least developed countries will have conditions very different to Chile and Australia. However, the thesis tries to draw lessons on policies that work and could work also in the context of other resource-rich developing countries.

The following part consists of five chapters, starting with the literature review (Chapter 2), discussing different strands and concepts related to resource governance and development. The literature review chapter identifies the need to align the traditional and predominant literature on resource-based economic growth and development with concepts of resource productivity, ecological modernisation and eco-innovation, which have been mostly focusing on resource-dependent, industrialised countries with a large manufacturing base. It discusses outstanding academic works, which make the case for integrating environmental protection and eco-innovation into the broader academic discussion of resource governance, with which this dissertation aligns itself and aims to advance as a subject of study in the context of resource-rich countries.

Chapter 3 frames the analytical framework based on the conclusions of the literature review and consists of two main parts, namely the theoretical reflections and methodological tools this thesis adopts to answer the research questions. Due to the interest in the subject of reforms supporting eco-innovation at the national and sectoral level, the theoretical lens is grounded in theories of domestic change. Based on a differentiated discussion on historical institutionalism, sociological institutionalism and rational choice institutionalism, the thesis follows the rational choice institutionalism propositions, while discussing also its limitations and alternative explanations. Chapter 3 takes into account bounded rationality and discussions around corporate environmentalism, which provide challenging answers to the propositions of rational choice institutionalism. The chapter concludes with hypotheses derived from the theoretical reflections. It must be noted that this dissertation is not a theoretical work with

ambitions to advance the study of institutionalism. It is rather interested in making use of existing theoretical tools to analyse the different eco-innovation outcomes of two similar resource-rich OECD countries. The second part of Chapter 3 reintroduces the research objectives and questions and presents the mixed method approach this thesis applies. It provides a detailed justification of the case selection and the causal propositions building on the first part of Chapter 3, which structure the case study analyses. It then presents the data collection process, the different sources of data and how data saturation has been achieved. As part of the mixed method approach, the thesis made use of semi-structured interviews, which were used as a validation exercise for other sources of data. Therefore, Chapter 3 explains in detail how interviews were sampled, including the inclusion criteria. The chapter concludes by providing an explanation of why also process tracing and content analysis and coding were applied as part of the method mix. The chapter shows how a set of different methodological approaches was applied to answer the complexity of the subject and address the research questions sufficiently. The application of content analysis and coding is particularly novel in this field, since, to the knowledge of the author, there have not been any studies on eco-innovation in mining countries making use of this innovative research tool.

Chapter 4 represents the core of this dissertation, which is located in the broader academic work of comparative institutional analysis. The literature review and theoretical reflections informed the structure of this empirical chapter. After a brief introduction of the resource and economic profiles of Australia and Chile, it analyses different levels of causal mechanisms, which are relevant for the explanation of the difference in political and institutional outcomes. The chapter starts by looking at the level of international organisations and agreements and how they have unfolded, if so, an effect on domestic policies and institutions. It focuses on domestic reactions to climate change agreements and the effects of trade and cooperation agreements of relevance for eco-innovation. The second level of analysis relates to the domestic policy and institutional framework, focusing in particular on issues of policy certainty, policy coherence and horizontal coordination, which are determining factors for the successful transition towards eco-innovation. The third level of analysis looks at the degree and structure of cooperation

between public institutions and the private sector. This is particularly important to overcome knowledge gaps, to create a level playing field for mining companies, for instance based on equal access to finance and to overcome first mover risks. Finally, the fourth level of analysis addresses the issue of domestic veto players, which, based on the literature review and theoretical discussion, provide a strong explanation for resistance to regime change, hence, for explaining the major difference in political outcomes between Australia and Chile. The chapter concludes by contrasting the different as well as similar effects of these levels of causal mechanisms on both countries.

Chapter 5 takes a closer look at the effects of the same analytical levels on the mining sector, focusing on three major companies, which have operations in both countries and are similar in terms of their size, portfolio and sustainability reporting structures. This chapter aims at analysing the eco-innovation profiles and how environmental sustainability is perceived by the sector. It also aims at understanding which one, if any, of the causal mechanisms this thesis identifies, has a significant effect on company performance and decisions related to eco-innovation.

Finally, Chapter 6 concludes by summarising the findings and discussing their relevance for policy and the academic debate on natural resource-based development and eco-innovation. It also provides a discussion on the usefulness of the analytical framework and methodological tools.

2. Literature review

This chapter is about addressing gaps in the literature, which this thesis aims to contribute to filling. In line with the research questions and objectives it revolves around the role of international agreements, institutions and the national policy frameworks for environmental sustainability and eco-innovation. It addresses the question of to what extent the existence of resource scarcity and climate change effects influence policy outcomes in support of sustainability and to what extent domestic actors and veto player influence eco-innovation trajectories. It starts by discussing the literature on the political

economy of natural resources. The first part introduces larger topic of resource governance, in particular the traditional and influential debate on transparency and accountability as part of good governance, ultimately, for an economically successful way of harnessing the benefits of natural resources in minerals and fossil fuel exporting developing countries. The question of what these countries could do to in terms of eco-innovation, going beyond the predominant notion that they will play a strategic role as “suppliers” of metals and minerals and benefit economically from that, remains not sufficiently addressed.

Therefore, the second part discusses the important academic writings on resource productivity, ecological modernisation and eco-innovation. This strand of literature suggests that improved environmental performance can be achieved through better information on policy choices, institutional reforms and a robust policy framework based on a mix of policies. In line with rational choice institutionalism, which is discussed in this chapter, the main driver of eco-innovation and thus environmental sustainability is not necessarily environmental degradation itself but rather strategic interests such as competitiveness, minimising investment supply risks and saving costs. On the other hand, this literature provides explanations for the question of why in some cases the status quo prevails: incumbent sectoral players, or veto players, benefitting from the status quo are likely to show resistance to regime change.

2.1. Resource governance and development

This strand of literature deals with the question of why resource-rich economies often do not benefit enough economically from their natural resources and under which circumstances they do succeed to do so. It makes a strong case for the need for “inclusive institutions” (Acemoglu and Robinson, 2016), providing stability and helping to overcome suboptimal outcomes created by individual powerful actors seeking profit maximisation for the sake of achieving ultimately a more optimal outcome for the broader society. According to Acemoglu and Robinson, inclusive institutions have two dimensions: “First, there must be a state with capacity; second, political power must be

broadly distributed in society.” Yet, that resource-rich economies have long been doomed to suffer from a structural inability to harness their resource abundance for sustainable economic development is a common conclusion in the academic literature based on patronage and weak institutions. The windfall profits associated with the abundance brings about policy and economic challenges to resource-based development. The “resource curse” also known as the “paradox of plenty” describes the correlation between resource abundance and political and economic restraints of development (Ville and Wicken 2012). Sachs and Warner have introduced the “resource curse” hypothesis in the mid-1990s supported by a significant number of data analysis across a large number of countries. Furthermore, they show a negative correlation between resource intensity and economic indicators such as GDP growth, human capital or innovation (Van der Ploeg, 2011).

There is a wide range of economic, political or sociological approaches to the resource curse argument. At the heart of these studies, the poor performance is explained by one major variable, which is the focus on a specific sector, namely the resource sector based on resource governance and institutionalism as the main strand of theory, including economic policies. The literature offers several examples of the resource curse effect: Dutch disease, governance, conflict, excessive borrowing, inequality, volatility, and lack of education (Collier and Goderies, 2008). Prebisch and Singer (1950) highlighted that there are limited opportunities for innovation in resource industries and their exposure to experience long-term decline in their trade performance. Hirschman (1958) stressed that manufacturing could contribute to greater growth-inducing linkages with other sectors, while resource production usually occurs in sudden windfalls, motivated by changes in the supply conditions such as new discoveries or technologies, or through increased demand with the rise of new emerging economies. Graesley and Madsen (2010) argue that there is more learning and knowledge, i.e. human capital, in manufacturing than in other sectors. Resources divert economies away from manufacturing or other high-skill activities reducing incentives for people to acquire additional skills or to continue with skill development and education (Michaels, 2006).

A related discussion in the literature emphasises government failures in the misallocation of resource revenues. Robinson et al. (2006) argue that resource booms have adverse effects because they provide incentives for politicians to engage in inefficient redistribution in return for political support, for example the provision to public employment in return for votes (Robinson et al., 2006). Collier and Hoeffler show that resource abundance comes with increased incidences of violence through easy access to finance for rebels or warlords (Collier and Hoeffler, 2004). They demonstrate that resource abundance is strongly related to conflict, creating incentives and opportunities for looting and patronage. His large "n-studies" also show the correlation between proximity to mine and level of violence. Manzano and Rigobon (2007) discuss the relation between resource abundance and excessive borrowing. Resource abundance exposes countries to commodity price volatility creating vulnerabilities and discouragement for potential investors (Sala-i-Martin and Subramanian, 2003). Gylfason (2001) asserts that there is a correlation between natural resources and lower incentives for citizens or the public sector to invest in education.

One of the well-known economic effects of a strong resource sector is the Dutch Disease. The term originated in The Netherlands in the 1970s describing the high revenue generated by the country's natural gas discovery, which led to a sharp decline in the competitiveness of its other, non-booming tradable sector. Today, the term is used to express the negative growth in non-resource exporting sectors as a result of high currency value. Another element of the resource curse stems from the strong specialisation on single resources and sectors, such as metals, for exports, which creates additional vulnerabilities created by potential price volatilities (Dwyer et al. 2011). The focus on resource extraction in resource-based economies may lead to a "specialisation trap", possibly accompanied by deteriorating trade performance (Harvey et al. 2010) also depending on price developments and the role of other sectors in the broader economy. While at the beginning of this century, the resource boom contributed to specialisation, declining demand might reinforce the structural problems of resource-based economies (Schaffartzik et al. 2016).

The initial explanation of the resource curse was purely economic, i.e. the Dutch Disease, the specialisation trap, and has gradually become more political addressing institutional, governance and policy issues (Collier, 2010). The resource curse is not only about the economic failures of harnessing the benefits of resource abundance but also about political failures. In political science, the theory of “rentier state” plays an important role in providing political explanations for the resource curse. It describes the reliance on resource revenues and the use of these for patronage. Collier and Hoeffler (2009) investigate the effect of natural resource rents on the economic performance of democracies and find out that to some extent resource rents happen to undermine the normal functioning of democracies, facilitating the erosion of checks and balances. One way in which resource rents undermine democratic processes and institutions is through patronage, the use of money to maintain power, which reduces the accountability of the government (Collier and Hoeffler, 2009). Moving away from the purely economic explanation of the resource curse, Collier (2010) states rightly that it has become more evident that the key issues are of political nature. Analysing the interplay between politics and valuable assets, Collier discusses ways in which governance deteriorates: in a democracy resource rents might reduce the efficacy of electoral accountability; second, in an autocracy, resource rents might reduce the incentive to use public goods as the means of benefiting the elite; third, resource rents might alter the likelihood of democracy relative to autocracy (Collier, 2010). Resource rents bring about non-productive lobbying and rent seeking occurring in countries with "grabber-friendly institutions" rather than "producer-friendly institutions" (Torvik, 2002; Mehlum et al., 2006). From a rational choice institutionalism lens, institutions would be needed to moderate the different rational interests, ensure greater efficiency and generate a better outcome for the broader society. As Collier stresses, the lack of institutions leads to suboptimal outcomes.

The political economy literature provides a variety of analyses on the relation between natural resources and economic growth in the sense of development and political stability and conflict. Case studies and cross-country studies point at the correlation between natural resource abundance and violent conflict. The economic literature addresses the effects of the resource curse on growth rates, constituting low opportunity costs for

rebellion and civil wars; while the political science literature analyses the relationship between resource abundance and weak institutions. Resource-rich economies create a system of patronage hindering the development of a democratic system based on electoral competition, scrutiny and civil rights (Collier and Hoeffler, 2009). For economic growth and human development the most important question is whether public funds are used for public investment or looted to maintain power through patronage. Resources can motivate conflict, especially in the form of secessions. Secessionists not only claim ownership of the resources, they also claim that the national authorities are misusing the money. Resources can induce patronage politics. The policy world started to react to this problem through the Extractive Industries Transparency Initiative, which has now been picked up by many resource-rich governments. The starting point is transparency in the reporting of revenues, to ensure that they flow into the budget rather than into the pockets of ruling elites.

The political economy literature provides a number of answers as to under which conditions a country can economically succeed through extractivism. Norway, Chile and Australia are used as benchmark countries to illustrate how especially African countries could seize the opportunity of harnessing the benefits of their natural resource abundance. These countries have been successful in harnessing their resource revenues for long-term, stable growth. This thesis looks at two of those countries and draws lessons on any transferability cautiously. McMahon and Moreira from the World Bank (2012) show that in addition to economic growth, countries rich in minerals other than oil experienced significant improvements in their Human Development Index (HDI) and scored on average better than countries without minerals. They highlight improvements in the health and education fields and note small improvements in governance, contradicting the widespread deterioration proposition put forward by the resource curse literature (McMahon and Moreira, 2012). Paul Collier (2008), a strong advocate of extraction-based development, especially for Sub-Saharan African countries, calls in his book "The Bottom Billion" for codes and laws to correct past mistakes and boost institutional innovation. He argues, in line with rational choice institutionalism, which is introduced below, that laws, codes and charters can contribute to fixing the policy failures and

fostering good governance by introducing exogenous constraints, providing a level playing field and facilitating learning based on best practice sharing. He suggests that new codes could cover the design and conduct of the auctioning process by which the rights to extract minerals are granted. He also puts forward ideas on the tax regime or limits on the horizon of rights sold by transitional governments as well as savings rate out of resource revenues and procedures for public investment.

Collier stresses that low-income developing countries with resource abundance could not deliver transformational development during the commodity booms of the 70s or more recently in 2007/2008. This has been mostly the result of wrong government decisions taken by insufficiently trained or informed decision-makers. “The Bottom Billion” and an article written by Collier and Goderis (2007) investigate the adverse long-term effects of price booms in non-agricultural commodities statistically using data for almost the entire world covering the period between 1963 and 2003. They conclude that instead of benefitting from price booms, resource-rich developing countries show adverse effects after 20 years, such as a reduced economic output of around 25 per cent less than it would be without the boom (Collier and Goderis, 2007; Collier, 2008). Although in the short run commodity prices raise growth through exports, in the long run growth is substantially reduced (Collier, 2010).

“The Bottom Billion” describes also the author’s work with Hoeffler, investigating whether democracy improves the economic performance of resource exporters. It finds that whereas in other economies, democracy has such an effect, amongst the resource exporters, performance is significantly worse. Instead of democracy disciplining the decision-making process, resource revenues undermine the democratic process. They conclude that the economic damage done by democracy comes from electoral competition and is offset if checks and balances are sufficiently strong. The instant democracies of the 1990s have electoral competition without checks and balances because the latter are much more difficult to establish. Overall, stability and inclusiveness are crucial elements of the characteristics of polities that are well suited to the management of natural assets (Besley and Persson, 2008). Collier and Hoeffler conclude

that checks and balances significantly improve performance whereas electoral competition significantly reduces it and point out that their findings are consistent with those of Robinson et al. (2016), stressing that a key characteristic of a policy is providing effective institutional safeguards against political patronage. Indeed, institutions create constraints for the actions of rational individuals and enforcement mechanisms reduce the risk of patronage.

Rational choice institutionalists have developed a distinctive approach to the problem of explaining how resource governance institutions such as the EITI originate and survive. They create a functional value for actors affected. Actors create institutions in order to realise this value, which is most often conceptualised in terms of gains from cooperation and which often revolve around voluntary agreements by the relevant actors (Hall and Taylor, 1996). Transparency and disclosure protect investors from claims of bribery and makes the country receiving mining investments a reliable destination for foreign direct investment, proving that it is not corrupt or trying to tackle it. Collier suggests that voluntary codes can be one way of fixing the governance of resource rents. The Extractive Industries Transparency Initiative (EITI) and the Kimberley Process Certification Scheme have shown how powerful voluntary codes improve the situation in resource-rich countries. Building on these two examples, he highlights some reasons why voluntary codes can be effective: they are informational, illustrating best practices and informing governments; they codify impartial, scientific input; they provide a common neutral goal around which reformers can rally; they can be used effectively in creating external pressure – the EITI has become part of conditionality used for European trade and aid cooperation policy; and finally, voluntary initiatives can be effective through reputational pressure: while countries willing to complying with standards are revealed, those who are not are also revealed.

Collier rightly points out that in many cases of economic activity the role of government is rather peripheral, while in the case of resource exploitation the role of the government is central. He makes a philosophical point based on ownership. According to Collier, the government holds custodial rights on behalf of citizens who collectively own the

resources. Therefore, the role of the government is to ensure the effective management of the assets in its custody in a way that maximises their value to citizens. Misdistribution comes about because the strong are advantaged over the weak. Rent seeking comes about when ownership is conferred by physical control of territory. People then will divert their efforts into violence to gain that control and benefit from the rents. In conclusion, the absence of government or the existence of a weak government contributes to the socially dysfunctional exploitation of natural resources. He points out that "first, natural assets have to be discovered and extracted, and then the revenues must be well spent" (Collier, 2010). Collier's point that resource revenues need to be well spent, maximising value to citizens, because of collective ownership of natural resources is an important one. However, other natural resources used for the mining of metals and minerals need at least as much value maximisation as possible, especially with non-renewable resources such as land and water, access to the use of these for the next generations need to be secured (Bleischwitz et al. 2018). Collier leaves other crucial natural resources in his custodial rights approach unaddressed even though the use of resources are interlinked and sustainable development goals encompass different interlinked dimensions of natural resources and the environment. The extraction of resources require high levels of water and energy use as well as land. Yet, his points regarding the need for strong institutions and regulatory oversight is a widely accepted one, as mining is a unique activity in which the state retains resource ownership and assigns rights for exploitation (Eftimie and Stanley, 2005).

Collier advocated initiatives supported by the international community to improve the information for decisions-makers. The ultimate aim should have been the effective harnessing of natural resources for development: "resource-rich countries can only get these decisions right to the extent that they understand them" (Collier, 2010). He concludes that there is room for international action "to improve understanding of difficult but crucial social choices", which is the intention of the Natural Resource Charter, an initiative Collier has started together with a group of independent academics and practitioners. The Natural Resource Charter drafted by Paul Collier, Professor of Economics and Public Policy at Oxford University, together with a group of academics

and practitioners including Director of Revenue Watch Institute, aims at providing an independent perspective on 12 principles throughout the resource extraction decision chain, from discovery to use. They suggest some guidance for the choices that resource endowed governments should make. The charter was launched in 2010 at the Annual Meetings of IMF and World Bank and since then was adopted as a flagship programme by the New Partnership for Africa's Development; it is now working to accommodate the Africa Mining Vision into its methodology (Franks, 2016). The charter has gradually become an organisation with a technical advisory board with Nobel Laureate in Economics Michael Spence and an oversight board. The Natural Resource Charter is not a transparency initiative, but has transparency at its core and seeks to shift the focus from resource revenues to resource governance (ibid.). The charter contains elements of reducing environmental effects - always linked to social impact. Innovation, resource efficiency or investments in environmental protection are not mentioned. The Natural Resource Governance Institute is the result of this initiative, which has put the Resource Governance Index (RGI) in place. The Index measures the standard of governance in the oil, mining, and gas industries in over fifty countries. It is divided into four major parts, consisting of (1) institutional and legal setting with ten indicators that assess whether the laws, regulations and institutional practices enable comprehensive disclosures, open and fair competition, and accountability; (2) reporting practices with twenty indicators that evaluate information and reporting practices by government agencies; (3) safeguards and quality controls with 15 indicators that measure the checks and balances that guard against conflicts of interest and undue discretion, such as audits; finally (4) enabling environment with five indicators of the broader governance including open budget or the rule of law (Resource Governance Index, 2017). The category under "reporting practices" is the only one that includes "environmental and social impact assessment". Apart from that single indicator, no other environmental indicators are included. The latest report shows that most of the progress has been made in the field of transparency and disclosure, whereas least progress has been made in the environmental and social categories (ibid.).

The economic and political relations between raw materials exporting and importing countries are mostly influenced by the extraction-based growth agenda. Past experience with the “resource curse”, i.e. failed attempts of harnessing the benefits of commodity cycles in developing countries, has led to a number of transparency initiatives to fight corruption and related conflicts through good governance. The participation in the EITI has become conditional for trade and aid relations between developing countries rich in resources and EU members or the United States. The EITI as a voluntary code has proven to be a powerful instrument (Collier, 2008). The basic rationale is informational, suggesting global standards to promote the open and accountable management of extractive resources. It is a source of pressure revealing those who are willing to comply with the EITI standards and those who are not - creating strong incentives for governments not to be seen in the latter category. After the launch of the EITI, the United States (Dodd-Frank Act) and the European Union (EU Accounting and Transparency Directive) have introduced legislation supporting the voluntary initiative through “hard law” - making it a requirement for listed companies to disclose their payments for exploration and extraction in resource-rich countries as well as the use of conflict minerals. In turn, the disclosure of payments and transparency on public investments make up for a great contribution to economic development and political stability. Given that the world’s 100 largest oil and gas and mining companies are listed in the United States, EU, Norway and Canada, as figure 1 shows, the initiatives being translated into law have been very impactful. Most of the mining as well as oil and gas companies are listed in the United States and the European Union. With the EU Directive and Dodd-Frank Act their impact on company compliance with laws and thus international standards has been quite significant. The question is whether this initiative would have been also successful without the “hard law” component, constituting a clear “exogenous constrain”, just by “norm diffusion”. Enforcement mechanisms reduce uncertainties about the corresponding behaviour of others and allow gains from exchange thereby leading actors toward particular calculations and potentially better social outcomes, as rational choice institutionalists predict (Hall and Taylor, 1996). Nevertheless, in conclusion, Collier’s work is very important and sheds light on the great achievements of transparency initiatives, contributing indirectly also to the explanation as to why there is a

room for improvement in eco-innovation in resource-rich economies, developing and developed alike. There are no concise, targeted initiatives focusing on environmental sustainability and framing greener growth as an economic opportunity for the sector to save costs and for countries to achieve greater environmental sustainability coupled with enhanced competitiveness and new supply chains and jobs.

Figure 1. Countries where oil, gas and mining companies are listed, top 100 of world’s largest companies (Transparency International Australia, 2017)

	Oil and gas	Mining
United States	68	40
European Union	24	28
Norway	2	1
Canada	14	16

Ruettinger and Schroll (2017) analyse 42 global standards and conclude that none of these only address environmental aspects. According to them, it is not possible to identify a globally recognised and comprehensive environmental standard specifically geared towards the mining sector or a large part of it. Environmental aspects are often addressed together with social and economic matters as part of wider sustainability standards and less frequently solely in conjunction with social aspects. An increasing number of standards such as the EITI are aimed at preventing the financing of conflicts through mining and trade of minerals and ensuring transparency. They fail to take sufficiently into account the environmental dimension. Due to the political fragility and environmental vulnerabilities of resource-rich developing countries (Bleischwitz et al. 2014), there is the need for the inclusion of environmental standards in existing technical cooperation for the sustainable use of resources and consistent with the aim to promote good resource governance. Collier’s work has its limits, i.e. he neither addresses the nexus in a systematic manner nor the eco-innovation challenges. The research questions of this work result from the identification of these gaps in the literature, requiring a broader mix of methods, which are introduced below.

In conclusion, international initiatives are expected to have less of an impact on mining countries’ policies and mining companies’ eco-innovation efforts but rather on their

financial disclosure policies. There are no global standards directly related to environmental sustainability in mining, whereas global standards, translated in national laws, have had influence in making progress in the field of transparency and accountability.

2.2. Integrating environmental protection into resource governance

There are a couple of very important works on the importance of integrating environmental perspectives into the resource governance debate. Schaffartzik et al. underline the increasing environmental pressures because of more extraction in times of rising commodity prices or the fact that valuable metals and minerals have become more difficult to mine, as valuable and easy to mine ones have been mostly exploited (Schaffartzik et al. 2016). New reserves will be more difficult to access and exploit. New technologies will be needed and the extraction processes will be more energy and water intensive (Moyo, 2016). Water is a highly complex issue in the context of mining with site-specific interactions (Northey et al. 2016). In Australia, there are different water management approaches and different strategies to mitigate water related risks. The significant variability across industry pose challenges to quantify as well as monitor the water footprint or applies a large-scale life cycle assessment approach. There is a lack of availability of mine site water use data and inventory data for mining supply chains in Australia. Furthermore, many sites have a poor understanding of how water flows their operation and associated impact of water. The evaporation of water is poorly quantified; there is not long-term baseline data. In fact, long-term baseline data is non-existent (Interview, 2016). There are difficulties to account cumulative impact of extreme events such as dam failures or flooding. Addressing these limitations are beyond the scope of this research project. Nevertheless, it is useful to improve the understanding of water use in the mining context and address these challenges (Younger et al. 2002, Northey et al. 2016). Mining is one of the most diverse industries as to how it interacts with water resources (Younger et al. 2002). The local climate and hydrology dictates infrastructure conditions and influences risks faced by mines and close communities. Mining is a relatively small consumer of water at a global scale but in the regions it occurs it can

often represent a major local consumer. For instance, BHP is the single largest consumer of water in South Australia.

Bleischwitz et al. point out vulnerabilities arising from the resource nexus - especially of concern to the poorer Sub-Saharan countries (Bleischwitz et al. 2014). Yet, they provide a strong case for a conceptual rethinking of resource governance and policy change and new institutions. The resource nexus, describing the interlinkages between resources such as energy, land, water, minerals and food, illustrates new complex challenges (Bleischwitz et al. 2018a; Bleischwitz et al. 2018b). Declining ore grades and the increasing intensity of water and energy use in mineral extraction processes (Giurco et al. 2014; Meinert et al. 2016) will contribute to "new scarcity" exacerbating the vulnerabilities of the resource sector and downstream manufacturing and last but not least the fragile developing countries Collier particularly aims to address.

Figure 2. List of countries with environmental vulnerabilities (own compilation based on IMF 2012 and Bleischwitz et al. 2014)

Country	Resource	Vulnerability
Low-income country		
Democratic Republic of Congo	Cobalt, copper, oil	Highest risk
Liberia	Gold, diamond, iron ore	
Niger	Uranium	
Guinea	Bauxite, iron ore	Highest risk
Mali	Gold	
Low-income country (prospective natural resource-rich country)		
Sierra Leone	Diamonds, iron ore	Highest risk
Afghanistan	Copper, gas	Highest risk
Madagascar	Oil, gas, nickel	Relevant risk
Mozambique	Gas, bauxite, coal	
Central African Republic	Diamonds, gold	
Tanzania	Gold, gems	
Kyrgyz Republic	Gold	
Lower-middle income country		
Mauritania	Iron ore	
Zambia	Copper	Highest risk
Papua New Guinea	Oil, copper, gold	
Uzbekistan	Gold, gas	
Mongolia	Copper	

Ghana	Gold, oil	Relevant risk
Low-middle income country (prospective natural resource-rich country)		
Guatemala	Gold, silver	
Upper middle income country		
Peru	Copper, gold	Relevant risk
Botswana	Diamonds	
Mexico	Oil, silver	Relevant risk
Russia	Oil, nickel, bauxite	Relevant risk
Chile	Copper	Relevant risk
China	Copper, aluminium, rare earths, gas, coal, uranium	Relevant risk
Indonesia	Copper, nickel, gold, oil	Highest risk
South Africa	Diamond, coal, copper, silver, uranium, platinum	Relevant Risk
High income country		
Australia	Bauxite, iron ore, gold, lead, lithium, uranium, nickel, silver	Relevant risk

In their paper, Bleischwitz et al. analyse the inter-linkages of resources, also known as the resource nexus, focusing on the extent to which food and water stress may impact extraction activities in fragile states and regions (Bleischwitz et al. 2014). This is an important question to address for two reasons: countries crucial for the raw material supply might face bottlenecks in their mining projects and affect global supply of strategic metals and minerals and the respective markets. Second, the bottlenecks would not only cause challenges for the supply chain but also contribute to or exacerbate domestic fragility and conflicts. 15 countries, most of which are in sub-Saharan Africa, are identified as at high risk, while 30 other countries are considered as being at relevant risk of causing resource supply disruptions. Bleischwitz et al. (2014) define fragility and vulnerability as the collective outcome of various factors: political instability, environmental stressors, such as the effects of climate change, and the lack of resource reserves, such as water or land. Chile, despite being a stable democracy, is considered vulnerable due to its water shortages in the mining areas which make it susceptible to restricted supplying of its copper for instance to the global markets. There are different layers adding up to the degree of a country's vulnerability. As figure 2 shows, countries such as Congo, Guinea, Indonesia, Sudan, Yemen or Zambia share a high degree of political instability and environmental stress, while holding globally strategic mineral

reserves. Any supply disruption due to political turmoil or lack of water or energy resources would hit these countries' economies badly and the economies of those, depending on their supplies. They analyse the relationship between resource abundance, economic growth and conflict and focus especially on the most vulnerable countries in the world, hoping to lift up their economies by harnessing their resource abundance without addressing the potential threats Bleischwitz highlights.

Collier calls for a strong government role vis-à-vis private business in the extractive sector in order to increase the economic benefits of revenues and to ensure the equal distribution of the benefit across the population and generations. Governments that pursue extraction-led development models use the revenues to improve the standard of living within the country. The rise and expansion of new mining frontier countries is linked to water stress, contamination and biodiversity loss, additionally fuelling socio-ecological conflict (Gudynas, 2010). However, even if the revenues are used in a way that benefits the maximum possible part of the population, the interventions into the given social and ecological areas of the extracted areas remain. This is why the purely extraction-led development pathway remains inherently linked to (potential) regional conflict (Bebbington, 2011; Schaffartzik et al. 2016). The depletion of metal reserves and declining ore grades must be taken into account when evaluating the economic benefits associated with extractivism. Even more, the biophysical data of material intensity and water, energy footprints suggests that if sustainability is not addressed seriously as part of the development agenda, in terms of broader indirect effects, the trade-off between financial incomes and high environmental costs may ultimately lead to failure to achieve the sustainable development goals (Schaffartzik et al. 2016). As suggested by Collier's research, increasing demand and long-term increase of global market prices for many metals and minerals could create a window of opportunity and incentives for resource-rich countries to seek revenue through the extraction and export of primary raw materials. Yet, the expansion of extraction exacerbates the potential for conflict between nature conservation or the provision of important ecosystem functions such as carbon sequestration. Competition also arises between different forms of resource use and sectors, especially over land access and water use (Schaffartzik et al. 2016). This is not a

phenomenon, which occurs only in fragile or developing countries. Conflict as a cause of extraction projects occurs also in industrialised, developed mining countries such as Australia, with recent conflicts erupting over water use in the Murray–Darling basin between farmers and miners (Berry, 2010). A national survey of 8,020 citizens conducted by CSIRO reveals what mining means to Australians in 2017 and shows that 50.3% of those asked think that mining affects the agricultural sector negatively (CSIRO, 2017).

Furthermore, Schaffartzik et al. (2016) find in their material flow analysis that the distribution of metals extraction shows a shift away from the early industrialisers in Europe and North America to the emerging economies of especially Latin America and Asia. However, high rates of metal deposit depletion might mean that today's metal extractors and exporters may depend on imports of metal from anthropogenic deposits (stocks in buildings, infrastructure, and durable products) in the next coming decades. The extraction-based development path and the shifting of metals from natural to anthropogenic deposits might cause another potential for conflict, which needs to be taken into account. In Australia, one of the largest global providers of metals, deposits are exploited at high rates. Therefore, the metal content of mined ores has declined considerably during the 20th century, and extraction is assumed to have “peaked” or to peak in the near future for some important metals. Mining of lower grade ores means increasing energy and water inputs as well as emissions (Mudd, 2010; Prior et al., 2012; Schaffartzik et al. 2016, Northey et al. 2018). Secondary metals production is gaining a bigger strategic importance, especially in "resource poor", demand-side countries with a large manufacturing base. Germany, for instance, is Europe's number one exporter of secondary, recycled metals, while South Korea and Japan are important exporters as well (Hilpert and Mildner, 2013). As opposed to fossil fuels and minerals such as phosphate, metals are not throughflow materials that are transformed into waste and emissions after a short period. They are accumulated in landfills, buildings, infrastructure, and durable products such as mobile phones or fridges, providing opportunities for future “urban mining” (extraction of metals from anthropogenic sources) and recycling (Schaffartzik et al. 2016).

Advanced European economies, i.e. the Netherlands, France, Germany, Italy, or Japan, have focused over the past decades on competitiveness, security of supply, recycling, resource efficiency and clean production, while producer countries, such as Australia, Brazil, Canada, Russia, and South Africa welcome the rising prices and see them as a chance for prosperity and development – regardless of environmental implications, lower ore grades, more energy and water use (Hilpert and Mildner, 2013). The environment is given, but natural resources are the outcome of socio-economic processes where the environment is transformed into economic resource (Ville and Wicken 2012). Given the importance of existing environmental and resource challenges in relation to climate change, energy and other resources, international organisations, policy makers and governments call for changes in the economic use of natural resources (Ekins, 2010). This is a topic which does not only concern developed, industrialised countries, but also emerging and developing ones. It is in the interest of resource-rich economies to pursue an eco-innovation agenda that helps protecting their ecosystems, using resources efficiently, saving materials costs, contributing to green growth and new business opportunities and reducing their vulnerabilities to scarcities and vulnerabilities. While there are good reasons to assume that mining countries want to be part of an orchestrated global effort to tackle climate change for image reasons, to benefit from aid and trade cooperation (Collier, 2008), there also domestic conditions resulting from extensive water and energy use along with additional stress factors linked to climate change such as draughts, floods or storms which contribute to the strategic relevance of eco-innovation and environmental sustainability (Andrews-Speed et al. 2014).

There are worldwide about 170 mining countries providing “the skeleton” of industrial development (Schaffartzik et al. 2016). A high share of raw materials exports along with high levels of resource and emission intensity characterises mining countries. A number of authors use the amount of waste rock produced as a proxy to determine whether a country is a net-exporter of primary metal commodities. Amounts of waste rock are also used as a proxy for the socio-ecological pressures associated with metal mining (Mudd, 2010; Franks, 2015; Schaffartzik et al. 2016). According to Schaffartzik et al. (2016), Australia, Brazil or South Africa are net exporters of primary as well as secondary metal

commodities with a developed mining sector and metals processing industry. There are also exporters of primary and net importers of secondary metal commodities. These countries have large-scale mining operations in relation to the size of their territory mining metals with comparatively low ore grades: Chile, Jamaica, Indonesia, and Uzbekistan followed by China, Peru, South Africa, and Ghana. Low ore grades mean higher energy and water input as well as higher levels of emissions. Yet, the extractivism literature advocates good governance for resource-based growth, particularly in the poorest and most vulnerable places in the world, without sufficiently addressing environmental and related future economic challenges. These points clearly contribute to the understanding of future challenges resource-based economies will be facing and show that the extraction-based development agenda needs a strong environmental angle to address the regional and international needs for eco-innovation, highlighting the relevance and important contribution of this research project to a new and exciting field of research.

2.3. Resource productivity

The literature on resource productivity makes a compelling case for the sustainable use natural resources and how to address unsustainable and inefficient production and consumption. From a rational point of view, it highlights the economic benefits of a change towards a greener economy. Developed along the needs and interests of early industrialisers with large manufacturing sectors, the literature suggests that difficult access to many critical metals and increasing prices might create barriers for the low-carbon economy. Following this reasoning, resource productivity, meaning the efficient use of natural resources to produce goods and services, is seen as a key determinant of economic success (Bleischwitz, 2010; Bleischwitz, 2012). Suggesting that climate change and natural resources are the major issues of international environmental economics and policy, some scholars call for the promotion of resource productivity as a major source of competitive advantage contributing to the transition to a low-carbon economy. Bleischwitz suggests that materials should be used more efficiently through technological innovation resulting from policy incentives and the right institutional set-up (Bleischwitz,

2010). This would lead to energy savings along the value chain and material purchasing costs – a major concern for demand-side countries.

Bleischwitz creates an interesting link between the strategic importance of some metals and minerals and the low-carbon economy by highlighting that all potential substitutes for fossil fuels will have implications for materials demand, which need to be used sustainably to achieve climate change mitigation and green growth goals. He illustrates that lithium batteries, needed for electric cars, will come from a limited number of salt lakes located in Bolivia, Argentina or Chile. Photovoltaic cells or energy efficient lighting rely on gallium, a by-product of aluminium. The reserve holders are, among others, Guinea, China or Kazakhstan. Tantalum, used for computers or mobile phones, comes from Australia or Brazil. This reasoning also implies that resource productivity would reduce the negative externalities in countries extracting these materials and the import dependence of demand-side countries.

Bleischwitz concludes that the transition to a low-carbon economy coupled with resource productivity can only be achieved through a well-designed mix of institutional change and policy instruments (Smith et al. 2005; Bleischwitz, 2007; Bleischwitz, 2010; Bleischwitz, 2012). He puts forward principles of a “Resource Policy” based on extraction, production, consumption, recycling and sustainable disposal respecting the boundaries and limits of ecosystem services. He suggests the use of materials with better environmental performance; substituting environmentally intensive materials with new materials; establishing life-cycle wide processes of material efficiency, e.g. sustainable mining through more efficient production and application of materials and strategies with enhanced re-use and recycling. Yet, he does not address the issue of what exactly sustainable mining might look like. Finally, according to Bleischwitz, there are two reasons to favour the formulation of such a policy: firstly, to increase resource productivity growth and reducing environmental pressures occurring along material flows at an international scale; secondly, to address the economic opportunities, i.e. positive sum outcome of cooperation, stemming from eco-innovation and spill-over effects.

Bleischwitz's contention that lack of information, policy and regulatory frameworks as well as technological and infrastructure conditions drive the unsustainable use of natural resources is from a rational choice institutionalism point of view plausible. Rational actors cannot make the right choices based on extensive calculations if they lack information, e.g. availability of data, about the likely outcome of their decisions and how others would decide. Bleischwitz's argument based on the availability of information has gained the support of other scholars as well (Hirschnitz-Garbers et al. 2016). These also align themselves with the suggestion to focus on a mix of policies rather than single instruments (Bleischwitz, 2012; Hirschnitz-Garbers et al. 2016). Some suggest that technological progress is key for reducing ecological pressures and achieving environmental sustainability through eco-innovation; others highlight that policy reform is crucial in reconciling economic and ecological goals; another stream in the literature focuses on the role of shift in societal values to meet societal demands and remain within the Earth's carrying capacity. Hatfield-Dodds et al. (2015) demonstrate in their extensive scenario analysis for Australia that policy choices and technological progress are interlinked, and that ultimately policy choices are crucial - not changes in values (Hatfield-Dodds et al. 2015). Exploration and extraction of raw materials generate negative environmental effects. Policies addressing these issues might bring about positive externalities by setting the right incentives, for instance based on ambitious targets in the field of resource efficiency, process and product innovation (Bleischwitz, 2010b). Paul Ekins (2010) and Rene Kemp also discuss the crucial role of policy. Ekins' paper supports a strong role for policy, stressing the importance of regulations in the policy mix leading to the undeniable success of economic incentives. Kemp (2007, 2010) highlights in his analyses of the Dutch Energy Transition that dialogue and cooperation among public and private stakeholders is an effective way of achieving eco-innovation and environmental sustainability rather than a top-down policy.

In conclusion, the resource productivity literature suggests policy and regulation and a collaborative institutional set-up as drivers of resource efficiency and productivity, which are part of the eco-innovation agenda. Rational private actors favour resource productivity, if it results in greater competitiveness, efficiency gains and cost savings and

is moderated by strong institutions moderating the best optimal outcome for all market participants within a predictable framework providing certainty, consistency and coordination.

2.4. Ecological modernisation

Ecological modernisation emphasises a win-win situation of environmental protection and economic growth. Ecological modernisation emerged in the early 1980s and was presented as a “technology-based and innovation-oriented” approach focusing on the efficient use of resources and providing benefits both for the environment and economy (Mol and Jänicke, 2009). According to ecological modernisation, solutions to environmental problems can create win-win situations leading to new markets and business opportunities, while driving innovation and eco-efficiency (Hajer, 1995). That concept posits that economic growth and environmental protection can be reconciled, as addressing environmental pressures is therefore regarded as a positive-sum game (Hajer, 1995, 1996). The transformation of industrial systems relies on the reorientation of inter-sectoral and government-business relations, which is based on cooperation and partnership. Under ecological modernisation, there is a restructuring away from a hierarchical, command-and-control state towards a more decentralised flexible state. Ecological modernisation bridges the traditional dichotomy between market and state. While markets provide goods and foster innovation, the public sector sets the framework conditions and provides guidance. Together they overcome knowledge deficits and uncertainties by cooperating in knowledge creation.

Its underlying principle is that environmental regulation can stimulate the application of green technologies, improving the design of products and the economic performance of businesses (Orbegozo et al. 2016). Indeed, market participants would be all subject to the same rules and non-compliance would cost more than compliance. The theory assumes that well designed interventions by governments do not hinder economic growth but instead stimulate new and more efficient industries (Blowers 1997; Weale 1998; Mol and Sonnenfeld, 2000; Jänicke and Jacob, 2004; Huber, 2008; Jänicke, 2012). The industry

reduces its costs from increased technological efficiency and both the environment and community benefit from less pollution. Governments continue to play a regulatory role and cast as a facilitator to assist the industry in becoming more sustainable (Huber, 2008). The incorporation of innovative technologies rather than end-of-pipe measures is being advocated (Welford and Hills, 2004). Technological development is intended to reduce industrial emissions at the source and encourage a more efficient use of resources (Berger et al. 2001). Huber (2008) argues that national governments play a key role in encouraging the creation of lead markets that are technologically innovative and encourage others to follow. This includes promoting renewable energy and low emission technology, or eliminating hazardous chemicals. Such technological changes have to move beyond simple efficiency.

Ecological modernisation concepts range from strong to weak versions. Strong ecological modernisation argues for a more substantial transformation towards decentralised, consensual forms of governance, and a focus on new forms of political intervention (Spaargaren, 2003). For the industry, this political shift means less hierarchical command-and-control measures, more self-regulation, and an increasing use of market mechanisms (Berger et al. 2001). Strong ecological modernisation also advocates greater public disclosure and community participation in decision-making (Mol, 1999). The benefits for businesses include better technology and informed decision-making leading to increased efficiency and profit as well as reduced waste and lower raw material and energy costs. Investments in renewable energy technology help to lock-in the energy price and reduce vulnerabilities coming from price fluctuations. Weak ecological modernisation focuses on autonomous technological innovation and the application of market mechanisms, while the stronger versions focus on substantial institutional restructuring, a renewed role for social movements and a major discursive shift to new ways of thinking about environmental issues and responses. The conceptual strengths are that it is an integrated approach to environmental issues by conceptually linking ecological priorities with other policy areas (e.g. economic growth and development). Second, its theoretical framework feeds into the broadly accepted policy goal of sustainable development. Third, it can generate programmes for change that

constructively engage with the existing institutions of power. Ecological modernisation has helped to place environmental issues firmly on the mainstream political agenda. It offers the opportunity to hardwire ecological feedback into economic decision-making and goes beyond business as usual and may prepare the ground for more substantial transformations. It can be a useful tool for analysis and a strategic programme for action. Ecological modernisation is essentially a political concept, which highlights the role of public policy (Jänicke, 2006). Ecological modernisation is criticised for being only applied to certain problems and industries. It does not address the equity and justice concerns that underpin many environmental problems; it is perceived as techno-centric and as largely silent on the overarching and sectoral power relations of many environmental issues (Bluhdorn, 2007; Buttel, 2000). Ecological modernisation does not sufficiently address the "modernisation losers" (Jänicke, 2006) of environmental reform – that is, those industries, sectors and actors that stand to lose the most from the application of even a modest ecological and political reform program. The goal of ecological modernisation is to create a more balanced relationship between economic growth and the sustainable use of natural resources, but one in which each of these sectors continues to thrive. Geels addresses incumbent actors and conceptualises regime stability as the outcome of active resistance by incumbent actors (Geels, 2014). Geels introduces rational interests, power and politics into the multiple-levels perspective framework and defines different forms of regime resistance based on instrumental, discursive, material and institutional aspects. He concludes that the resistance and resilience of coal, gas and nuclear production regimes negate benefits from increasing renewables, in particular through influencing the discourse. Yet, path dependencies can also be unlocked through incentives at different levels. While at the national level incumbents might play a great role, transitional change can be supported at the local or international level. Based on the coal example, which is of relevance for the case study on Australia, he concludes: “the coal regime has so far resisted climate change pressures through a “clean coal” discourse and the innovation promise of carbon capture and storage (CCS)” (Geels, 2014). Rather than historical institutionalism and path dependencies, this approach feeds better into the concept of veto players within the rational-choice institutionalism debate on regime resistance and the continuation of status quo. The Australian case shows that as long as

incumbents exist, they will continue to block sustainable change. Past reforms in Australia such as the carbon tax or the renewable energy target were revoked quickly with the following elections several times. The “unlocking of path dependencies”, therefore, never lasted long enough. Setting the right incentives at the national level with long-term “phase out” plans would be the right level to address incumbents.

Much of the early investigation of this theory was based on European case studies and a few studies have been done on the application of the theory to the Australian case (Curran, 2009, 2015). As discussed above, ecological modernisation originated as a theoretical framework to explain rapidly evolving responses to environmental issues within Europe, and Germany in particular, where the theory originated (Dryzek et al. 2003; Grant and Papadakis, 2004). Some work has been done on the problems of applying ecological modernisation to the USA (Schlosberg and Rinfret, 2008), China (Huan, 2007), Brazil (Milanez and Buhrs, 2008) and Hungary (Gille, 2004). To the author’s knowledge, so far no study was done on Chile, providing an opportunity for some original research provided by this dissertation.

2.5. Eco-innovation

As mentioned above, the exploration and extraction of raw materials is linked to a wide range of negative environmental externalities, such as land use change, loss of biodiversity, pollution and depletion of water resources as well as high-energy use and emission intensity. However, besides these negative externalities, environmental challenges can also stimulate eco-innovation through technological progress "provided that governments and international organisations set the incentives right" (Bleischwitz, 2010). Eco-innovation has been attracting a growing interest for the past three decades among firms, governments and scholars as a means of achieving a higher degree of sustainable development (Tamayo-Orbegozo et al. 2016). Diaz-Garcia et al. (2015) find drivers of eco-innovation to be a recurring topic - yet, with a focus on European countries with large manufacturing sectors. This is certainly due to the eco-innovation performances of European early industrialisers such as the Netherlands or Germany

because of environmental public policies (Ekins, 2010). Carrillo-Hermosilla et al. (2010) note in their literature review a lack of clear definition of eco-innovation, often used as a synonym for sustainable innovation. This research uses the definition put forward by Oltra and Saint Jean (2009): “innovations that consist of new or modified processes, practices, systems and products, which benefit the environment and so contribute to environmental sustainability”. This in line with the definition of the Eco-Innovation Observatory funded by the European Commission: “eco-innovation is any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle” (Eco-Innovation Observatory, 2012). Essentially, eco-innovation refers to any solution introduced in any stage of the life cycle of a product involving a significant improvement in the productivity of the resources or a reduction in the environmental impact (Tamayo-Orbegozo et al. 2016).

Eco-innovation has particular features distinguishing it from other types of innovation (Jänicke, 2012). Jänicke stresses that it is a prerequisite for long-term industrial growth and competitiveness. At the same time, the greater scarcity of raw materials increases their price and the pressure to improve recycling rates, resource efficiency, making on-going innovation necessary (Jänicke, 2012). This leads policymakers to focus on resource efficiency policies and companies to innovate, looking for new materials and more efficient processes. Thus, competitiveness, price and scarcity, which are interlinked, are the major drivers, together with policies. The emphasis on economic benefits and costs fits better into the rational choice institutionalism debate rather than historical or sociological institutionalism. Efficiency, competitiveness and economic gains such as cost savings are fixed preferences of rational actors rather than "identity", "norms" or "historical traditions". Institutions set the necessary framework for a fair competition with the best possible outcome for all market participants, and ultimately, the wider society.

Eco-innovation is seen as a key factor in achieving environmental sustainability or reducing environmental pollution without compromising on competitiveness at company or regional level. There is wide evidentiary support in the literature that eco-innovation improves competitiveness (Carrillo et al., 2011; Porter and van der Linde, 1995; Pujari,

2006). There are different drivers of eco-innovation being discussed, such as the growing environmental awareness among civil society and consumers (Carrillo-Hermosilla et al., 2009). However, it is probably the institutional and regulatory perspective that best explains why eco-innovation comes about. Jaffe and Palmer (1997) and the “Porter's hypothesis” stress that "strict" environmental regulation oblige pollutant companies to innovate in order to reduce the costs of non-compliance. Businesses can benefit from “first mover advantages” with eco-innovation and the creation of new niche markets contributing overall to their competitiveness.

Porter and van der Linde (1995) support the theoretical assertions that well-designed environmental policies and standards trigger eco-innovation (Porter and van der Linde, 1995). In their view, companies lack information and experience on the potential savings linked to resource productivity and eco-innovation. Thus, environmental regulation contributes to exploring positive economic and environmental benefits of eco-innovation (Tamayo-Orbegozo, 2016). Environmental regulations are often seen by businesses as costly and a threat to their competitiveness (Vicente et al., 2012). Yet, there is evidence that eco-innovation can help overcoming the traditional divide between competitiveness and environmental protection, since it reduces environmental pollution, improves resource efficiency, contributes to cost savings and the opening of new markets and business opportunities (Tamayo-Orbegozo et al. 2016). Similar to Porter and van der Linde, Misun Park et al. (2017) also highlight that environmental regulations are an important part of a country's eco-innovation capacity and performance. They define eco-innovation capacity based on four indicators representing government's institutional support enabling the environment for eco-innovation, company responses towards regulations and support and mutual relationships in innovation: public R&D expenditure in green industry as well as the implementation of environmental regulations, the maturity of investment setting for green technology industry and investment scale of green technology SMEs (Misun Park et al. 2017).

There is strong evidence in the literature highlighting the important role regulation plays in eco-innovation (Díaz-García et al., 2015). However, specific country or regional

contexts also play a key role in driving eco-innovation, for example in regions with pressing environmental stress factors such as draughts or energy dependence. Moreover, the proximity to external knowledge as a source of informational input to make the right and most efficient choice can also be a determining factor for eco-innovation (Horbach, 2014). The more information the rational actor has, the more he will be informed about the likely outcome of his choice, ultimately, leading to a more optimal outcome. Factors such as financial and market conditions, i.e. access to finance; energy and resources prices; the technological capacity of the industry (technological path, knowledge, etc.) as well as collaboration and networking also appear to determine the development of eco-innovations (Díaz-García et al., 2015; Horbach et al., 2012). Triguero et al. (2013) point out that entrepreneurs who consider it important to collaborate with research institutes and university are more active in eco-innovation. Takala et al. (2014) conclude that in Finland the closest collaboration happens between local and foreign companies. They stress the importance of further analysis of the cooperation between universities, businesses and the public sector. Platforms and networks consisting of public and private sectors with different technical skills and competences, resources and experiences can contribute to overcoming lack of information and support successful eco-innovation (Díaz-García et al., 2015). Cooperation between different actors on the management of the value chain with a focus on product lifecycle contributes to the success of eco-innovation and has a positive influence on businesses' performance (Kemp and Pearson, 2007). Hodson and Marvin (2009) propose the creation of networks of collaboration as an element of support for developing and implementing eco-innovations based on the promotion of renewable energy, resource efficiency or the efficient disposal of waste. Bleischwitz's (2004, 2007) analysis of the successful coordination between political and corporate strategies to eco-innovation supports this proposition.

Achieving eco-innovation requires a long-term approach and investment. The company product portfolio, the way different tasks are organised and the company's relations with the different stakeholders are equally important (Carrillo et al., 2011). The extent of collaboration and networking the country is pursuing is often a result of the capacity to establish relationships with stakeholders and other agents. Such competence should

therefore be taken into account (Díaz-García et al., 2015; Hodson and Marvin, 2009; Kemp and Pearson, 2007; Pujari, 2006). Furthermore, especially in the mining context, concerns of social acceptance or the social license to operate play an important role and must be included in any eco-innovation analysis (Kemp and Foxon, 2007; Prno and Slocombe, 2012; Koivurova et al. 2015; Constanza, 2016). Eco-innovation can reduce environmental damage, increase the acceptance of communities affected and ensure the social license to operate.

Paul Ekins (2010) looks at eco-innovation for environmental sustainability in European countries assessing existing concepts, progress and the policies put in place. Tamayo-Orbegozo et al. (2016) look at eco-innovation in the Basque region of Spain. The Eco-Innovation Observatory, a project funded by the European Commission, monitors eco-innovation in EU member states. Falk and Ryan (2006) analyse eco-innovation in Australia based on the country's role in and reaction to the Montreal Protocol. They draw lessons for climate policy. To the author's knowledge, there is no in-depth, academic analysis of eco-innovation on Chile. The OECD Environmental Performance Review on Chile (2016) describes some recent policies and initiatives as well as patent and R&D expenditure developments in the country without looking at the underlying reasons supporting or hindering eco-innovation in Chile.

In conclusion, eco-innovation builds on insights gained from the ecological modernisation literature. It suggests that innovations that consist of new or modified processes, practices, systems and products benefitting environment sustainability, e.g. through resource productivity, are the result of successful coordination between the public sector, research organisations and businesses. A mix of right public policies and incentives coming from the level of international organisations and partners can be a driving force.

2.6. Conclusions on the literature review

This literature review helped identifying some important gaps in the literature this research aims to address. The resource governance and development strand has been mostly focusing on extraction-led development models to improve the standard of living within resource-rich developing countries. However, they neglect the environmental risks related to water scarcity, climate change, increasing emissions and energy use due to declining ore grades and increasing demand. The depletion of metal reserves and declining ore grades must be taken into account when evaluating the economic benefits associated with extractivism. At the conceptual level, there is the need to integrate concepts of ecological modernisation and eco-innovation; not only to mitigate potential environmental costs but also to capitalise on the economic benefits of adopting eco-innovative measures, such as enhancing competitiveness, saving costs and benefitting from technology and knowledge transfer based on win-win solutions with international partners. If sustainability is not addressed seriously as part of the development agenda, this might lead to a failure to achieve the sustainable development goals. Therefore, the question is how resource-rich countries react to these potential challenges, how they position themselves in terms of public policy, and how stakeholders adapt. On the other hand, the eco-innovation and ecological modernisation approaches were developed along cases of European demand-side countries with a large manufacturing base, thus, providing a comprehensive analysis of policies and practices of advanced European states. To the knowledge of the author, there is no comparative analysis of eco-innovation in resource-based economies. Therefore, this dissertation investigates to what extent mining countries and large mining companies adopt environmental innovation and if so, why. The academic aim is to contribute to the literature and policies on ecological modernisation as well as on resource governance and development. Both strands are not yet well aligned and are often treated separately from each other.

3. Analytical framework

The following section introduces the analytical framework based on the conclusions of the literature review and consists of two main parts. It starts by reintroducing the research objectives and questions and presents the mixed method approach this thesis applies. It

discusses theoretical reflections on policy change and introduces methodological tools adopted to answer the research questions. Due to the interest in the subject of reforms supporting eco-innovation at the national and sectoral level, the theoretical lens is grounded in theories of domestic change. After considering alternative explanations, the dissertation aligns itself with the rational choice institutionalism approach for two reasons: firstly, the theory provides sufficient explanation for how change comes about and why status quo is maintained. Secondly, it can be applied to explain domestic change at the national level, which serves the comparative analysis of our most similar cases, and it can be applied to the nested case study on the sector, as it provides useful insights on why firms invest in environmental solutions within the broader discussion of corporate environmentalism. Nevertheless, this chapter takes also into account bounded rationality and discussions around corporate environmentalism, which provide challenging answers to the propositions of rational choice institutionalism. This thesis does not have the ambition to advance the theoretical debate of institutionalism. The function of theory for the purpose of this PhD is to serve as a heuristic guide to formulate propositions and to frame the analytical framework. This thesis is rather located in comparative institutional analysis. The first part of the chapter concludes with hypotheses derived from the theoretical reflections. The second part of this chapter reintroduces the research questions and objectives and presents the mixed method approach this thesis applies. It provides a detailed justification of the case selection and the causal propositions building on the first part of Chapter 3, which structure the case study analyses. It then presents the data collection process, the different sources of data and how data saturation has been achieved. As part of the mixed method approach, the thesis made use of semi-structured interviews, which were used as a validation exercise for other sources of data. Therefore, Chapter 3 explains in detail how interviews were sampled, including the inclusion criteria. The chapter concludes by providing an explanation of why also process tracing and content analysis and coding were applied as part of the method mix. The chapter shows how a set of different methodological approaches was applied to answer the complexity of the subject and address the research questions sufficiently. The application of content analysis and coding is particularly novel in this field, since, to the knowledge

of the author, there have not been any studies on eco-innovation in mining countries making use of this innovative research tool.

3.1. Research objectives

- Examine when and why states implement international agreements and recommendations, align with international organisations, and the ensuing strategies of large key companies;
- Unpack the divergence between policy and institutional decisions on eco-innovation in Chile and Australia despite various similarities; in particular with a view on policy consistency, new tools such as roadmaps, coordination with the private sector, and the role of incumbents;
- Explore the scope and reasons behind eco-innovation investments and priorities of BHP, Rio Tinto and Anglo American; and understand how sustainability is defined by the three companies representative for the mining sector (environmental, social, economic sustainability or health and safety or human rights) and discuss implications;
- Derive policy conclusions for the transition towards eco-innovation in mining countries based on discussion about the transferability of the research findings; derive conclusions on the analytical framework.

3.2. Research questions

Based on the research objectives above the dissertation is guided by the following research questions:

- Why does Australia as an OECD member for over 40 years and party to the Paris Agreement perform worse in reforming its policies and institutions than Chile? What is the role of international agreements, institutions and the national policy frameworks? Do the existence of resource scarcity and climate change effects influence policy outcomes in both countries in a similar way? To what extent do domestic actors and veto players influence the eco-innovation trajectories?

- Why do mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia?

Addressing these questions will ultimately help us to answer the following overarching question:

- How does eco-innovation in resource-rich countries look like and what transition pathways lead towards a cleaner and more sustainable growth model? Which role do institutions and domestic actors play in such a transition?

3.3. Theoretical discussion: Theories of domestic change

The question of domestic change is covered by a wide theoretical discussion. Particularly different streams of institutionalism provide answers to questions why institutions and policies change. As Douglass North defines them, institutions are “the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction” (North, 1990). Shepsle (2008) defines them as “exogenous” constraints (Shepsle, 2008). These include public authorities, policies, laws or norms. Over the past two decades, three different analytical approaches have developed – independently from each other, yet, parallel to each other. All three see different reasons behind the evolution of institutions: historical institutionalism, rational-choice institutionalism and sociological institutionalism (Hall and Taylor, 1996). They opt for different explanations for political phenomena, namely, the relationship between institutions, political behaviour and the process of the origination or change of institutions (ibid.). All three help us find explanations for the distinctiveness of political outcomes.

3.3.1. Historical institutionalism

Historical institutionalism defines institutions as formal and informal procedures, routines, norms and conventions, embedded in organisational structure of the polity or political economy. They can include the constitutional order, bureaucratic procedures and

traditional state-firm relations. Historical institutionalism describes institutions and individual political behaviour in broad terms (Hall and Taylor, 1996). The theory underlines that there are asymmetries of power associated with the operation and development of institutions. Some actors or institutions exert more influence than others. Yet, historical institutionalists also see some path dependency and desultoriness in the evolution of institutions due to persisting ideas and traditions. Any major deviation would make the individual worse off than adherence. In addition, institutions influence the identity of an individual and changes become difficult because institutions influence the reform choices. Historical institutionalism is associated with a particular historical perspective. Such a perspective asserts that social causation is “path dependent”. This does not mean that changes do not happen or institutions do not evolve. Yet, changes are the mediated result of an historical context with patterns inherited from the past. Institutions are persistent and if they change, they change along a set of historical paths. Shifts from those paths are seen as unpredictable or costly. Therefore, inefficiencies are inherited from the past and unintended, as opposed to efficient and purposive.

3.3.2. Sociological institutionalism

Sociological institutionalism started by questioning the distinction drawn between parts of the social world with modern forms of organisation and bureaucracy. Institutions are seen as culturally specific practices, in which norms and traditions are enshrined into organisations. This is not seen as a result of the intention to enhance formal means-ends efficiency but rather as a result of the kind of processes associated with the transmission of cultural norms and practices more generally (Hall and Taylor, 1996). While historical institutionalism sees the continuity of institutions as a result of historical trajectory, sociological institutionalism sees them as the result of culturally specific practices (Mayer and Rowan, 1977; Mayer and Scott, 1983). Individual actors who have been socialised into particular roles internalise the norms associated with those institutional roles and in this way institutions affect their behaviour. Institutions provide the terms through which meaning and perceptions are assigned in the social realm. This means that

institutions do not simply influence the strategic calculations of individuals, as rational choice institutionalists argue, but they shape the most basic preferences and very identity. One related branch of sociological institutionalism is international norm diffusion. Risse and Sikkink (1999) argue that international norms influence state choices under certain conditions. They investigate the causal relationship between international human rights and domestic change in human rights practices and assert that transnational advocacy networks and a socialisation process within those networks are the determining factors in international norm diffusion and eventually domestic change. Transnational advocacy networks are “organised to promote causes, principles, ideas and norms, involving individuals advocating policy changes that cannot be easily linked to rationalist understanding of their interests” (Keck and Sikkink, 1998). Campbell makes an illustrative differentiation between rational choice institutionalism and sociological institutionalism as the “logic of appropriateness” in contrast to the “logic of instrumentality” (Campbell, 1989).

3.3.3. Rational choice institutionalism

Rational choice institutionalism provides an interesting analytical tool emphasising property rights, rent seeking and dealing with transaction costs in the context of the generation and evolution of institutions. The development of a particular institutional form is the result of joint efforts of rational actors to reduce transaction costs of undertaking the same activity without such an organisation (Williamson 1975 and 1985). North (1990) used a similar reasoning to the history of political institutions. Theories of agency with a focus on institutional mechanisms whereby “principals” monitor and enforce compliance on the “agents” proved useful for many analyses (Hall and Taylor, 1996). Tsebelis (2002) and others investigated the implications of institutional reform in the EU and scholars of international relations used rational choice institutionalism to analyse the rise and fall of international agreements and how nation states delegate to international organisations.

Rational choice institutionalism uses a set of behavioural assumptions, building fixed preferences on instrumental behaviour for benefit maximisation. Such a maximisation of the attainment of preferences is entirely based on a strategic calculation. Rational choice institutionalism sees politics as a collective action dilemma, which is the result of individuals acting to fulfill their own preferences, producing an outcome, which is collectively suboptimal (Hall and Taylor, 1996). What prevents those political actors from taking collectively better outcomes is the absence of institutional arrangement that would guarantee complementary behaviour by others. The tragedy of the commons or the prisoner's dilemma is famous example of such a suboptimal outcome. The very interest of benefit maximisation per se does not necessarily mean automatically suboptimal outcomes, if there are institutions, which mediate within a regulatory and policy framework. Yet, individual actors with fixed preferences of benefit maximisation without mediating institutions create suboptimal outcomes for the greater society. In the case of Australia, the existence of coordination on water at the Council of Australian Governments created improvements in the sustainable use of water resources. Evidence discussed in the case study suggests that since the abolishment of that cooperation, there is a regional race to the bottom and a worsening of the sustainable use of water resources.

3.3.4. Bounded rationality

Scholars of bounded rationality such as Herbert Simon (1996) describe cognitive constraints and argue that individual behaviour can only be limitedly rational. Rational-choice institutionalists stress global rationality, assuming that decision makers choose after a comprehensive contemplation process the most utility maximising alternative of action. In turn, bounded rationalists highlight that decision makers are confronted with incomplete and inaccurate knowledge and choose actions that are expected to be satisfactory. Barros (2010) stresses that Simon (1996) contributes to the debate on rationality is based on procedural rationality, as it refers to the process of reasoning in decision making in administrative organisations. According to Simon, “a theory of bounded rationality is necessarily a theory of procedural rationality” (Simon, 1997). It is true that global rationality requires knowledge of all possible behaviour alternatives,

while in reality only a selection of alternatives is considered. In fact, not even in the same company all alternatives are considered – different local conditions influence selections of behavioural alternatives. Global rationality requires full knowledge of alternatives and the potential consequences of each option – such knowledge is always fragmentary; valuation of the consequences needs to be predictable – but depends on imagination. Therefore, bounded rationality is built as the negative concept of global rationality. The theory of global rationality operates based on an ideal description of the environment of decision. Yet, there are external concerns (rules and regulations) and internal constraints (cognitive). The key to the simplification of the choice process in both cases is the replacement of the goal of maximising with the goal of satisficing, of finding a course of action that is good enough (Barros, 2010). According to Simon’s hypothesis, decision makers, instead of trying to maximise values in a given choice, aim at satisficing: they search for alternatives that are good enough according to some pre-established criteria.

Rational choice institutionalism outlines a situation of strategic interaction in the determination of political outcomes, in which individual behaviour is driven by a strategic calculation influenced by interests and expectations about how others would behave as well. Institutions play a crucial role in improving such suboptimal outcomes of collective actions problems by structuring those interactions and affecting the set of political choices. In its 2019 environmental performance review on Australia, the OECD highlights the importance of coordination and the creation of a level playing field by addressing the lack of inter-state coordination in Australia. The report underlines that Australia’s governance structure is not very enabling for a better environmental performance, e.g. in its water or energy policies and concludes that more coordination is needed (OECD, 2019). Furthermore, by providing information and enforcement mechanisms that reduce uncertainty about the corresponding behaviour of others, institutions allow gains from exchange, influencing the individual calculations and perceptions on transaction costs, and ultimately, leading to potentially better social outcomes. Rational choice institutionalists have developed a distinctive approach to the question of how institutions come about or evolve. They create a functional value for actors affected. Institutions are created because they create gains from cooperation and as

they are beneficial to relevant actors, they survive (Hall and Taylor, 1996). Another interesting and useful analytical approach concerns particularly a firm's organisational structure, which is relevant for this dissertation, as three mining companies are analysed within a nested case study. The organisational structure of a firm is explained by drawing the attention to the preference of minimising transaction, production or influence costs. Rational choice institutionalists explain the development of an institution by reference to the efficiency with which it serves the material end of those who accept it. The lack of change can be thus explained by the influence of powerful incumbent actors. If their interests are being served, status quo remains more likely as well as the inclusion of new market entrants.

Established and influential incumbents can be important veto players blocking the origination of new institutions or the evolution of existing ones. They are individual or collective actors whose consent is necessary for the change of the status quo (Tsebelis, 2002). Tsebelis follows a rational choice institutionalists reasoning by asserting that veto players only approve changes they prefer over the status quo (Caplan, 2004). The veto players approach does little to explain the position of policy. Yet, it provides a powerful explanation for the stability and persistence of certain policies. Tsebelis' main argument is that the more veto players you have; the more stable is the policy. The more people you need to change a policy, the less likely is policy change (Caplan, 2004). Historical institutionalism does not provide the right analytical tools to explain major domestic change. For the explanation of status quo, the veto player argument is more convincing than path dependence. The influence of rational interests is more plausible and clearer to identify than the influence of traditions and customary procedures.

Individuals seek to maximise the attainment of a set of goals given by a specific preference. Institutions affect by providing actors with greater or lesser degrees of certainty about the present and future behaviour of actors. Institutions provide information relevant for the behaviour of others, enforcement mechanisms for agreements, penalties etc. As opposed to that, sociological institutionalism or constructivism emphasises the extent to which individuals turn to establish routines or

familiar behaviour to attain their purposes. From this point of view, institutions provide a moral template for interpretation and action. Institutions affect self-images, preferences and the very identities. All the theories provide interesting insights into how institutions affect behaviour. Rational choice institutionalism has developed a more precise conception of the relationship between institutions and behaviour alongside with a set of concepts that lend themselves to systematic theory building and can be generalised. Institutions survive if they deliver benefits. Nevertheless, rational choice institutionalism has certain limitations. It does not provide sufficient explanation as to why institutions are inefficient, overestimating the drive for efficiency. Moreover, it assumes always an intention, whereas the process of institution creation might also be not a purposeful but a historical or value-based one. Rational choice institutionalism started to incorporate “culture” or “beliefs” into their explanations. Norms or ideas provide important “focal points”, allowing the convergence of rational actors (Garrett and Weingast, 1993).

3.3.5. Corporate environmentalism

Corporate environmentalism provides particularly important insights into why firms come up with eco-innovative solutions. The literature differentiates between greenwashing and corporate environmentalism. Greenwashing focuses on communicative practices, while corporate environmentalism arises from green solutions implemented at firm level. Yet, the extent and magnitude of the solution might differ. It is important to understand the reasons behind a firm’s decision on the scope and type of such solution (Bowen, 2014). Husted and Salazar (2006) conclude in their explanation of strategic corporate environmentalism that it can be profit maximising to invest in green solutions. Even though such investments might be done in the first place for a firm’s own economic interests, it can also be beneficial for the whole society with actual improvements in environmental performance, e.g. energy efficiency and pollution control, sustainable use of water or land resources. Corporate environmentalism describes decision taken at the company level connected to environmental reasons. These decisions could relate to greener or eco-innovative products or cleaner processes, for instance through reduced waste generation, water and energy use or resource efficiency. Some decisions might be

taken in order to address production risks, rising costs or environmental challenges with the aim to reduce waste, water use and carbon emissions. Some might be taken as a response to NGO campaigns or poor ethical investment rankings (Bowen, 2014).

A critical view of corporate environmentalism problematises green solutions put forward by firms as a social distraction away from environmental consequences of industrial activity (ibid.). The critical view challenges the view that investments, sustainability strategies and policies do not necessarily have to mean the solving of environmental problems. Yet, from a rational choice institutionalism lens, eco-innovative solutions could become economically beneficial in order to lower transaction costs compared to the likely costs of non-action, for instance in a scenario of a carbon tax. Indeed, the introduction of a carbon tax or declining levels of water availability could be factors triggering corporate environmental decisions for resource efficiency or pollution prevention. Corporate strategy is about matching a firm's internal organisation with external institutional and environmental surroundings. Since the late 80s and 90s, managers began to adjust their corporate responses to external environmental demands. In line with rational choice institutionalism, investments in environmental solutions enhance a firm's competitiveness and lead to long-term cost savings (Sharma and Vredenburg, 1998).

Conventional corporate environmentalism analyses how natural environments affect a firm's policies and investments. Hart (1995) adapted a framework to build a natural resource based perspective of the firm, looking at firms facing resource scarcity, this could be energy poverty in a country of operation or reliance on natural ecosystems such as water supply, and how these react to such challenges. This is challenged by the critical view, asserting that businesses add the prefix "sustainable" to old practices and continue prioritising growth and consumption (Banerjee, 2012; Bowen, 2014). The problem is, the critical approach disagrees with the very concept of businesses playing a leadership role in the transition to a greener economy. Businesses are seen as another concept or form of neo-colonialism competing for access to natural resources at the lowest possible cost (Bowen, 2014). Yet, this view neglects the very likely scenario of environmental

degradation becoming a cost and risk factor for businesses, creating the need to act. Key mining locations in Chile and Australia, for example, are exposed to heightened levels of water stress. It is estimated that 27 per cent of the world's most important twelve mining companies' production equivalent to up to 50bn USD in revenue, will be exposed to high or extremely high baseline water stress risk and arid conditions by 2030 (Soliman, 2017). Therefore, mining companies invest in costly desalination or water recycling technologies to reduce these financial and environmental risks. Corporate environmentalism could help mitigating environmental damage. Yet, from a rational choice perspective, there might be a first mover problem, which is why the existence of moderating institutions and a strong long-term policy framework contribute overcoming uncertainties, creating a level playing field for all relevant rational actors. The existence of resource scarcity alone does not qualify itself as a sufficient reason for eco-innovation, as the case of Australia shows. It is among the most carbon intensive and the worst environmental performer in the OECD despite being the driest continent in the world with high levels of water scarcity and areas directly affected by climate change (OECD, 2016).

In conclusion, many of the objectives of green transformation cannot be achieved in the short-term. Long-term strategies and intermediate milestones are needed. Altenburg and Rodrik (2017) identify three uncertainties: Firstly, there is uncertainty about technologies and markets. The fact that no country has succeeded in decoupling its economic welfare from resource consumption means that no country can serve fully as a role model for others. Therefore, the predominant notion is that every country has to find its own pathway rather than following the institutions, policies and technologies of others. Governments need some degree of flexibility in responding to different emerging technologies, price developments or environmental risk assessments. Secondly, political guidance and objectives, rather than technologies or markets drive green transition, which shows how essential it is to have a predictable and long-term policy framework in place. Here, the political will to introduce a carbon tax or subsidies for renewable energy is a decisive factor. At the same time, these political decisions are often controversial and might be changed very fast with change in the political leadership of a country, leading to

uncertainties and discontinuity (Altenburg and Rodrik, 2017; Karp and Stevenson, 2012). Finally, there is uncertainty about the ecosystem. The effects of environmental damage are unpredictable and non-linear. Therefore, a certain level of research and scientific understanding is needed to understand the economic consequences of environmental disruptions for policymakers and investors. From a rational choice institutionalism point of view, institutions, and governments in particular, have an important role to play in reducing those uncertainties and a responsibility in creating confidence in the markets and reducing investment risks. As the literature review shows, eco-innovation and green transformation of an economy rarely happens smoothly without a proactively coordinating public institution. Well-managed coordination process with strong political support is needed for change. In line with rational choice institutionalist reasoning, public institutions are important in optimising the outcome for all sectors in society. They are crucial in reaching compromises between different interests. One might pose the question as to whether the need for long-term strategies and intermediate milestones Altenburg and Rodrik highlight contradict the argument of the need to go for low-hanging fruits by applying existing innovative technologies in production and short-term immediate gains resource productivity literature suggests. These two are not mutually exclusive. For a deeper and wider transformation of economies a broader and more collective effort is needed based on a long-term strategy supported across different parties and stakeholders. Yet, this does not exclude the effectiveness of short-term, smaller steps by applying proven innovations, leading to cleaner production and cost savings.

The international level can be an important driver for the greening of an economy. The Paris Agreement for instance has led to rising ambition levels for CO₂ reduction and the promotion of renewable energy in many countries across the world. With overseas development assistance many developing or emerging countries even have an economic incentive, in addition to the environmental, one to contribute to the global and collective effort to tackle global warming with their nationally determined contributions. In addition, organisations such as the International Energy Agency (IEA) or the Organisation for Economic Cooperation and Development (OECD) provide knowledge and assistance to the members of their club. For many emerging economies, such as

Chile, Brazil or Mexico it is a matter of prestige and self-interest to join these organisations developed countries are member of. The IEA or OECD reports contain thorough analysis of different national policy areas, including energy and the environment, along with a list of policy recommendations for future action.

International norm diffusion, as sociological institutionalists suggest, following the “logic of appropriateness”, does not happen if there is no institution or international regime, with the majority of other countries following, creating a level playing field within a common system, overcoming collective action problems. In fact the resonance created by the Paris Agreement or international transparency initiatives in the mining sector and in countries shows that a legal regime is needed as an exogenous factor conditioning behaviour rather than norm diffusion. The Australian case, in contrast to the Chilean one, shows that the degree of implementation of international agreements differ due to domestic realities and interests. Chile does not have powerful incumbents in its energy sector; it is even import dependent. Therefore, international agreements and institutions come in handy to promote energy independence and reduce costs through the promotion of renewables. There is a short-term economic interest, fixed preference, which is reconcilable with the broader global agenda of fighting climate change. Mining companies in Chile recycle up to 80 per cent of the water they use, while they only recycle about 40% in Australia. The delegation of water matters in Australia from the coordinated federal to the state level has fostered regional competition for the creation of a business friendly environment for mining companies. This has come at the expense of sustainable water use, as water is seen as an economic comparative advantage in attracting mining investment. Power relations in the energy sector in Australia, with coal playing an important role, have played at the expense of the large-scale deployment of grid connected renewable energy. The absence of such an incumbent energy player in Chile has been to the advantage of the expansion of clean energy. Sociological institutionalism has also methodological limitations. How can we isolate the effect of international norms as the determining factor of a certain outcome? How can we determine who is really part of the “transnational advocacy network”, diffusing norms effectively, and how can we exclude that the members of that network follow a rational

agenda based on self-interest? These are theoretical shortcomings, which make the use of sociological institutionalism difficult.

3.3.6. Conclusions on the theoretical discussion

In conclusion, building on the theoretical discussion, there are two theoretical puzzles that need to be addressed. First, if norm diffusion through international regimes and so called “advocacy networks” would be decisive for the explanation of the divergence in outcome, why does Australia as an OECD member for over 40 years and party to the Paris Agreement perform worse in reforming its policies and institutions than Chile? Second, why do mining companies operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia? Certain environmental investment decisions could be the result of an extensive calculation of transition costs and risks or of a socialisation process within an organisation which influences the perception of what is the “appropriate” decision to make. Norm diffusion and sociological institutionalism would suggest similar eco-innovative outcomes in Chile and Australia if the company is the same and part of an institutions or international initiative, forming the corporate identity in a normative way. Yet, the case study on the three companies suggests some differences between the same company’s investment decisions and performance in the two countries. To understand the difference in outcome between the two countries, we need to first understand the policy and institutional frameworks and the degree of change in institutions and policy in Australia and Chile supporting eco-innovation and address the question of how the eco-innovation profile of mining companies operating in both countries looks like, what their priorities are and in which projects they invest, and why. It is also important to understand how they define sustainability, the information and data they look at the initiatives guiding their corporate decisions. To answer these questions, this thesis follows the propositions put forward by rational choice institutionalism, as these help explaining best the variance between the two case study countries, while also considering alternative explanations. Addressing these questions will ultimately help us to answer the broader, overarching question of how eco-innovation in resource-rich countries looks like

and what transition pathways could lead towards a cleaner and more sustainable growth model. Based on the theoretical reflections above, the following hypotheses are being derived:

3.3.7. Hypotheses

- States choose their position towards international agreements and organisations based on strategic choices. They implement international agreements and recommendations by international organisations on environmental protection and eco-innovation with higher levels of ambition, if these bring economic gains and converge with their domestic agenda.
- A strong policy framework based on inter-institutional coordination and continuity reduces uncertainty and supports investments in eco-innovation. Strong institutions create a level playing field for private sector actors, making cost and risk calculations more predictable, reducing transaction and influence costs, thus, incentivising investments for eco-innovation and providing concrete benefits based on new tools such as policy roadmaps that align technological developments with potential future policies.
- Coordination mechanisms between inclusive and moderating public institutions and private sector actors with strategic interests and fixed preferences, such as competitiveness, cost and risk reduction, can enhance mutual understanding and overcome knowledge and financial barriers, leading to the experimentation with technological novelties coming from emerging niche markets and to a swiftly shift from market failures (environmental pollution, depletion of water resources) to positive externalities, i.e. investments in eco-innovation and the development of new business models.
- System incumbents likely to lose from eco-innovation act as veto players in the policy change process. The higher the number of incumbents, the more likely it is to expect strong and effective lobbying at different policy levels, and the less ambitious would the policy framework be. These could be state institutions with

different priorities, such as trade promotion, or significant energy producers as part of fossil fuel based supply systems.

3.4. Methodology

This section provides a detailed justification of the case selection and the causal propositions building on the first part of Chapter 3, which structure the case study analyses. It then presents the data collection process, the different sources of data and how data saturation has been achieved. As part of the mixed method approach, the thesis made use of semi-structured interviews, which were used as a validation exercise for other sources of data. Therefore, Chapter 3 explains in detail how interviews were sampled, including the inclusion criteria. The chapter concludes by providing an explanation of why also process tracing and content analysis and coding were applied as part of the method mix. The chapter shows how a set of different methodological tools was applied to answer the complexity of the subject and address the research questions sufficiently. The application of content analysis and coding is particularly novel in this field, since, to the knowledge of the author, there have not been any studies on eco-innovation in mining countries making use of this innovative research tool.

The comparative case study design in combination with process tracing, semi-structured interviews, document/content analysis and coding is expected to be particularly useful in unpacking the different eco-innovation policy outcomes in Chile and Australia despite various similarities and the reasons behind political choices. The case study design was chosen to enable the research to take different variables into consideration and look at historical explanations and complex inter-relation between different prevailing interests and domestic actors. Different sources of documents and regulations were analysed and validated or “saturated” with the help of semi-structured interviews conducted with professionals from academia, government, private sector and civil society. Coding is expected to support this research in conducting a structured, standardised analytical exercise, providing further insights on government interests and preferences influencing policy and institutional decisions. Moreover, for the chapter on the mining sector, coding

is expected to be useful to understand how the three large mining companies define sustainability and to conclude implications based on these definitions and perceptions for the overall eco-innovation performance of the sector. Process tracing linked to the different levels of causal mechanisms (international agreements, domestic policy and institutional frameworks and structure and degree of cooperation between public institutions and the private sector) should serve the detailed exploration of the reasons behind specific eco-innovation investments and priorities of BHP, Rio Tinto and Anglo American. This is methodologically triangulated with semi-structured interviews to validate preliminary conclusions. Finally, the comparative nature of the empirical part, contrasting different effects of different drivers with the help of process tracing, document analysis and semi-structured interviews, taking specific actor preferences as well as domestic policy and institutional framework into account, is expected to help in deriving policy conclusions for the transition towards eco-innovation in mining countries and understanding the role of institutions and domestic actors in such a transition.

Figure 3. The link between research questions, objectives and the methodological tools

Research objective(s)	Research question(s)	Methodological tools
<ul style="list-style-type: none"> • Unpack the divergence between policy and institutional decisions on eco-innovation in Chile and Australia despite various similarities • Examine when and why states and companies implement international agreements and recommendations 	<ul style="list-style-type: none"> • Why does Australia as an OECD member for over 40 years and party to the Paris Agreement perform worse in reforming its policies and institutions than Chile? • What is the role of international agreements, institutions and the national policy frameworks? • Do the existence of resource scarcity and climate change effects influence policy outcomes in both countries in a similar way? • To what extent do domestic actors and veto player influence the eco-innovation trajectories? 	Comparative study of most similar cases, process tracing, semi-structured interviews, document analysis/ content analysis and coding

<ul style="list-style-type: none"> • Explore the scope and reasons behind eco-innovation investments and priorities of BHP, Rio Tinto and Anglo American • Understand how sustainability is defined by the three companies representative for the mining sector (environmental, social, economic sustainability or health and safety or human rights) and discuss implications 	<p>Why do mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia?</p>	<p>Nested case study, process tracing, semi-structured interviews, document analysis/ content analysis and coding</p>
<p>Derive policy conclusions for the transition towards eco-innovation in mining countries based on discussion about the transferability of the research findings</p>	<ul style="list-style-type: none"> • How does eco-innovation in resource-rich countries look like and what transition pathways lead towards a cleaner and more sustainable growth model? • Which role do institutions and domestic actors play in such a transition? 	<p>Comparative case study, process tracing, semi-structured interviews, document analysis</p>

3.4.1. Case selection

The case study research design is beneficial for the objectives of this PhD because of theoretical and empirical insights that can be gained from in-depth examination of a single case, which is expected to follow a multi-level and complex stream of activities operating in an institutional context. This research project follows the case study research design in order to exemplify theoretical considerations by showing how it manifests at the individual level and how it helps to describe, interpret and explain social behaviour (McAdams and West, 1997). Case studies can have significant advantages relative to statistical methods (Collier, 1993). These include the heuristic identification of potential new variables or hypothesis, historical explanation of cases and the inclusion of complex relations like path dependency. The greatest strength of case studies is the opportunity of

achieving high levels of construct validity and the ability to measure in a case the indicators that best represent the theoretical concept intended to measure (Bennett, 2005). In the case studies analysis, process tracing is being used to examine in detail the observable implications of hypothesised causal mechanisms outlined in the individual cases. The use of multiple methods facilitates the process of triangulation, in which multiple sources and methods are used and alternative explanations for outcomes considered (Bryman, 2008). Indeed, the conclusions of this research then can be put forward for validation in other cases.

The selection of cases for this research is purposive and not random. This research opted for the most similar cases and influential case study selection in order to have a representative sample with useful variation on the dimensions of theoretical and policy interest. One may ask why Australia and Chile and not Norway and South Africa were chosen or whether Chile and Australia are appropriate benchmarks for Sub-Saharan Africa and Papua New Guinea? In the first year of the PhD research leading up to the upgrade process, different potential case study countries were screened and discussed with the supervisors. South Africa was one of the interesting case study country candidates, yet we excluded it for two reasons: one concern was the security situation and the other one was directly related to the research interest: South Africa is a country with a very high conflict potential together with Zambia, Indonesia and Guinea due to existing poor working conditions, low wages and high levels of violence between mining companies supported by state security institutions and employees and communities (Ruettinger and Schroll, 2017). Environmental concerns are of secondary concern compared to social problems, which would have influenced the data collection process. Norway was not extensively considered, as it is not a significant global exporter of metals and minerals but other energy resources, mostly gas and oil. The country only started exporting oil and gas in the late 70s, whereas Australia and Chile have large minerals deposits with the same mining companies operating and a long history of extraction dating back to colonial days. Sweden could have also been an option but was excluded for other reasons– the country is an exporter of metals and minerals but in smaller volumes. Moreover, both countries do not have the same level of potential to produce

solar energy and are not exposed to high risks of water shortage or draughts as Australia and Chile are. Choosing Least Developed Countries (such as the Democratic Republic of Congo) would have been conceivable but challenging due to a lack of data and fundamental policy and institutional weaknesses. In line with this research's analytical framework, analysing Chile could well represent a resource-rich emerging economy and modernisation attempts.

The potential shortcomings of this approach of having two countries as case studies include challenges in identifying deterministic causality and questions of external validity. Yet, small-N studies (studies that examine one or a few individual cases) have better internal validity and provide in-depth understanding of particular cases with potential for generalisation. A comparative study covers two or more cases in a way that produces more generalisable knowledge about causal questions. They involve the analysis and synthesis of similarities, differences and patterns across cases (Goodrick, 2014). Choosing suitable cases for small samples is a challenging task, as the chosen cases are expected to perform a difficult role, which is to represent a population of cases that is often much larger than the case itself and to be suitable for meaningful inferences. Seawright and Gerring (2008) assert that a random sampling is not a viable approach if the number of cases is small and the analysis in depth. Chosen cases must provide variation on important dimensions. There are different case selection techniques Seawright and Gerring discuss by which they offer the possibility to develop a more rigorous and elaborate explanation of case selection for case studies. Purposive case selection cannot overcome entirely the inherent unreliability of generalising from small samples but they can make an important contribution to the inferential process by enabling the research to choose the most appropriate cases for a given research question and research objective.

Seawright and Gerring differentiate between seven different case selection techniques: typical, diverse, extreme, deviant, influential, most similar and most different cases. The typical case selection method refers to typical examples of cross-case relationships. They are confirmatory and useful to probe causal mechanisms that may either confirm or

disconfirm a given theory. The typical case is by definition representative, given the pre-determined relationship. The typical case is a suitable method for this research project because it is well explained by the existing mechanisms discussed in the literature review. The puzzle of interest lies within the cases and the aim is to explore the causal mechanisms, helping to explain it.

Diverse cases exemplify different values of the independent and dependent variables. They are in many to some extent representative but do not fully represent the variation of different case populations. Chile and Australia have similar x values but differing y values – yet, they are likely to represent a larger set of population than a diverse case selection. Moreover, the objective behind this method is to have maximum variance along all different dimensions with various causal paths. That is not what lies behind the overall aim of the research strategy. The methodological aim is to compare two most similar cases and explain the variance in their policy outcomes as well as explaining the variance within a nested case study on three mining companies operating in Chile and Australia, which is directly linked to the research questions and wider research objectives.

The extreme case selection method uses cases of extreme or unusual values of the variables. In such a case, representativeness can only be achieved in comparison with a larger sample of cases. Our comparison entails only two cases, which do not have extreme or unusual variable values. Therefore, this one is not well suited for this research. Another case selection method is the deviant case, which deviates from some cross-case relationship. The understanding that lies behind the deviant method is closely linked to the investigation of theoretical anomalies, surprising values. The influential case selection is motivated solely by the need to check the assumptions behind some general model of causal relations. The goal is not to propose a new or modified theory but to explore cases that might be influential. The most suitable method from a research question and objective point of view is the most similar method, which involves at least two cases. Here the two cases show similarities across all background conditions that might be relevant for the outcome of interest. Yet the cases differ on one dimension X1

and on the outcome. It is presumed from this pattern of co-variation across cases that the presence or absence of X1 is what causes variation on the independent variable Y (ibid.). Most similar cases have similar specified variables and provide the strongest basis for generalisation. The most similar method is one of the oldest recognised techniques of qualitative analysis. Most different cases instead show differences on the specified variables. Scholars tend to agree that this research method provides less of a robust tool for causal inferences than the most similar method (ibid; Gerring, 2007).

In conclusion, this dissertation opts for a comparative study on most similar cases with a nested case study on mining companies. The countries analysed and compared are Australia and Chile, which despite significant similarities, show a potential divergence in their eco-innovation efforts. They are analysed through the lens of rational choice institutionalism, as it provides, compared to the other institutionalisms discussed, a robust analytical toolkit to explain change on the one hand and status quo on the other. Furthermore, it can also be applied to the nested case study on three large mining companies this research project focuses on, providing an explanation for their different corporate responses to eco-innovation in the two countries. The section below provides a detailed justification for the selection of the cases.

Figure 4. Comparative study of most similar cases and a nested case study

Comparative study of most similar cases	
Australia	Chile
Nested case study	
BHP, Rio Tinto and Anglo American	

3.4.2. Comparative study of most similar cases

Australia and Chile are democracies with liberal economies and well integrated in the world markets. They are traditional mining countries with important supply capacities and a large share of resource exports. There are a number of factors which determine

what a resource-based economy is. Sachs and Warner (1995) look at the resources sector's share of GDP or net exports or investment and suggest that a share of exports between 20 and 40% is a defining factor of a resource-based economy. In Chile, mining accounts for about 60% of exports and for 11% of GDP (OECD, 2016). The sector represents the largest share in Australian exports with 32.2% followed by manufacturing and contributes with 7% to Australia's GDP, ranking third after services and construction (Australian Industry Report, 2016). They are both referred to as benchmark for developing countries due to their economically successful resource-based growth model. Given their remarkable economic performance for the past two decades, any possible progress towards a greener economy in other mining countries, especially developing ones, can be seen as dependent on how environmental policies Australia and Chile evolve.

Australia still rates relatively poorly on resource productivity compared to other OECD economies. Looking at the country's carbon dioxide (CO₂), energy and material resource productivity measures, it ranks at the bottom of the OECD. In environmental performance terms, Australia ranks near the bottom of developed countries, i.e. 29th out of 32 OECD countries (Australian Innovation System Report, 2012). Despite its poor performance in environmental reforms and policies, Australia is referred to as a benchmark country in terms of harnessing successfully the country's resource endowment. Against Prebisch and Singer's hypothesis (1950) that resource-based economies have limited opportunities for innovation and experience a long-term decline in the terms of trade, Ville and Wicken (2012) conclude in their comparative study on Australia and Norway that these countries have achieved successful economic diversification. According to the authors, these countries have achieved modern levels of development as resource-based economies, avoiding the so-called resource curse. Ville and Wicken argue that Australia and Norway have achieved diversification into new resource products and industries based on a processes entailing close ties between resource-based industries and "knowledge producing and disseminating sectors of society". The authors develop a resource-based diversification model that analyses the interaction between "enabling sectors" and resource industries (Ville and Wicken, 2012).

They conclude that Australia's resource sector has become a driving force in the country's wider economic development and has particularly generated growth in business services including finance, transport, and marketing.

The successful development of Australia and Norway was dependent on close interaction with other sectors of the economy and society involving technology, knowledge, financial resources, and various kinds of expertise. Their focus is economic diversification regardless of eco-innovation and new business opportunities that come with it. Chile's fiscal policies and institutions are often referred to as benchmark or best-practice example highlighting that resource abundance can be a blessing, if there are well-designed fiscal policies in place (Klaus Schmidt-Hebbel, 2012). McMahon and Moreira from the World Bank (2012) show in their study that in addition to economic growth, countries rich in minerals other than oil experienced significant improvements in their Human Development Index (HDI) and scored on average better than those countries without minerals. They highlight improvements in the health and education fields and note small improvements in governance, contradicting the widespread deterioration proposition put forward by the resource curse literature. They refer to Chile as a best practice example, in which the mining sector contributes significantly to social and economic development. Furthermore, they point out the "World-class suppliers programme" by highlighting that Chile has become an important regional supplier aiming to enter the global markets; "in 2011 the Ministry of Mining joined forces with large mining companies to establish a programme to transform 250 Chilean-based firms into world-class suppliers by 2014" (McMahon and Moreira, 2012). Chile sets the course for more than extraction-based growth by using economic relations and international support as an anchor to transform its economy towards eco-innovation, bringing in knowledge, innovation and linking those actively to universities, local suppliers, benefitting from technical knowledge. Recent policies and initiatives put in place have contributed to the increase of eco-innovation patents, renewable energy and desalination investments. The Chilean case helps drawing lessons for a new resource-based growth model.

They are high-income countries and OECD members as well as party to the Paris Agreement on climate change. Chile joined the OECD in 2010 and can be thus considered a newcomer in the club of advanced economies, while Australia has been an OECD member for over 40 years. Before Chile joined, Australia was the only high-income country with a dominant extractive sector, forming an exception among OECD countries (Schandl et al., 2008). The fact that another high-income country with a large mining sector joined the OECD eight years ago provides an exciting opportunity for the comparison of most similar cases. Australia is a party to the Paris Agreement and one of the most vulnerable countries to climate change effects. Yet, the analysis shows surprisingly that it does not have the policies in place to fulfill its obligations under the Paris Agreement. The federal renewable energy target of 20% by 2020 will not be effective in achieving the national greenhouse gas reduction target and there is a lack of policy certainty, as the target remains unrevised for the period after 2020. During the Paris Conference in 2015, Chile committed to reducing its GHG emission intensity by 30% by 2030 compared to the 2007 level, and by up to 45% if sufficient international support is provided. Several energy market reforms have enabled rapid growth in renewable electricity generation without subsidies. Power generation is the largest GHG emitter and, so far, the only direct measure used to limit its emissions is a carbon tax (IEA, 2017). Chile has a vast untapped potential for renewable electricity, which can help limit carbon dioxide (CO₂) emissions and air pollution, and reduce import dependency. The government has set a target for a 60% share of renewable power by 2035 and 70% by 2050. The share is currently around 40% (IEA, 2018). Chile is the first country in South America to introduce carbon taxation. The carbon tax is applied from 2017 and paid from 2018 onwards, but it is, at least initially, set at a relatively low level of 5 USD per tonne of CO₂. A carbon-pricing scheme in Australia was introduced in 2011 and was abolished three years later by the following government. Today, renewables cover nearly a third of Chile's total energy needs – fifth highest share in the OECD. A major achievement of the government has been to develop a long-term energy policy to 2050. The Ministry of Energy was put in charge of the planning process. The process involved a nationwide public consultation and culminated with the adoption of the National Energy Policy 2050. The Chilean public was consulted on a broad basis for the first time

and the exercise has become an internationally outstanding example for public consultations on energy policy (IEA, 2018). Chile's mining industry proactively develops solar thermal projects in the isolated northern regions. In 2013, the world's then-largest solar thermal plant was inaugurated in the Antofagasta region, which supplies 85% of the heat demand of the Gabriela Mistral (Gaby) copper mine, owned by the state company Codelco. The business model adopted by Codelco for the Gaby copper mine is an interesting example of increasing industrial competitiveness and reducing energy-supply risks. A ten-year heat supply power purchasing agreement was signed with a solar thermal plant owned and operated by the Chilean–Danish consortium Energia Llaima/Sunmark (IEA, 2015; IEA RETD TCP, 2017). In Australia, renewable energy provided 17.3% of the country's electricity in 2016, compared to the previous year, when renewable energy provided 14.6% of Australia's electricity (Clean Energy Council Australia, 2016). Chile has more than double as much renewable electricity in its energy mix than Australia despite similar potentials particularly for solar installations in large deserted areas (Mathews, 2016).

Finally, both countries face similar environmental challenges, which also create risks for the production and competitiveness of their mining sector. Compared to others Australia and Chile have the worst resource productivity performances in the OECD as well as the highest GHG emission and intensity (OECD, 2016). Soliman et al. (2017) conclude in their analysis of 12 major mining companies' operations across the world that a range of carbon and water-related indicators could have a material impact on company performance. Key locations in Chile and Australia are exposed to heightened levels of water stress with the estimation that 27 per cent of the 12 companies' production equivalent to up to 50bn USD in revenue will be exposed to high or extremely high baseline water stress risk and arid conditions by 2030. Water security remains a critical operational issue and costly to address: increased efficiency, reduced freshwater usage and higher recycling rates are essential to hedge against some of the physical risks that water poses to business continuity (Soliman et al. 2017). For instance, all assets in Chile face significant water stress that is why companies such as BHP invest increasingly in the use of desalination and water recycling. It is currently building desalination infrastructure

at its Escondida copper mine in Chile. In Australia such investments are lower as well as the water recycling rates of the same mining companies operating in Chile as well. In 2018, the Australian Minerals Council submitted to the Senate's Environment and Communications References Committee a report on the water use by the extractive industry, highlighting its relatively low water use and remaining business risks due to the lack of water availability. Yet, the same report emphasises the “comparatively small” amount of water the industry uses compared to the agricultural sector and the higher economic value added per unit of water consumed (Minerals Council Australia, 2018), which reads like a justification for the lack of action.

3.4.3. Nested case study on mining companies

Why is it interesting to analyse eco-innovation at the level of mining companies? All three mining companies analysed in a nested case study are among the 12 largest publicly listed diversified mining companies (Soliman et al. 2017). According to the analysis of Soliman et al., based on a detailed analysis across a range of carbon and water-related indicators non-action on eco-innovation could have a material impact on the companies' performance. Mining companies operating especially in Chile, Australia and South Africa are exposed to high levels of water shortages, or water stress, with an estimation of billions of dollars on their production and revenue. Water and energy are critical operational issues, which are costly to address: on water, increased efficiency reduced freshwater use and increased recycling rates are essential measures to take. The same study finds that significant risks remain as supplier too emission-intensive industries from downstream regulation and changing consumption patterns. Potential risks might stem from downstream industry carbon regulation and changing demand patterns. China has introduced an Emission Trading Scheme (ETS), Chile a carbon tax as well as Canada and South Africa. Therefore, it is interesting to look at the transition opportunities, i.e. assessing progress made towards transitioning towards a low-carbon system based on the revision of capital allocation across commodities and innovative solutions such as smart and renewable energy infrastructure.

The global low-carbon transition is an important collective effort to tackle climate change and achieve sustainable development worldwide. This trend will affect economies with large mining sectors in several ways. The technologies needed for the transition will require large amounts of materials that will come from environmentally vulnerable countries, many of which are developing countries, bearing potential benefits but also economic and environmental risks. There is currently no insightful, impact-oriented country-level policy analysis focusing on eco-innovation in the mining sector within the broader context of the low-carbon transition and sustainable development. The global low-carbon transition will require significant technological change, particularly in the electricity and road transportation sectors. These technologies require large amounts of minerals. Low-carbon energy systems are more mineral-intensive than traditional energy systems (Koning et al. 2018). The world is relying on low-carbon technologies such as wind, solar and batteries – each of these requiring large amounts of base and specialty or niche minerals. Even considering potential substitutes and recycling, there will be a growing demand for primary materials (World Bank, 2019). Building new mines and expanding existing ones have negative local environmental consequences, which can also be a delaying factor, especially if these reserves are located in fragile environments. In the case of several materials, it is necessary to exploit new deposits, which may have lower ore grades than currently available ones. Extracting from ore bodies with lower metals concentrations means that more energy (coupled with more emission intensity), water and auxiliary materials will be needed with possibly higher environmental impacts and larger political risks. To meet the growing demand, sustainable and reliable production will need to keep up.

McLellan et al. indicate that an inadequate problem definition of sustainability by the industry is one of the key obstacles for eco-innovation. Sustainability is understood as reducing impacts associated with metal-producing activities of mining and minerals processing at the local level – theoretically and practically disconnected from broader environmental challenges at the national and international level (McLellan et al. 2009). While much uncertainty remains regarding the full ramification of sustainable development, it is uncontested that preventive environmental and resource productivity

strategies, or eco-efficiency are conditional for the minerals industry's ability to progress in sustainable development (Van Berkel, 2006).

This PhD asserts that the global transition to a low-carbon future can create opportunities for the decarbonisation of mining countries while at the same time the projected steady demand for metals and minerals, coupled with declining ore grades and deposits that are harder to access, will increase the environmental footprint of the mining sector, including higher energy and water consumption and increasing mine waste. The integration of renewable energy into mining is one of the best, illustrative examples of eco-innovation in the sector. According to Batterham, sustainable development in the context of mining requires the input of clean energy: “In time, the once-through usage pattern that characterises mining, metal production and metal use will change to a process of continuous use and recycling where the only input to the system is renewable energy” (Batterham, 2003). While mining is crucial to the clean energy transition, it also accounts for up to 11% of global energy use. Many mining companies still supply their own electricity with diesel generators because of unreliable energy supply from national power grids (Alova, 2018; CCSI, 2018). Mining represents more than 20% of installed diesel generator capacity, making the sector the second-largest user after the electricity sector (World Bank, 2015). To benefit from the increase in mineral demand and reconcile climate, mining and development objectives, mining companies must adopt a mining practice that minimises carbon and material footprints. Replacing diesel generators with renewable energy has a great emission savings potential. Almost all mining countries, including Chile and Australia, are party to the Paris Agreement, for which they have developed Nationally Determined Contributions (NDC), affecting the mining and energy sectors. According to Choi and Song (2017), solar and wind power in the mining industry would have positive environmental and economic effects, as the reduction of fossil fuel use contributes to a reduction in greenhouse gas emissions. In economic terms, in remote areas renewables could be a substitute for fossil fuels, especially taking potential high oil prices into account. They conclude that the deployment of renewables in mining has the potential to create new business models and jobs in the field of construction or the installation and operation of renewable energy systems. Therefore, the use of renewable

energy technology in the mining industry is expected to continue to spread. There are 28 mines which use either solar or wind, of which four are in Australia and eleven in Chile (Choi and Song, 2017). Therefore, there is a need to understand the current state of the integration of renewables into the mining sector and what their motives and drivers are.

There are several reasons why this research focuses on three large mining companies. As expressed above, mining companies with coal or other fossil fuel assets in their portfolio are at risk under the Paris Agreement; yet, they may also apply eco-innovation and shift to a mining practice that focuses on minerals that are relevant for the Sustainable Development Agenda. BHP, Rio Tinto and Anglo American are among the 12 largest publicly listed diversified miners by market capitalisation and market value (Soliman et al. 2017). Among the 12 largest publicly listed mining companies is also Teck Resources, a Canadian company. Canada was one of the considerations; yet, the country's extremely decentralised political system would have made a meaningful comparison difficult. In the Chilean case analysing Antofagasta or Codelco as a company would have also been interesting. It is also one of the major global suppliers but without any operations in Australia. BHP is an Anglo-Australian multinational mining, metals and petroleum company headquartered in Melbourne, Australia. It is the world's largest mining company measured by 2015 market values and Australia's fourth largest company, formerly the largest. BHP is the largest shareholder of the Escondida copper-gold-silver mine, which is located in the arid, northern Atacama Desert of Chile. The mine is a joint venture between BHP (57.5%), Rio Tinto (30%), a Japanese consortium (10%) and the International Finance Corporation (2.5%). Minera Escondida produces more copper than any other mine in the world. Escondida celebrated 25 years of operation in 2016, having processed more than two billion tons of ore. In 2006, 338.6 million tons were mined (928,000 tons per day), of which 251.5 million tons were waste and oxide ore (BHP, 2016). Rio Tinto is a British-Australian multinational mining company with a diverse portfolio including aluminium, iron ore, copper, uranium, coal and diamonds. Its headquarters are in London and Melbourne. It is the second largest Australian exporter and third largest global exporter of thermal coal. In its 2014 report, Rio Tinto stresses that “renewable energy at a remote site is not an easy proposition even where it is replacing

expensive diesel generation, until economic storage is available, renewable energy is simply replacing the use of diesel, while diesel still remains as a back-up.” Yet, in the same year the company was the first in Australia in asking for financial assistance from the Australian Renewable Energy Agency (ARENA) for a joint project with First Solar to develop a 1.7-megawatt solar capacity for the mining project in Weipa. Anglo American is one of the world’s biggest mining companies based in Johannesburg and London. It has five coal-mining sites in Australia and interests in four copper mines in Chile. 70% of Anglo American’s operations happen in water-stressed areas (Anglo American, 2016). The company has put in place a water, energy and GHG targets to improve its environmental performance. All three mining companies have a diversified portfolio including coal and strategic minerals, which will be needed for the global low-carbon transition. This makes them an interesting case as suppliers of critical minerals and partners for the low-carbon transition, while at the same time, due to their business interests in coal mining, they could also count as potential incumbents or veto players, showing resistance to regime change.

Due to their size they have greater environmental impact and thus greater responsibilities in delivering on the global agenda of sustainable development and climate change mitigation, which makes them relevant for policy. The dissertation does not analyse small and artisanal mining, as these are almost non-existent in neither of the case study countries. These are mines that are independent and informal, providing a subsistence livelihood for millions of people across the globe. Water pollution, deforestation, community health, safety or child labour are among the concerns caused by small-scale mining. While in Australia there are small-scale gold mines owned by private individuals, in Chile there are some small and medium sized mines, which are neither independent, nor informal. Thus they do not qualify fully as artisanal or small-scale mining. BHP, Rio Tinto and Anglo American have investments and stakes in operations in Australia and Chile (see figure 5). This is important to analyse and answer the question whether there are similarities or differences in the same company’s investment decisions and eco-innovation efforts across the two countries. If there is variance, which evidence suggests, rational choice institutionalism is expected to provide the explanatory tools. Theory

would suggest that a strong policy framework reduces uncertainty and supports investments in eco-innovation; that cooperation for eco-innovation between state institutions and private sector actors, overcoming information deficits, lead to a swifter shift from business as usual to investments in eco-innovation and the development of new business models. Finally, that market incumbents are likely to act as veto players in the policy change process. The higher the number of incumbents, the less ambitious would the policy framework in a country be, thus, the higher the uncertainty for eco-innovation investors. International agreements such as the Paris Agreement would only influence company decisions if they put a company's economic assets at risk and create uneasiness among shareholders about the future economic viability of the asset portfolio.

Figure 5. Operations and portfolios of mining companies

	Description	Australia	Chile
BHP	Anglo-Australian multinational mining, metals and petroleum company, copper, uranium, petroleum, HQ Melbourne, largest Australian coal exporter	8 Operations Petroleum (1), coal (4), uranium/copper (1), iron ore (1), nickel (1)	2 Operations (copper)
Rio Tinto	British-Australian multinational Aluminium, iron ore, copper, uranium, coal and diamonds, HQ London and Melbourne, second largest Australian and third largest global exporter of thermal coal	18 Operations Iron pore (4), energy and minerals (7), aluminium (6), copper/diamonds (1)	1 Operation (copper) 30 per cent interest in Escondida mine, managed by BHP
Anglo American	HQ Johannesburg, London Platinum, copper, diamonds, nickel, iron ore and coal	5 Operations (coal)	Interests in 4 copper operations, production of copper concentrate, by-products etc.

Many companies produce annual sustainability or environmental reports required for listed companies. Environmental and social reporting is voluntary in most countries, and there are no regulations concerning form and content. Quality has been a major issue since the beginning. Early reports were unreliable, many companies were selective about what they included in reports and data were not comparable between reports in different years or between reports from different companies (Hopkinson and Whitaker, 1999;

Franks, 2015). The reports of BHP, Rio Tinto and Anglo American are, however, comparable because they have similar reporting structures in compliance with the Global Reporting Initiative (GRI). GRI is a non-profit organisation based in Amsterdam, formed in 1997 with the support of UNEP and the aim of raising the standard and consistency of reporting. About 1500 organisations from 60 countries used the GRI reporting framework and GRI sustainability reporting guidelines in 2009 to produce sustainability reports. The reporting framework provides guidance on preparing the report and is designed to be applicable to organisations widely differing in size and location. The sustainability report is structured around a CEO statement, key environmental, social and economic indicators, a profile of the reporting entity, descriptions of relevant policies and management systems, stakeholder relationships, management performance, operational performance, product performance and sustainability overview. The guidelines specify the information relating the triple bottom line performance of an organisation reported. The sustainability indicators against which companies are required to report are listed in Appendix III.

Furthermore, all three are members of the International Council on Mining and Metals (ICMM). In response to increasing concerns about the social and environmental impact of the mining industry and in line with CSR principles, nine large minerals companies established the Global Mining Initiative (GMI) in 1998 and commissioned a three-year international project to explore the issues of sustainability in relation to the industry. This resulted in the major report “Breaking new ground: mining, minerals and sustainable development” (Franks, 2015) – often referred to as the MMSD report. Another outcome of GMI was the formation in 2001 of the International Council on Mining and Metals (ICMM), a CEO-led association based in London, established to provide “a platform for industry and other stakeholders to share challenges and develop solutions based on social license and the principles of sustainable development” (ibid.).

From an analytical-theoretical point of view, being part the same organisations and reporting initiatives provides the opportunity to test different alternative explanations of an outcome. Certain environmental investment decisions could be for example the result

of a calculation of transition costs and risks based on information or of a socialisation process within an organisation which influences the perception of what is the “appropriate” decision to make. Norm diffusion and sociological institutionalism would suggest similar eco-innovative outcomes in Chile and Australia if the company were part of the same institution, which forms its identity in a normative way. Yet, the case study on the companies suggests some differences between the same company’s investment decisions and performance in different countries. This is an interesting puzzle, which needs theoretical explanation.

3.4.4. Causal propositions and the structure of the case studies

The purpose of this analysis is to explain the variance between Chile and Australia and across mining companies, operating in both case study countries. The literature review and theoretical discussion on pathways of change helped identifying four causal propositions to guide the comparative case studies. They are an integral part of the analytical framework and determine the organisation of the empirical case studies for a systematic evaluation. The figure below shows the multi level scheme and causal propositions derived from the analytical framework above.

Figure 6. Multi level scheme and causal propositions

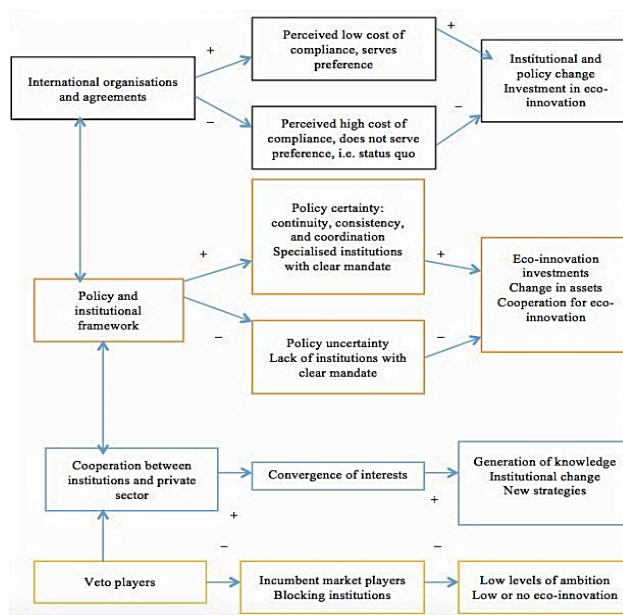


Figure 7. Different levels of analysis

Level of analysis	Causes (independent v.)	Effects (dependent v.)
International organisations and agreements	Compliance with recommendations Perceptions of compliance and non-compliance costs with the Paris Agreement Financial incentives: trade agreements, technical and financial cooperation with third parties (assistance)	Institutional and policy change for eco-innovation High policy ambitions New, long-term roadmaps Change in assets and investments (stakeholder pressure)
Policy and institutional framework	Policy certainty: binding targets Economic incentives: carbon tax, subsidies, government loans Include also procedural ideas: cooperation, continuity and consistency Specialised institutions with clear mandates Enforcement mechanisms (compliance)	Eco-innovation investments Change in assets and investments Emergence of technical cooperation projects
Cooperation between institutions and private sector actors	Convergence of preferences: Formulation of joint goals	Generation of knowledge Informed decisions and better choices, saving costs and reducing risks Creation of new institutions to overcome information deficits New strategies
Veto players	Incumbent fossil fuel players in the energy sector Established influence of big market players Blocking Institutions (ministries) due to different priorities	Less levels of ambition Low or no eco-innovation

In order to answer the overarching research question of how eco-innovation in resource-rich countries looks like and what transition pathways leads towards a cleaner and more sustainable growth model and the question of which role institutions and domestic actors

play in such a transition, the case study analyses address different levels of analysis derived from causal propositions shown above. The first section of the case studies analyses international organisations and agreements and the potential causal effects taking place at that level of analysis. Higher compliance rates with international agreements and recommendations of international organisations, such as the OECD, provide a condition for institutional and policy change for eco-innovation, as well as higher policy ambitions and/or new long-term roadmaps. The higher the perceived costs of compliance are, the less likely these changes will happen. If the perceived costs of non-compliance are higher than those of compliance, the more likely it is that an actor decides to change. For instance, a country is more likely to give ambitious responses to the Paris Agreement, if it serves its own domestic agenda. It could be of support to promote renewable energy development for long-term cost savings, competitiveness, economic diversification or reducing energy independence. Cases in which the global agenda does not converge with domestic interests, compliance costs are perceived as high, for instance if the economy needs major restructuring, which would bring about some major “modernisation losers” whose business model would not be viable anymore. Furthermore, in a carbon-restricted future supported by the international climate regime, mining companies would need to review their asset portfolios. Under the scenario of 196 countries agreeing to reduce carbon emissions, coal would not find many buyers. Therefore, under such a scenario coal assets would create an economic risk for the shareholders and the entire company. Financial gains could also incentivise domestic change. Overseas development assistance for economic restructuring and introducing climate change mitigation measures create a net economic interest in technical and financial cooperation with third parties. This level of analysis helps us answering in answering the question of why international agreements have a different transformative effect in Australia and Chile.

The second section analyses the policy and institutional framework at the national level and investigates the causal link between the coordination at the national level between institutions and states, policy certainty e.g. binding targets, economic incentives for eco-innovation, such as carbon tax, subsidies, government loans and eco-innovation

investments or the emergence of technical cooperation projects. Specialised institutions with clear mandates and goals as well as enforcement mechanisms add up to the policy certainty. Governments play a key role in ensuring inter-state and inter-institutional coordination, providing political guidance and certainty for the markets. A predictable and long-term policy framework is thus essential along with tools for the development of roadmaps that help to manage expectations regarding technology development and adoption. In this context, the political will to introduce a carbon tax or subsidies for renewable energy is a decisive factor (Altenburg and Rodrik, 2017). Lack of coherence, uncertainties and discontinuity in policy, in turn, are expected adverse effects on eco-innovation efforts. This level of analysis helps us in addressing not only the question of why Australia and Chile follow different transition pathways but also why mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia.

The third level of analysis contributed to answering the latter question and concerns the degree of cooperation among public institutions but also private actors as well as between institutions and firms. Cooperation between institutions and private sector actors can be critical in generating convergence of preferences and the formulation of joint goals. Cooperation supports the overcoming of financial risks, information sharing and the generation of new knowledge based on mutual learning to take informed decisions and make better choices, leading to saving costs and reducing risks. From the creation of new cooperation within new initiatives or institutional set-ups lower perceived costs of change and create more optimal outcomes for the broader society. Therefore, different initiatives and institutions for cooperation are analysed to assess their effect on eco-innovation efforts.

Finally, the fourth level of analysis is on exploring the existence and role of potential veto players and their resistance to domestic regime change. National ministries of economy or trade might block higher ambitions of ministries of environment or incumbent and influential fossil-fuel companies in the energy sector might hinder the large-scale use of renewable energy within a country, and thus, lead to lower levels of ambition and eco-

innovation. In turn, the absence of such veto players creates an environment in which change toward eco-innovation would be welcome for the new economic opportunities and environmental benefits it would bring about. In conclusion, these different levels of analysis constitute important aspects of determining where the drivers and barriers to transition towards eco-innovation lie and provide us with a multi-level explanation. The following section describes the different data sources and data collection process to collect evidence for the answering of the different research questions based on the different levels of analysis.

3.4.5. Data collection and triangulation

Chile and Australia are both advanced resource-rich economies and OECD members with a sufficient availability of data due to international reporting requirements. They share climate and energy use data as well as water related data. The OECD environmental performance reviews require them to report extensively on policies, institutions and regulations. Therefore, to a large extent the data availability expectations have been met. The data availability in relation to the companies have been a bit more challenging due to the aggregated nature of, for instance, energy or water use data, in their sustainability reports. Mine-site specific data would have been more useful in explaining the variance in investment and company decisions across the two countries. Nevertheless, the choice of three large mining companies with same reporting standards has made the comparability of their eco-innovation performances and decisions easier. This would have been more challenging with companies who do not comply with global reporting standards or with more limited institutional capacities to produce such reports.

The following section describes in detail what kind of data was collected and how. The explanations for the puzzles are built in a way that can be tested through triangulation with other data sources. Triangulation is often used in evaluation to check answers. In the context of comparative studies it is used to strengthen answers to causal questions by identifying or ruling out alternative explanations (Yin, 2014). The case studies discuss alternative explanations derived from theory and a compelled explanation of an

individual case requires both demonstrating that the hypothesised explanation fits the evidence in the case and that it fits the evidence better than alternative explanations (George and Bennett, 2005). This thesis builds upon a comparative study of most similar cases and nested case study with a particular focus at what is happening in the mining sector at firm level. We control for many alternative explanations generated from historical and sociological institutional which compete with explanations from rational-choice institutionalism this thesis derives its analytical framework from.

3.4.6. Sources of data and data saturation

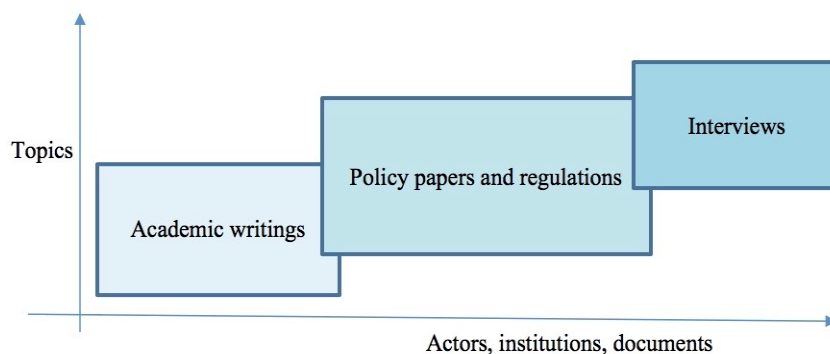
Data saturation has an impact on the quality of the research conducted and hampers content validity (Fuchs et al. 2015). Data saturation is reached when there is enough information to replicate the study (O'Reilly and Parker, 2012). Therefore, data collection is important. Dibley (2011) differentiates between rich (quality) and thick (quantity) data. Thick can be a lot of data which is not very useful, while rich could be very useful but limited in the scope and size. Scholars suggest a combination of both. The depth of the data is as important as the size. For the purpose of this research, the sample size of data was chosen according to the need to provide sufficient answers for addressing the research questions and the triangulation of different sources of information.

Key themes for discussion during interviews were identified on the basis of the data and document analysis. These documents were chosen based on the evaluation of their potential contributing to answering the research questions. Therefore, specifically documents outlining the responses of Chile, Australia, and the three mining companies on the Paris Agreement were chosen. Moreover, the OECD environmental performance reviews on Chile and Australia were analysed and the national policies, institutions and initiatives were compared with the recommendations. Normally, those reports include a section on the compliance performance with the recommendations of the previous reports, which helped the evaluation process. Company reports were only comparable from 2014 on. The previous reports were not following the GRI structure and did not provide sufficient room for a meaningful comparison. Therefore, the timeframe for the

analysis of corporate documents include only the period between 2014 and 2016. Furthermore, to understand the policy framework, laws, regulations and policy documents related to eco-innovation were analysed against criteria of policy certainty, e.g. binding, long term targets, carbon tax, timeframe of policies, subsidies and related clear incentives.

For this research, institutions such as the University of Technology Sydney, The Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Institute for Sustainable Futures, OECD, CEPAL and University of Chile proved to be valuable sources. Policy documents provided an important starting point for data collection and content analysis. This project used also secondary data, which is rather quantitative such as water and energy use and land use data, trade statistics, as well as data on productivity and international price developments. They form an important part of the research, as they provide contextual information. It was difficult, however, to gather data, which stretch over a long period of time, as the mining sector began only recently to monitor and report resource use patterns and environmental impacts.

Figure 8. Sources of data



Interviews were used in addition to academic writings, policy papers and regulations for data validation and one way of reaching data saturation. They were structured to facilitate asking multiple participants the same questions in order to reach data saturation. Otherwise, one would be constantly moving the target (Guest et al. 2006). Another method to ensure that data saturation would be reached was the constructing of a

saturation grid, wherein major topics sourced from the literature review and related to the research questions were listed on the vertical and interviews to be conducted were listed on the horizontal (Brod, Tesler and Christiansen, 2009). As shown in figure 9, for the purpose of this research a saturation grid was constructed listing the topics of interest on one side and the different interview sources on the other. The answers to the same questions by different stakeholders were compared against each other and similar answers were seen as source of data saturation. Extremely diverging answers were dismissed during the data collection process as not evident and reliable enough. The latter has, however, not been the case during the actual data collection process. The answers were quite similar with differing small nuances based on the institutional perspective on the specific topic asked.

Figure 9. Saturation grid

Topics					
<u>Policies (past and present)</u> Institutional & regulatory reforms (eco-innovation and environmental policies) Corporate policies and strategies of the mining companies					
<u>Process (past and present)</u> Collaboration between government and international organisations Collaboration across government institutions Collaboration between public and private sector					

Future strategies Assessment and anticipation of trends and challenges Policy response					
	NGOs	Public policy officials	International Organisations	Private sector stakeholders	Academics

Data saturation can be attained in a number of methods; however, a researcher should keep in mind the importance of data triangulation (Denzin, 2009). To be sure the application of triangulation, the application of different sources of data, contributed substantially to the reliability of the results and saturation, multiple methods and sources of data were used, whereby interviews as well as coding via NVivo were supporting sources for validation of document and policy analysis, for which process tracing was used. These enabled the research to explore different levels of perspectives and approaches to the same analysed phenomenon, whereby methodological and data triangulation ensured the richness and depth of data.

3.4.7. Interview sampling

Interviews are needed for in-depth data and to gain access to information, which cannot be obtained through document analysis. Yet, company, think tank, agency and corporate documents provided sufficient information for this research, for which reason interviews were used for further validation of the data obtained from document analysis. For the purpose of validation, semi-structured interviews were conducted, guided by an inventory of issues that were discussed. The key benefit of a semi-structured approach is that they adopt a flexible and discursive approach, one that allows divergence. They were in-depth, starting with a single question, allowing the interviewee to respond freely. However, in some instances, there was a follow-up on those issues, which were considered as important for the research.

Robinson (2014) proposes a four-point approach in defining “the sample universe” also called “study population” or target population” – this is the sum of the interviewed people

from which cases may legitimately be sampled in an interview study. To determine a sample universe a set of inclusion and exclusion criteria is necessary (Luborsky and Rubinstein, 1995). Inclusion criteria specify attributes the interviewed must possess to qualify for a study while the exclusion criteria specify the attribute disqualifying. These describe the boundaries of the sample universe. The more inclusion and exclusion criteria are used, the more defined the sample universe will be and the more specific the criteria are, the more homogeneous the sample universe will become.

Figure 10. The four-point approach to qualitative sampling (Robinson, 2014)

Name	Definition	Key decisional issue
Define a sample universe	Establish a sample universe, specifically by way of a set of inclusion or exclusion criteria	Homogeneity or heterogeneity, inclusion/exclusion criteria
Decide on the sample size	Choose a sample size or sample size range, by taking into account what is ideal and what is practical	Small or large
Devise a sample strategy	Select a purposive sampling strategy to specify categories of person to be included in the sample	Stratified, cell, quota or theoretical strategies
Source the sample	Recruit participants from the target population	Incentives, snowball sampling, advertising

The more specific the criteria are, the more the sample becomes homogeneous. The choice needs to be between homogeneity and heterogeneity should be guided by the research aim, questions and theoretical guidance. There are challenges inherent in using a heterogeneous sample, for instance, the lessening of the likelihood of meaningful core cross-case themes being found during the analysis. Therefore, all researchers must consider the homogeneity/ heterogeneity trade-off themselves and delineate a sample universe that is coherent with their research aims and questions. For this research, we opt for a homogeneous sample for comparability. The more homogeneous the interviewee sample is, the more comparable becomes the data. Moreover, a homogenous sample suits better the most similar cases research design.

Figure 11. Inclusion criteria for interview sampling

Source of homogeneity	Description
Professional history homogeneity	Homogeneity resulting from interviewees sharing a past work experience – duties, role, area of expertise, achievements, contribution to policy-making, same sector (non-government, international organisation, private mining sector, government)
Geographical homogeneity	National authorities, international organisations, universities and business associations, companies working in/on Chile and/or Australia specifically
Topical homogeneity	Mining, energy, water, climate change, innovation

There were no exclusion criteria. For the purpose of this research, everyone who was interested and available to speak was seen as a useful contact that could have led to reaching further people, providing different perspectives. This approach has proven effective, as all interviewees were important sources of information and contacts. For the sampling of interviews, three sources of homogeneity were identified as inclusion criteria. The first one is the professional history homogeneity, resulting from a shared past work experience either in the same organisation or same files and projects. Geographical homogeneity constitutes the second category and means that stakeholders from national authorities, international organisation, universities, business associations and companies working in or on Chile and Australia specifically were targeted. The last category is topical homogeneity given the specific focus on eco-innovation involving sustainability practices and projects, involving energy, water, climate change and innovation issues in the mining sector. The expectation was that based on these categories of homogeneity, a policy outcome or process could be understood from different stakeholder angles without going beyond the topic or geography of interest.

Deciding on the sample size needs some flexibility. Instead of deciding a priori on a fixed number, an approximate number and range was determined. Robinson (2014) suggests a guideline of 3-16 participants for a single study, as this sample range provides a good scope for developing cross-case generalities, while preventing the researcher being bogged down in data and permitting individuals within the sample to be given a defined

identity (Robinson and Smith, 2010). During the research process, some flexibility was also maintained due to snowball sampling, involving asking participants for recommendations of acquaintances and network. Interviewed experts recommended contacts and names of people to speak to. This does not mean that the sampling process was not rigorous enough. In fact, rigour in the sampling process is determined by the adequacy of the sample not in terms of size but purposive selection of the interviewees according to their ability to supply meaningful information needed for the analysis (Yardley, 2000).

For the purpose of this research ministries, public stakeholders, government agencies and mining companies were interviewed as well as academics and NGO representatives. For Chile, Paul Ekins and Hector Altamirano provided initial contacts. Additional respondents were identified through familiarity with the field. Participants from different sectors, i.e. policy, civil society, industry (water, energy, and mining) were approached on the basis of an organisation’s or expert’s knowledge and involvement. A mapping exercise facilitated the sampling process. This project sought to engage with as wide a range of actors as possible in order to enhance the understanding of this diverse and complex field, but also gain access to the worldviews of actors not directly involved in mining and eco-innovation. Staff from UCL Australia was incredibly helpful in establishing a wide-network of experts helping to access data and arrange interviews in Sydney, Canberra, Melbourne and Adelaide. All interviews were summarised and a full list and short description of the organisations were noted down. To protect anonymity, expert participants are referred to in the text by a code: the first letter refers to the case study country (C=Chile, A=Australia).

Figure 12. Summary of interviews

Location of field work	Expert actor group	Code in text	Number of interviews
Chile (October to November 2014, March 2015 and October 2015)	NGO	CNGO	1
	Academic	CA	2
	Government	CG	5
	International organisation	CIO	3
	Private Sector	CP	2
Australia (May 2016, May	NGO	ANGO	3

2017)	Academic	AA	6
	Government	AG	5
	International organisation	AIO	2
	Private Sector	AP	4
Total			33

The interviews started with questions on past policies for eco-innovation and the experiences made with those and continued with a set of question to understand the most recent policies or planned regulations, the role and mandate of existing institutions and their interaction with each other as well as the position of the mining sector in the broader economy and how the sector interacts with other segments of the economy. The final set of questions related to future initiatives and strategies under discussion. This approach proved useful to understand past policy outcomes and processes in order to understand whether there were any lock-in or path dependencies as historical institutionalism suggests or established networks and groups with established interactions, as sociological institutionalism would suggest. From a rational choice institutionalism perspective it was important to understand past preferences and rational interests of policy makers and business stakeholders. The issue of path dependency and lock-in or established fixed preferences of powerful stakeholders in the sector was particularly important in addressing the research question, why Australia shows a less promising performing in reforming its policies in support of eco-innovation. Asking questions about current policy priorities and processes has proven useful to address the research questions, providing an understanding of the different industry responses in both countries despite similar challenges. Finally, the questions of future strategies helped in understanding better the anticipated and planned steps in support of eco-innovation, providing an indication for the pathway for a future transition or the continuation of status quo. The questions were logically structured and helped the interviewees to understand and explain properly the connection between past, current and future policies.

Figure 13. Interview questions

Past	<ul style="list-style-type: none"> • What are, in your view, the most important regulatory and institutional reforms in the past 25 years on eco-innovation and environmental protection?
Present	<ul style="list-style-type: none"> • What are your department's current policy priorities? • Who are the main government departments/ agencies, international partners,

	<p>NGOs and business associations you work closely with - in which area of collaboration?</p> <ul style="list-style-type: none"> • How do you facilitate exchange with the mining sector? Which topics do you focus on? How often do you meet? How does the collaboration look like? • Do you think more needs to be done? If so, how should the reform or strategy look like? • How does/ can your country/ business support eco-innovation? • How much do you invest in eco-innovation and resource efficiency compared to other areas? • How important is the mining sector's size and contribution to the economy? • Is the mining sector well integrated with other sectors? Any linkages/ collaboration with eco-innovative sectors?
Future	<ul style="list-style-type: none"> • Which initiatives or strategies are you currently working on? • What are the most pressing environmental challenges in your view? How does/ should the government address them? • Do you think a target is needed? • How could the transition to eco-innovative look like? Which steps need to be taken in your view?

3.4.8. Process tracing

There are three methods of within-case analysis, namely, process tracing, congruence testing and counterfactual analysis. Process tracing focuses on whether the intervening variables between a hypothesised cause and observed effect move as predicted by the theory under investigation (Bennett, 2005). It is a useful supplement for “obtaining an explanation for deviant cases” (George and Bennett, 2005). Process tracing is a widely used analytical approach for case analyses, supporting the establishment of causal mechanisms in a particular context with the aim to produce analytically generalisable insights. The methodological term mechanism describes the analytical construct, which is derived from patterns of social behaviour abstracted away from their specific contexts. Drawn primarily from interpretivism, process tracing acknowledges the singularity of cases with the conviction that no social relationship or practice is so unique to exclude the possibility of theorisation or categorisation (Pouliot, 2014). Process tracing is therefore a useful methodological tool to understand patterns of social behaviour and abstract those away from local context in the form of social mechanisms that can be transferred to other cases as well (ibid). As Bennett and Checkel (2014) underline, “within a given context, practices exhibit regularities, otherwise there would be no

structure to social interaction” (Bennett and Checkel, 2014). Nevertheless, the interpretative boundaries or limits of transferability need to be discussed and identified to define the generalisable and transferable insights (Hopf, 2002; Bennett and Checkel, 2014) – see separate chapter on transferability. The validity of analytical generality lies in the usefulness to explain various cases. Therefore, there cannot be a true or false but only a useful or not (Bennett and Checkel, 2014).

Process tracing is particularly helpful in measuring and testing hypothesised causal mechanisms, providing answers to the questions as to how to measure these mechanisms and how to test competing explanations that invoke different mechanisms. Bennett and Checkel (2014) suggest a list of criteria for the determination as to whether a particular research counts as good process tracing. In 1979, George appropriated the term to describe the use of evidence from within case to make inferences about historical explanations (George, 1979). There is a great amount of research on the errors individuals make and the biases they exhibit in their decision making process. Therefore, process tracing is often viewed as not compatible with rational-choice theories. Yet, many prominent rational choice theorists see a strong case in using process tracing as it is a helpful methodological tool to analyse hypothesised processes through which individuals make decisions (Schimmelfennig, 2014; *ibid*).

Process tracing is defined as the use of “histories, archival documents, interview transcripts and other sources to see whether the causal process a theory hypothesises or implies in a case is in fact evident in the sequence and values of the variables in that case” (George and Bennett, 2005). It attempts to identify the causal process between the independent and dependent variable. It means the analysis of evidence on the processes, sequence and conjunctures of events within a case for the purposes of either developing or testing hypotheses about causal mechanisms that might causally explain the case. Put differently, the deductive theory-testing side of process tracing examines the observable implications of hypothesised causal mechanisms within a case to test whether a theory on these mechanisms explains the case (Schimmelfennig, 2014). Causal-process observations are “observations on context, process or mechanism” and are used within-

case analyses such as process tracing (Brady and Collier, 2010). Therefore, process tracing is closely related to historical explanations. In terms of the richness of historical data, it was easier to find more data on Australia, which has a longer history of environmental policies than Chile, which only in 2010 established a Ministry of Environment. To address such a disproportion the analysis of historical data in Australia dating back longer than 2010 in Australia was kept rather brief. In order to increase the validity of the research, different alternative explanations were discussed, providing a wider theoretical discussion on the topic. Potential biases of evidentiary sources were critically reflected upon, taking “greenwashing” or potential ideological biases into consideration.

3.4.9. Content analysis and coding

As part of the mixed method approach, this PhD research project makes use of coding as part of content analysis, as it fits the purpose of the research and helps achieving the researching objectives. The analysis, for instance, focuses on sustainability reporting of mining companies, national innovation strategies and energy policies over time showing changing focus, perceptions and strategies. This aids the research in achieving its aim to understand existing eco-innovation policies and targets at the national and firm-level, how the mining industry addresses resource efficiency and eco-innovation in corporate reporting with a focus on water and energy as strategic resource input for extraction, how environmental challenges are defined, i.e. technical, social, and economic, health and safety and existing international cooperation targeting eco-innovation and environmental sustainability. Coding is a way of attaching names, ideas to pieces of text in a transcript and linking chunks of data as representative of same phenomenon, activity, action, concept or action occurring more than once. Qualitative research is usually used in the micro level of natural situation and by describing and analysing individual things carefully and dynamically, it can get a more comprehensive explanatory comprehension of the “quality” of something (Chen, 2000). NVivo, a computer-based qualitative textual analysis programme, has the biggest advantage of coding and helping to generate, process and use large volumes of data in a standardised and structured way, to make analysis of

relationships between information and the analytical framework, as well as data querying as a measurement technique and hypotheses testing. Using coding for data analysis and the statistical functions of text analysis, this study carries out theme coding and hierarchical coding and analyses the explicit and implicit relationships between data, so as to test assumptions. The software has the advantage of quickly generating large volume of data using queries, linking, annotating and creating relationships between codes.

Through the analysis of primary and secondary sources, large amounts of data were collected, processed, transcribed, coded and imported into the software. Subsequently, the research took the following steps: begin to code data and find the priori-chosen important and highlighted themes. The a priori chosen coding scheme was complemented throughout the research process. Codes (or nodes) were chosen based on their relevance for the research questions and the degree of their linkage with the analytical framework; however, the standard is also the frequency of related words and content, i.e. when a particular topic or concept appears repeatedly and forms a certain code, it becomes the focus. Initially, larger sets of codes were identified but were later added (e.g. “affordable” to “energy” and “cost”), dropped because of lack of relevance (e.g. “conflict”) or subsumed under another code (e.g. “draught” and “scarcity” were subsumed under “security of supply” or “hydro”, “solar”, “wind” were subsumed under “renewable energy”). While applying the coding scheme to a certain document type, the document types have to be separated and categorised from each other. The length and language of a legal or strategy paper differ from each other. Thus, similar document types were compared.

Pre-defined codes were identified and aggregated under specific headlines. The software supported the examination of the frequency of words or codes. While examining and identifying the frequency and number of words, it was important to look at words leading into and leading out of the identified code. For example the code “risk” or “cost” appeared in different contexts: “supply risk”, “pollution risk” or “recruitment cost”, “energy cost”, “cost of damage”. Therefore, additional manual control was needed. Word

frequencies serve as an indication for focus, emphasis and relevance of specific concepts or issues in reporting. The frequency of identified codes was identified in absolute numbers and the percentage was calculated based on the sum of repetition of the codes. Links were identified before in subgroups in the coding scheme. With the help of the software, the percentage of frequency of links between pre-identified codes was calculated.

One World Bank paper uses coding in the “evaluation system” in an analysis on sustainable development and extraction (Eftimie and Stanley, 2005). The authors analyse policy documents and laws and use a measure of “presence” or “absence” to record the inclusion of previously identified components, which they do not explicitly define as codes but which could also be described as such. They point out that missing information could be misconstrued or indicate absence from the instrument itself. Therefore they take care to assess whether the component is not included or simply overlooked in the reporting.

To the author’s knowledge, this methodological approach was never applied in the context of eco-innovation and environmental sustainability in the mining sector. It provides transparency, makes the research traceable and replication possible. This methodology also helps providing meaningful insights into the eco-innovation profiles and priorities of three major mining companies, their thematic and conceptual approach to sustainability reporting, the major issues they focus on and to what extent these have changed between 2014 and 2016. This time frame was chosen for the sake of comparability and to analyse the reactions and potential preparations for the Paris Agreement as well as the Agenda 2030 for Sustainable Development. Earlier reports were diverse in their structure between and within companies. In some cases there is only data for the years 2016 and 2015, which is highlighted later in the text.

Figure 14. The coding scheme

P1. Innovation

Codes	Subcodes	Description
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P1a.	Eco-innovation	Resource productivity, energy efficiency, technology	Innovations with new or improved processes, practices, and products which benefit the environment and contribute to environmental sustainability
P1b.	Green growth	Low-carbon growth, low-carbon future, environment, sustainable, sustainability	Growth with reduced emissions, waste and inefficient use of natural resources, maintaining biodiversity
P1c.	Climate change	Emissions, GHG, global warming	Human-induced global warming and change of climate, weather conditions; six groups of greenhouse gases included in the Kyoto Protocol
P1d.	Resource efficiency	Materials efficiency, recycling, reuse, sustainable consumption and production	Using limited resources in a sustainable manner while minimising environmental impact
P1e.	Water	Seawater, surface, groundwater, wastewater, target, standards, desalination, scarcity	
P1f.	Energy	Fossil fuels, gas and oil, gasoline, diesel	
P1g.	Renewable energy	Solar, PV, photovoltaic, wind, hydro, geothermal, clean energy	Clean energy sources from sunlight, wind, water or geothermal heat
P1h.	Coal	CCS, CCU, carbon, thermal coal	
P1i.	Competitiveness	Cost, pricing, price, trade, affordable, patent, R&D	
P1j.	Mining	Metals, minerals, resource sector, extractive sector, extraction	Extractive sector producing metals and minerals

P2. Energy

Codes	Subcodes	Description
P2a. Cost	Affordable	Energy cost
P2b. Emissions	GHG	Six groups of greenhouse gases included in the Kyoto

			Protocol
P2c.	Climate change	Global warming, Paris Agreement, Kyoto	Human-induced global warming and change of climate, weather conditions
P2d.	Coal	Carbon	
P2e.	Low-carbon technology	CCS, CCU	Low-carbon technology refers here to end-of-pipe technologies such as Carbon Capture and Storage, not renewable energy technologies
P2f.	Innovation		
P2g.	Energy efficiency		The goal to reduce the amount of energy required to provide products and services
P2h.	Renewable energy	Solar, PV, photovoltaic, wind, hydro, geothermal, clean energy	

P3. Water

	Codes	Subcodes	Description
P3a.	Cost	Affordable, cost-competitive	Cost of purchasing water at a competitive, affordable price
P3b.	Climate change	Availability, draught, flood	Human-induced global warming or other forms of changes in weather and climate
P3c.	Security of supply	Availability, draught, scarcity	Guarantee of continued supply
P3d.	Risk	Pollution, tailings, dam failures, waste	Any water-related risk with the potential to have a critical impact on the company's operation, reputation, community and environment.
P3e.	Quality	Potable, mine-water discharge, salinity	Chemical, physical, biological characteristics of water
P3f.	Recycling & reuse	Wastewater use	Reuse and recycling of water
P3g.	Efficiency	Efficient use of water	Water efficiency
P3h.	Target	Goal, aim, benchmark	Benchmark to monitor and achieve progress
P3i.	Desalination	Seawater use, desalinisation	

P4. Sustainability

	Codes	Subcodes	Description
Social & economic			
P4a.	Health & safety	Work-related deaths, work-related incidents, AIDS, tuberculosis, medical service, hospitals	
P4b.	Human rights	Child labour, labour rights	Rights enshrined in international agreements or national law

			referring to social rights, labour rights or employment of children
P4c.	Growth & jobs	Employment, local hire, local value-creation, local suppliers	Information on business cooperation with local suppliers, employment rates, numbers on local hire
P4d.	Communities & women	Women in labour, social expenditure, community projects, aboriginal people, indigenous people	Includes information on community projects funded by the mining company, information on targeted employment of women
Environmental			Ecological surroundings in which the company operates, including air, water, land, other natural resources, flora and fauna and their interrelation
P4e.	Water	Freshwater, seawater, desalination, surface water, groundwater, third party water, wastewater	Refers to potable water or good quality water, reused or recycled water, freshwater, seawater, desalinated water and the technology, groundwater, and other sources of water.
P4f.	Energy		
P4g.	Climate change	Global warming, Paris Agreement, Copenhagen Accord, Kyoto Agreement	
P4h.	Biodiversity	Land rehabilitation, nature conservation, species, flora and fauna	The variety of life on earth, the different animals, plants and organisms, which are part of the wider ecosystem.

The coding scheme was developed to analyse specific types of reporting, which were identified after categorising comparable themes and documents in order to increase the level of comparability. For innovation reporting, ten codes were identified: eco-innovation, green growth, climate change, resource efficiency, water, energy, renewable energy, coal, competitiveness and mining. Each of them has three to eight subcodes. Eco-innovation was chosen to search for a specific type of innovation leading to improved processes and products contributing to environmental sustainability. Innovation is often seen as a driver of economic growth. Yet, in view of a low-carbon future, green growth was identified as a key code. In order to assess to what extent climate change and global agreements influence innovation strategies, the code “climate change” was also added. Resource efficiency and the sustainable use of water are an important part of eco-innovation and were therefore also included. Water was divided into seawater, surface water, wastewater, desalination, standards and scarcity to create a full picture of the

different priorities. Yet, no significant difference was found between the codes. Therefore, these subcodes were collected under the major theme of “water” giving us an idea of the overall importance of water concerns in environmental innovation. “Energy”, “renewable energy” and “coal” were kept separate in the coding scheme. “Energy” refers to fossil fuels, gas and oil, gasoline and diesel, while “renewable energy” represents different types of clean energy technology including solar, wind, hydro and geothermal. “Coal” is seen as a special category given its critical role in global warming and human-induced climate change. Furthermore, eco-innovation can be a driver of competitiveness. All eco-innovation related competitiveness codes, i.e. “cost”, “pricing”, “trade”, “affordable”, “patent” and “research and development” were subsumed under one category. Finally, due to the focus of this research, “mining” forms a special category including the subcodes “metals”, “minerals”, “resource sector”, “extractive sector” and “extraction”.

A separate coding scheme for the analysis of energy strategies was developed consisting of eight codes: cost, emissions, climate change, coal, low-carbon technology, innovation, energy efficiency, and renewable energy. These codes, with one to seven subcodes each, help understand the energy priorities and the direction of the respective country’s energy policy. A higher frequency of “renewable energy”, “emissions”, “climate change”, “innovation” and “energy efficiency” were seen as an indication of a strategy based on the promotion of renewable energy. The results were complemented by in-depth, context-based, qualitative analysis.

The third category of the coding scheme refers to “water” with nine subcodes: cost, climate change, security of supply, risk, quality, recycling and reuse, efficiency, target and desalination. Security and supply represent a category, which shows the emphasis of supply bottlenecks, while quality refers to a particular challenge mining faces: water contamination and waste. This is also linked to the code “climate change”, which also refers to “availability”, “draught” and “floods”. These can be a source of supply problems. “Recycling and reuse” represent another code in order to identify the scope of recycling and company-specific targets. “Cost” as a code, consisting of two additional

subcodes, i.e. “affordable” and “cost-competitive” was included as a way to understand to what extent water costs play a role in corporate reporting and if they are seen as a challenge leading to greater efficiencies. The final code is “desalination”, which is of importance in understanding backward linkages between the sector and desalination technology providers. Desalination can be a sustainable way of reducing ecological pressures stemming from reduced groundwater levels or the depletion of surface water.

Finally, the last category “sustainability” consists of eight codes, divided into two groups. This scheme was developed to understand the weight of actual environmental themes in corporate sustainability reporting. The first category represents social and economic codes: health and safety, human rights, growth and jobs, communities and women. The second category refers to environmental themes: water, energy, climate change and biodiversity. The coding results show the share of social and economic themes and environmental issues in corporate sustainability reporting. This gives us insights about how sustainability is perceived and what the company’s “sustainability” priorities are and where improvement can be expected in the short to medium term.

For the purpose of this research, other software was also considered, yet, NVivo seemed to be the user-friendliest version. Through query functions the context the codes appear in is analysed. Coding requires a detailed analysis of the context. For instance, the word “environment” can have several meanings, thus necessitating a closer look. The word “environment” may refer to “a business-friendly environment”, while it can also refer to “environmental sustainability”. Moreover, the code “clean” can often be used in combination with “clean coal” or “low-emission technology”, whereas in other contexts it might refer only to renewable energy technology. To address such a complexity and challenge several passages in the coded texts were analysed qualitatively in addition to the coding exercise.

In conclusion, NVivo helped understanding the strategies of the world’s three largest mining companies through automatised, systemised document search and word frequency analysis. The results show the preferred areas of eco-innovation, perception of costs and

how they define sustainability in general. Finally, in the Australian context, NVivo was also a helpful tool in understanding the importance of the coal sector in terms of fixed preferences and rational interests within the context of the Australian economy while analysing the government documents on energy. “Coal” appeared in conjunction with “affordable” and “cost competitive” illustrating the economic benefit of coal for the broader Australian economy. From a rational choice point of view this means that the costs of continuing with coal, as part of a rational argument, is perceived as lower and more economically beneficial than transition towards cleaner options, which are perceived as costly.

4. The cases of Australia and Chile

In order to understand the policy and institutional decisions on eco-innovation, this thesis undertakes a comparative analysis of Australia and Chile. As outlined above, these two countries represent resource-rich OECD countries with different eco-innovation trajectories despite similar environmental challenges they face, such as exposure to climate change effects, water scarcity and similar potentials for renewable energy production. Following the analytical framework, this comparison starts with a brief introduction of the resource profile of both countries. It then addresses, based on rational choice institutionalism, the questions of why Australia and Chile perform differently in reforming their policies and institutions in support of eco-innovation by analysing different levels of analysis and causal mechanisms with a focus on the role of international agreements and organisations, the domestic policy and institutional framework, the structure of collaboration between public institutions and the mining sector, and finally, the role of domestic veto players as a particularly important factor for regime change resistance.

Australia is a traditional resource-based economy with important supply capacities and a large energy and mining sector. The country is at the same time a developed, high-income economy and an OECD member since 1971. Mining contributes 8 per cent to Australian GDP, whereas agriculture contributes 3 per cent. The mining industry is the

second largest export earner for Australia after agriculture. Among OECD members, Australia is the most dependent one on resource exploitation with agriculture and mining accounting for over 61 per cent of export earnings derived from trade in commodities (OECD, 2014). It is an usual case among developed countries, as its resource sector and commodity exports contribute so highly to annual export earnings (Hodgkinson, 2014). Australia, as a high-income, high-wage industrialised country with a dominant extractive sector, forms an exception among OECD countries (Schandl et al., 2008). Australia is the world's largest exporter of iron ore, accounting for 53 per cent of world trade in 2014 (Department of Industry, Innovation and Science, 2015). In 2010, 80 per cent of iron mined globally was extracted in only four countries, China, India, Brazil and Australia. Australia has been after Russia the world's largest resource supplier since 1995 even though the gap between both countries is small (Dittrich et al., 2011). The country is number one in aluminium production, second in lead and iron ore and seventh in copper production. However, environmental challenges are evident, as Australia is together with India, Pakistan, South Africa and North East China, one of the regions facing recurrent water stress (Hanasaki et al. 2008). Hatfield-Dodds et al. (2015) highlight the environmental pressures caused by two centuries of economic growth. The key environmental issues in mining are the increasing use of energy and water (Mason et al. 2013, Franks, 2016). Yet, the country's environmental policies do not provide the needed effective answer to these challenges. Australia rates relatively poorly on resource productivity compared to other OECD economies. Looking at the carbon dioxide (CO₂), energy and material resource productivity measures, it ranks at the bottom of the OECD. Overall, in environmental performance terms, Australia ranks near the bottom of developed countries, i.e. 29th out of 32 OECD countries (Australian Innovation System Report, 2012).

Chile is world's largest copper producer and major exporter of agricultural, forestry and fishery products. The mining sector leads in foreign direct investment 50.1 per cent, services 26.6 per cent, electricity, gas and water 10.9 per cent, industry 7.9 per cent, construction 2.4 per cent, transport and communications 1.7 per cent, agriculture and fishing 0.5 per cent. Between 2006 and 2011, mining reached 64.3 per cent of total

exports (OECD, 2014). The country benefitted from the commodity price boom leading to significant growth rates over the past 15 years. Economic growth was accompanied by increasing environmental pressures – notably air pollution, water shortages, habitat loss, and soil and water contamination. Since 2010, Chile strives to strengthen its environmental institutions and design a comprehensive environmental policy framework. Before 2005-2015, environmental policy and the sustainable use of resources did not play a major a role. Several environmental institutions were established around 2010, when the OECD’s first environmental assessment on Chile was published with concrete recommendations, including the creation of environmental agencies, the Ministry of Environment and Ministry of Energy.

4.1. International organisations and agreements

As discussed in the literature review and analytical framework, states implement international agreements or recommendations by international organisations on environmental protection and eco-innovation, if these bring economic gains and converge with their domestic agenda. Paul Collier (2008) highlights the potential interest of mining countries in global environmental agreements to benefit from aid and trade cooperation, while there could also be domestic conditions resulting from extensive water and energy use along with additional stress factors linked to climate change such as draughts, floods or storms, contributing to the strategic relevance of eco-innovation and environmental sustainability (Andrews-Speed et al. 2014). The following section analyses the effect of climate change and trade and international cooperation agreements on national policies and domestic politics in Australia and Chile.

4.1.1. Climate change agreements

Australia is an interesting case to study from an eco-innovation perspective. Changing environmental conditions with economic impacts, i.e. water shortages, droughts or the bleaching in the Great Barrier Reef, create reasons to act decisively and undergo substantial reforms. Yet, the economy vs. environment mindset characterised Australian

environmental policy over the past decade: "For the past six to seven elections we have had after every election new policy frameworks for climate change. Since last year's election, there is some bipartisan support and the government is working with the previous framework rather than starting from scratch again" (Interview, 2017).

Australia is responsible for the world's 1.5 per cent GHG emissions. The Stern review (2006) highlights Australia's paradoxical relationship to climate change: On the one hand, Australia is one of the countries with the highest per capita emitter of greenhouse gases; on the other hand, as a very dry continent, Australia is especially exposed to climate risk. Australian industry tends to import technology developed in other countries rather than develop its own (Howes, 2005). The relatively small population and vast distances create other problems for the deployment of new technology (McKenzie and Howes, 2006). The challenge for Australia is that a large part of its production and export earnings come from the extractive industries that mine and refine non-renewable resources, particularly coal, gold, alumina, and iron ore (Mercer and Marden 2006; Howard 2006; Australian Government, 2008; Pearse 2009). Australia invests less in technological research, the economy is more reliant on raw material extraction, there is less of a corporatist approach to politics, while environment groups have fewer opportunities to participate in national policy making, and the discourse of jobs versus environment remains strong. Adapting eco-innovation to the Australian case, either as an analytical tool or as a programme for action, requires therefore some care (Howes et al. 2010).

Climate change is evidently one of the biggest environmental challenges the driest continent in the world is facing. It is at the same time the arena that most directly reveals the political dynamics and sectors power relations of environmental reform (Christoff 2005, Lowe 2004, Curran 2009). The politics of climate policy highlights the challenges eco-innovation confronted vis-à-vis resistant domestic actors with strong economic interests in producing coal and interested in retaining the economic status quo. The Howard government, which was unable to avoid confronting the issue of climate policy, as its first term was coinciding with the global Kyoto Protocol negotiations in 1997, is an

eminent example of these dynamics at the level of domestic politics. The government's stance during Kyoto negotiations and eventual refusal to ratify the Protocol indicated its strong commitment to protecting the status quo from potential climate policies that seemingly challenged it. The Howard government was aware of potential implications for the economy of a too robust a climate policy response. Senator Hill, the Minister of Environment, a sustainability professor, was an important actor in Australia's policy Kyoto delegation, yet, the government ensured primary management of policy development and the Kyoto negotiations was managed by more senior party actors who treated the development of Kyoto with more circumspection, namely by Minister for the Department of Foreign Affairs and Trade, Alexander Downer. Downer was one of the most senior members of PM Howard's leadership team (Curran 2009, 2015). The Trade Minister was responsible for the oversight of the negotiations and for understanding the potential trade implications of an operational Kyoto outcome. This choice made sense on a broader political level: the tasking of environmental decision-making to those occupying key resources or economic development portfolios. Other Cabinet colleagues and, seemingly, the Prime Minister himself shared Minister Downer's suspicion of Kyoto's impacts on the Australian economy. The priority at the time was to ensure that the national economic interest took precedence in any development-environment dispute. The center-right Howard government resisted a modernisation agenda for climate protection and rejected even more modest climate policy proposals, e.g. Minister Hill's "greenhouse trigger" – a proposal giving the Commonwealth the capacity to place more stringent requirements on high greenhouse producing projects. Senior members of Minister Hills adopted a firm ideological resistance to climate policy emphasising the primacy of economic growth goals (Curran, 2015).

As a very dry continent, Australia is especially susceptible to climate risk. Yet, under Howard (1996-2007) Australia refused to sign Kyoto as the government contended that ratifying Kyoto would put the Australian economy at risk. Australia defended its "special economic case" status by claiming that the Protocol's binding emissions cap would disproportionately disadvantage the economy. Hence, it introduced an indicative, non-binding 8 per cent reduction target. The economic risks mostly relate to carbon leakage,

which describes the potential shift of fossil fuel industry investments to developing countries not subject to the Protocol's reduction targets and carbon prices.

Along with the United States, the Howard government committed itself to establishing an alternative to the Kyoto protocol: the Asia Pacific Partnership on Clean Development and Climate (AP6), which included Canada, Japan, India, China and South Korea. Howard argued that without the inclusion of the developing world, especially some of the world's biggest emitters such as China and India, any global agreement would be doomed to failure. The AP6 relied on voluntary partnerships and cooperation with industry to reduce emissions, but unlike Kyoto, set no binding emissions targets. At its heart sat technological modernisation, including a commitment to carbon capture technologies.

It is not within the cope of assessing in detail the outcome of AP6, not at least because it was a side agreement among countries who were not in support of a more ambitious climate agreements. In any case, due to the lack of continuity of political commitment especially at the elite-level in Australia, these attempts at the international level have had a limited sustainable impact mainly due to sectoral and structural resistance (Curran, 2015). Australia has since 1980s a track record of several attempts to reform its environmental and climate policies and institutions. The Hawke (1983-1991) and Keating (1991-1996) Labour Party government was the first government to come up with an ambitious plan to reform with a campaign launched in 1989: "Our country, our future" which laid the foundation for environmentally sustainable development in Australia. In 1991 a working group on environmentally sustainable development, which was created when the new government came into office, presented recommendations on integrating closely environmental and economic goals. This led to the creation of an environmental protection agency, which was limited in scope and short-lived, and the appointment of a Chief Scientific Adviser. There was much political and policy activity during this period including the launch of a National Strategy for Ecologically Sustainable Development (ESD) with the plan to mainstream ESD principles into departmental policies and responding to the global initiative Agenda 21, which was a non-binding, voluntarily implemented action plan of the United Nations on sustainable development, a result of

the Earth Summit, UN Conference on Environment and Development, held in Rio de Janeiro, Brazil, in 1992.

The supporting global climate for sustainability has had an impact on developments in Australia. Institutionally, the Department of Environment's status was elevated. In the same year as Agenda 21, the Department of Environment separated itself from a mixed portfolio, becoming simply the Department of Environment, Sport and Territories after the arts and tourism areas were relocated elsewhere. The number of staff increased between 1988 and 1993 from 992 to 2293 (Curran, 2015). The Labour government gave the environment portfolio to a senior member of the party, Senator Graham Richardson, which was a strategically important appointment (Interview, 2016).

Economou (2004) concludes "the ascendancy of one of Labour's key electoral strategists, Senator Graham Richardson, to the Hawke cabinet as Minister of Environment resulted in a period of unprecedented federal activity in the environment portfolio, reinforcing the criticality of support at the political elite level." The track record of this government is perceived as remarkable for the very reason that environmental concerns were no longer peripheral to national interests. There was the obvious attempt to mainstream environmental concerns and ecologically sustainable development principles into wide-ranging ambits and environmental policy and legislation (Curran, 2015). The Keating government (1992) did not make the momentum disappear; yet, there was an "apparent decline in political commitment" to ESD (Papadakis, 2000). This was the period when fast-track minerals development project approvals were introduced and the environmental decision-making was reallocated to the states (Doyle and Kellow 1995, Economou, 1999). Curran (2015) summarises the transition in the following words: "Keating was more successful in marginalising environmental demand than Hawke was in incorporating them into government policy." With the new centre-right, Howard government (1996 to 2007), there was some continuity in ecological modernisation, as a response to increased community awareness of environmental issues. In response to electoral pressures, the coalition took a considerably expanded environmental policy platform to the 1996 election, which it won. The new government abandoned the

terminology ESD and took a revised approach to sustainability issues with a focus on marketisation and privatisation (Papadakis, 2000).

Prime Minister Rudd, Howard's successor, framed climate policy approach in two ways: (1) moral appeal – labelling climate change the biggest moral challenge facing humankind; are more importantly, (2) economic arguments for change, emphasising that the consequences of climate change would outweigh the cost of timely mitigation for Australia; and that there are considerable economic benefits to be gained from acting. A timely action even before the rest of the world would serve national interests through a competitive advantage in investing in cleaner technologies for domestic use and exports (Curran, 2015). When in opposition Rudd commissioned the Garnaut report issued in July 2008 – Garnaut labels climate change as a diabolical policy problem: he argues that “Australia would be hurt more than other developed countries by unmitigated climate change, and we therefore have an interest in encouraging the strongest feasible global effort. We are running out of time for effective global action, and it is important that we play our full part in nurturing the remaining chance” (Garnaut Review, 2008). The report outlines a strong economic case for climate change mitigation, which, like Stern did before, views the costs of inaction as far higher than those of timely action. The Report proposed an emissions trading scheme (ETS) with broad sectoral coverage as the main policy instrument (Garnaut Review, 2008). It envisaged that proceeds from the preferred auctioning of emissions permits would be allocated for transitional adjustments to a low emission future – for both business and consumers. It recommends that approximately 50 per cent of permit revenues should be allocated to consumers, particularly vulnerable households, as compensation for increasing prices; 30 per cent as structural adjustment payments for business (particularly trade exposed emissions intensive industries); and 20 per cent for research and development into lower emission technologies, especially carbon capture technologies for domestic use and exports (Garnaut Review, 2008). The commitment to address climate change action did not translate to a reduced one to the coal sector; shortly prior to the Rudd government’s release of its Green Paper, the Queensland government, with federal government approval, announced the building of a coal port designed to accommodate a 40 per cent increase in coal exports over the next

decade (Interview, 2016). The commitment to the coal sector can also be seen in the active promotion of CCTs as the way forward, reinforced by the limited financial allocation to renewables in the 2008 budget. The Green Paper's strong focus on the CCT solution signals an effort to minimise disruption to the existing structural landscape, and to protect the fossil fuel sector from undue competition from renewables (Curran, 2009). Critics of both the Garnaut Report and the Green Paper highlighted limited investment in renewable energies. Therefore, even in times of change, the extent of eco-innovation has been limited in Australia due to established domestic interests and the economic importance of the coal sector.

Rudd used concepts of eco-innovation and modernisation to defeat the "climate-laggard" and his approach after the election was considerable: creation of a Ministry of Climate Change and Water, the ratification of Kyoto and release of a green paper on climate policy. Nevertheless, political and sectoral realities of an energy-intensive economy in which the issue of carbon leakage remains central needs to be taken into account. Despite its large coal industry, Australia has initiated a number of strategies and established a number of progressive institutions in support of renewable energy development and climate mitigation. Renewable Energy Development Initiative was a programme launched in 2004 supporting renewable energy innovation and commercialisation. It provided grant funding up to A\$ 100 million in competitive grants to Australian businesses over seven years for research and development, proof-of-concept, and early-stage commercialisation projects with high commercial and greenhouse gas abatement potential.

The creation of a dedicated climate change department in 2008, tasked with developing and implementing the Carbon Pollution Reduction Scheme (CPRS), was a significant instance of institutional modernisation. Prime Minister Rudd appointed a "competent climate change minister" (Curran, 2015), Senator Penny Wong, who exercised direct oversight and 'ownership' of this policy area. The newly established Department of Climate Change had a wide-ranging modernisation role, among which, greenhouse gas emissions reduction (mitigation), climate change adaptation (adaptation) and contribution

to a global solution (international engagement). The new department also expanded the Mandated Renewable Energy Target (created during the Howard era but with a much smaller target), and created a number of regulatory bodies overseeing the Carbon Pollution Reduction Scheme, including the Australian Climate Change Regulatory Authority. Not unexpectedly, the key industry sectors directly impacted by the proposed Carbon Pollution Reduction Scheme showed great resistance. They demanded a framework that limited any negative impacts on industry and on the country's overriding economic growth goals. These key industry sectors, mostly coal miners, demonstrated their opposition through three main amendments to Rudd's since withdrawn emissions trading scheme: the setting of low emissions reduction targets ranging from 5 to 15 per cent; the issuing of extensive free permits to affected industries; and the establishment of complex and extensive compensation schemes for a wide range of industries (Curran, 2011). The Rudd government faced difficulties in managing constraining sectoral power relations of "modernisation losers". The trajectory of the first Rudd government's experience with climate policy led to the prime minister's removal because of sustained pressure from various industry networks, domestic political pressures and fragmenting party relations. The Gillard government followed, under which most significant climate policy development in the form of a carbon tax was legislated and implemented. The carbon tax was a demand of its minority government partner the Australian Greens. The tax did not survive the 2013 election, which returned a coalition government committed to 'axing the tax'.

The incoming Abbott government (2013) represented a significant break from the modernisation agenda of the past 25 years. The new paradigm was "Australia is open for business" facilitated by the government addressing red and green tape making supposedly business harder to thrive in Australia. Tony Abbott, famous for his speech "coal is good for humanity" (Interview, 2016) annulled past decisions and restructured institutions. The Abbott government created of a one-stop shop, streamlining environmental approval of major projects, such as mines and infrastructure projects. The approval rights were transferred to the states without the requirement for Commonwealth input into matters of national environmental significance, as originally designated by the EPBC Act's bilateral

provisions. The Abbott government has been particularly active with regard to climate policy. It has successfully abolished the Gillard government's carbon tax and affirmed his primary support for the coal industry (Massola et al. 2014). As a logical consequence, funding for environment-related agencies – such as the Bureau of Meteorology and the Commonwealth Scientific Industrial Research Organisation (CSIRO) were significantly reduced (Towell 2014; Interview, 2016). This trend at the national level was also mirrored at state level. The center-right, Liberal National Party government in Queensland proposed simplified development approval process to “speed – not impede – development” (Curran, 2015). The state of Queensland lobbied the Commonwealth to transfer more power to the state for environmental approvals: a “green tape” reduction programme with a view to accelerate development proposals, including those with potential impacts on the Great Barrier Reef Marine Park was initiated and legislative measures introduced by the previous government over the protection of wild rivers and the management of native vegetation were abolished. Moreover, a broad range of climate, solar and clean energy initiatives were taken back.

Not least because of the important role of coal mining in the Australian economy, climate policy has been a difficult one in national politics marked by many interruptions and ideological battles. For the first time, since the 2016 election, there is some continuity in the country's climate policy (Energetics, 2017). Continuity means in this context that the framework for emission reduction and climate change mitigation of the previous government, which is the Safeguard Mechanism, was not changed. Nevertheless, the government response to the Paris Agreement and governance of the national electricity market has fuelled a lot of criticism. The policy is being criticised as "not doing anything" with "frameworks but no implementation" (Interview, 2017).

Figure 15. The carbon tax years in Australia (Energetics, 2017)

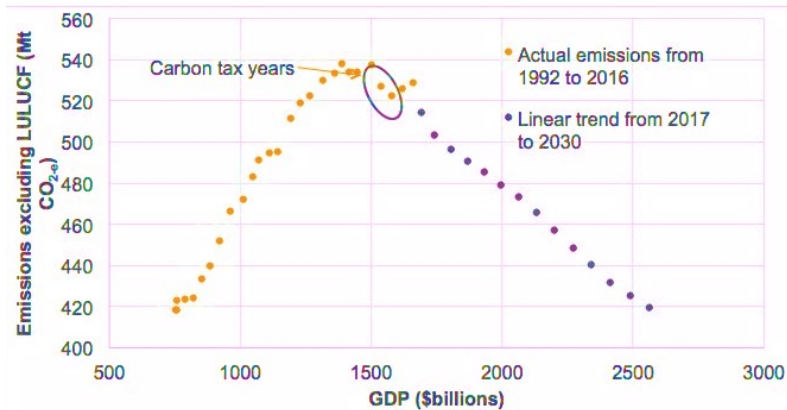


Figure 15 shows that the carbon tax years between 2012-2013 have been the most effective from an emission reduction point of view (OECD, 2019). It would have been an effective policy measure, if it would not have been abolished after two years (Energetics, 2017). The OECD highlights in its 2019 Environmental Performance Review Australia that overall progress in using economic instruments to internalise environmental costs as recommended in the performance review from 2007 “has been mixed” (OECD, 2019). Energy taxes do not reflect the climate costs of fuel, as fuel used to generate electricity benefit from full tax rebate while coal is not taxed at all. The same report asserts that “Australia is one of the few OECD countries taxing diesel and petrol at the same rate” – but diesel is less taxed on a carbon basis and road fuel taxes are “in the lower range among OECD countries” (ibid.). Such a framework is clearly not enabling the decarbonisation of the mining sector, which contributes to the explanation why Chile has made greater progress in that respect than Australia.

At the 21st Conference of Parties to the UNFCCC in Paris a 2015 a number of countries, including the world’s largest emitters such as China and India, agreed to establish a clear goal of limiting global temperature increase to below 2 Degrees Celsius, urging to limit the increase to 1.5 Degrees Celsius; establish binding commitments by all parties to make "nationally determined contributions" to emissions reductions and to pursue domestic measures to achieve them; commit to submit new contribution targets every 5 years, with the clear expectation that they will represent a progression beyond previous ones; extend current goal of mobilising 100 billion per year by 2020 through 2025 in support of developing countries responding to climate change with a new, higher goal to be set for

the period after 2025. Australia agreed to implement an economy-wide target to reduce GHG by 26-28 per cent below 2005 levels by 2030. The Safeguard Mechanism, which is the current government's response to climate change mitigation, started on 1 July 2016 and is administered by the Clean Energy Regulator through the existing National Greenhouse and Energy Reporting Act 2007 (NGER). The Safeguard Mechanism forms part of the Government's Emissions Reduction Fund (ERF) and has been designed to manage Australia's emissions. Specifically, the safeguard mechanism seeks to impose limits on large greenhouse gas emitting facilities to ensure that net so called scope 1 emissions are kept below a determined baseline. Scope 1 emissions are the emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level. They are sometimes referred to as direct emissions. Examples are: emissions produced from manufacturing processes, such as from the manufacture of cement, emissions from the burning of diesel fuel in trucks, fugitive emissions, such as methane emissions from coal mines, or, production of electricity by burning coal. If a facility exceeds its determined emissions baseline in any financial year, the Clean Energy Regulator has at its discretion a number of graduated enforcement options, which can be applied. As of March in the year following an excess emissions situation (i.e. a facility has exceeded its baseline), the Regulator may consider enforcement options as appropriate for a facility, ranging from issuing an infringement notice through to a civil penalty. Notably, responsible emitters are required to rectify an excess emissions situation, which occurs at a facility in order to comply with the safeguard mechanism. In exceptional circumstances, such as natural disasters or criminal activity being the cause of increased emissions, exemptions would apply (Department of Environment, 2017). The mechanism is being criticised as not being effective enough. Mining officials say that the benchmarks are so generous, taking the most polluting years of installations, that "it is almost impossible to emit that much again because technology has changed" (Interview, 2017). The federal renewable energy target of 20 per cent by 2020 is not sufficient for achieving the national greenhouse gas reduction target and it has not been revised yet, creating uncertainties for investors and the energy market (Energetics, 2017). Meeting the Paris goal will require enormous reduction of Australia's greenhouse gas emissions and a much steeper trajectory and more ambitious contributions. Much of Australia's fossil

fuels will need to remain safely in the ground (Pearman, 2016; McGlade and Ekins, 2015), posing a major challenge to the rational interests of government, such as economic growth and jobs; and businesses interests, i.e. fossil fuel production for domestic use and exports. It is still believed that coal will remain the backbone of Australia's, indeed the world's electricity supply for decades to come (The Australian, 2017). Therefore, like with previous governments, the most recent set of policies for tackling climate change are not far-reaching or effective enough while the influence of international institutions and agreements on domestic eco-innovation and environmental policies remains rather modest.

In its 2019 Environmental Performance Review on Australia, the OECD suggests that the country “needs to intensify efforts to reach its 2020 climate target” by “adopting an integrated energy and climate policy framework for 2030 with an emission reduction goal for the power sector” to avoid the projected rise in GHG emissions (OECD, 2019). The report identifies one major barrier to progress: lack of financing and weak coordination. It, thus, encourages state, territory and the federal governments to collaborate in order to address “data gaps, measure progress over time and identify priorities for action” (ibid.). Similar to the Paris Agreement, the 2030 Agenda for Sustainable Development has had almost no transformative effect on Australian policies. Australia's 2018 report on the implementation of the SDGs does not include a quantified, comprehensive evaluation of progress made or a timeline for implementation (ibid.). Moreover, Australia does not produce regular environmental expenditure accounts, limiting the country's efforts to well-intentioned lip service.

Unlike Australia, Chile does not have a long history of climate change policies. In fact, the Ministry of Environment was just established in 2010 with the accession to the OECD. Environmental policies have suffered a long legacy of neglect by the dictator regime (1973-1990). The transition to democracy has enabled the opening of the necessary political space for new environmental institutions and public discourse. After the Pinochet regime, democratisation provided an opportunity for a political discourse on environmental threats and concerns. With the rising environmental costs of Chile's

resource-based and export-led growth, climate change and environmental policies have become more important and high profile. Besides, domestic pressures, also international pressures have forced environmental issues into the national policy agenda (Carruthers, 2001).

Despite a brief history of climate change and environmental policies in Chile, today, climate change is one of the most important challenges the government intends to address (Interview, 2015). Greenhouse gas (GHG) emissions have continued to increase in line with economic growth and are projected to continue rising. The country is vulnerable to impacts of climate change: flooding, extreme heat and declining water availability. During the Paris Conference in 2015, Chile committed to reducing GHG emission intensity by 30 per cent by 2030 compared to the 2007 level, and by up to 45 per cent if sufficient international support is provided. Several energy market reforms have enabled rapid growth in renewable electricity generation without subsidies. Today, renewables cover nearly a third of Chile's total energy needs – fifth highest share in the OECD.

Chile put in place many of the elements required for an effective policy response to climate change. The 2005 Environmental Performance Review (OECD/ECLAC, 2005) recommended that Chile develop a strategy for addressing climate change, with a focus on energy efficiency and GHG mitigation. In line with this recommendation, Chile developed a climate change strategy in 2006 and the 2008-12 Climate Action Plan. Energy efficiency has been an increasingly prominent component of the government's energy strategy, alongside measures to encourage forestry and renewable energy. There is an energy efficiency target of 20 per cent by 2025. In 2009, Chile pledged to reduce GHG emissions by 20 per cent by 2020 compared to business as usual. It is likely to meet this target. In advance of the Paris climate change conference in December 2015, Chile submitted its Intended Nationally Determined Contribution (INDC) to complement its 2009 commitment. Chile commits to reducing GHG emissions per unit of GDP by 30 per cent relative to 2007 if economic growth is maintained at current rates; it has a separate target for forestry. This will be strengthened to 35-45 per cent if there is sufficient international financial support. The INDC is seen as more transparent than the 2009

pledge, but the use of conditions on growth and financing leaves some uncertainty about the strength of the commitment. Overall, the INDC should slow the increase in GHG emissions, rather than reducing them in absolute terms. By 2030, Chile is projected to have a GDP per capita similar to that of Spain and France now, but higher per capita emissions (OECD/ ECLAC 2016).

The overarching challenge is moving to an emission trajectory that is consistent with limiting global temperature rise well below 2°C, as indicated in the 2015 Paris Agreement. This will require Chile to develop measures to peak emissions as soon as possible and achieve more stringent emissions reductions thereafter. Chile will also need to avoid locking in emissions that will make future reductions more challenging to achieve.

Adaptation policy has taken shape with the release of the National Climate Change Adaptation Plan in 2014. This contains institutional reforms to improve horizontal and vertical co-ordination, as well as developing the evidence base for adaptation. Chile is developing sectoral adaptation plans to implement the national plan; those for biodiversity, forestry or aquaculture have already been completed. Two major challenges will need to be addressed to strengthen implementation of mitigation actions. The first is the need to further strengthen institutional arrangements for embedding climate change policy in government operations. Progress is being made, with an increasing number of ministries now having climate change focal points. The Office of Climate Change in the Ministry of Environment, overseen by the Council of Ministers for Sustainability, provides coordination. However, most responsibilities relevant to implementing climate policy lie outside of the environment ministry's remit. Implementation relies heavily upon voluntary engagement by, and sufficient capacity within, other ministries, resulting in delays in the delivery of information and variable implementation of climate change actions (OECD, 2016). The second major challenge is to ensure adequate and sustainable financing for the implementation of climate change policies, as Chile is still a developing country. The absence of sufficient and consistent funding was a barrier to action by ministries to implement the 2008-2012 Climate Action Plan (University of Chile et al.,

2015). International climate finance has been a major contributor to the development of climate measures to date, but Chile will likely no longer be eligible for overseas development assistance due to its increased level of income. Meeting climate goals will require efforts to broaden and strengthen the funding base: encouraging private sector investment or taking advantage of new international mechanisms such as the Green Climate Fund.

While Australia has taken back its effective policy, in January 2017, Chile introduced a tax on emissions of CO₂, PM, NO_x and sulphur dioxide (SO₂). Chile is the first country in Latin America to introduce a carbon tax (IEA, 2018). The tax affects approximately 100 facilities, particularly fossil fuel-based electricity plants. For CO₂ emissions, the tax rate has been set to 5 USD per ton of CO₂. The Ministry of Environment estimates the tax will address around 27 per cent of Chile's CO₂ emissions (Interview, 2017). CO₂ emissions of plants are measured as from 2017 and the tax is being charged in 2018. The tax intends to increase the costs faced by fossil fuel-based power generation, thereby encouraging the shift to low-carbon sources of electricity. The design of the system for auctioning long-term generation contracts, however, will shield some fossil-fuel power generators from the full costs of the tax. In addition, the CO₂ tax is designed to limit the costs to households and small businesses, which could reduce its effectiveness in encouraging more efficient consumption. While households are sheltered from increases in electricity prices, major industrial users, including the mining sector, are not. In 2013, for example, mining and quarrying used about 37 per cent of all electricity in Chile. These firms, however, will only be affected indirectly by the tax. Nevertheless, the introduction of a CO₂ tax is clearly a step in the right direction. The tax rate chosen, however, is low compared to most available estimates of monetary carbon values (Smith and Braathen, 2015). Hence, it could be desirable to apply a higher tax rate at the outset. A recent OECD survey of ex post analyses found that various carbon pricing mechanisms in use around the world had few, if any, impacts on sectoral competitiveness (Arlinghaus, 2015). In conclusion, despite remaining high levels of emissions, Chile has put a strategy in place, as an answer to the Paris Agreement, and made important reforms, which in the long-term should lead to emission reductions.

4.1.2. Trade and cooperation agreements

Chile is an open and export-oriented economy with numerous preferential trade agreements that have contributed to a three-fold increase in the value of trade since 2000, which reached almost 70 per cent of GDP in 2013. Until recently, the country has been also receiving overseas development assistance, which has stopped with the improving economic indicators, the ascendance from developing to emerging economy status and accession to the OECD in 2010. Ores and metals, mostly copper, and agricultural products dominate the export portfolio; main import products are fuels and manufactured goods. Chile attracts significant volumes of foreign direct investment (FDI); it received third largest amount in Latin America in 2014 (US\$ 20 billion) following Brazil and Mexico, and the largest relative to the size of its economy (8 per cent of GDP). Mining attracts nearly half of FDI, yet foreign investment has also been important for road and energy infrastructure development, sectors in which the government is keen to further promote FDI. Trade openness and integration into global markets allowed Chile to import environmentally friendly technologies that have helped reduce air and water pollution from industrial activity (OECD, 2016). Moreover, access to low-cost solar photovoltaic panels has helped Chile rapidly increase its renewable energy capacity as the country lacks domestic manufacturing capacity (*ibid.*). At the same time, with a large share of exports stemming from natural resource-based sectors, the opening of the economy has raised concerns about potential impacts of trade liberalisation on the natural resource base and the environment. Studies point to a reinforcement of environmental pressures through trade liberalisation due to greater production and exports, as well as scales of operation in sectors like mining, forestry, some agricultural activities and tourism (Borregaard, 2004; O’Ryan et al., 2010).

By mid-2015, Chile had concluded 24 trade agreements of which seventeen contain environmental provisions of varying scope and depth. The first trade agreement with environmental dimensions, concluded with Canada, the European Union and the United States, included strong environmental requirements, which Chile was willing to take on

in return for economic integration and access to new export markets. They involved obligations to promote high standards of environmental protection, to enforce environmental laws effectively and not to derogate such laws to attract investment. The negotiations of these trade agreements drove reforms, encouraging Chile to overhaul and codify its environmental legislation (OECD, 2007; OECD/ECLAC, 2005). Interviewed civil servants highlighted the push from international partners, specifically Canada and US, to include environmental protection and technological cooperation on eco-innovation clauses in their trade agreements, which were welcomed by the Chilean side due to the domestic interest in capacity development and knowledge transfer. Most agreements since the late 2000s include substantive environmental provisions in a dedicated environment article or chapter. Environmental provisions in trade agreements resulted in various cooperation projects. These included the Pollutant Release and Transfer Register (through the Chile-Canada and the Chile-US agreements), as well as various environment-related capacity building activities (OECD/ECLAC, 2005). Under the Chile-US agreement alone, 77 environmental collaboration activities have been carried out since 2005 (ibid.). Chilean officials stated that activities under trade agreement related instruments have helped strengthen institutional capacity and environmental management more generally. Chile has participated in extensive assessments of the environmental impacts of its trade agreement with the European Union and the United States, at the initiative of these partners. Similar exercises could be envisaged for agreements with emerging and developing economies, as they can help evaluate the effectiveness of environmental provisions in trade agreements. They can also help identify environmental pressures arising from expanding productive sectors, particularly those that cannot be identified through project-focused environmental impact assessments, and to formulate specific preventive or reactive actions. This, in turn, would likely increase public acceptance of trade agreements. Civil society has criticised environmental provisions in Chilean RTAs, or associated co-operation agreements, for being too general and lacking clear links to the implementation of trade and investment provisions. Criticism has also been raised with respect to insufficient co-ordination of policies and institutions; lack of specific action plans and concrete funds for public-sector

capacity building; and weak monitoring and reporting procedures, including little or no public involvement (George, 2011).

The European Commission undertook two ex-post analyses of the environmental provisions of the trade agreement with Chile. The first analysis found it has encouraged exporters in some industries to adopt higher environmental and social standards; this was due to larger trade volumes with European buyers who were putting increased pressure on exporters to demonstrate compliance. The second study also identified improvements in environmental standards and management practices, but cited numerous instances of continuing environmental deterioration in sectors where Chilean exports have risen. In both cases, however, the second study conceded it was difficult to distinguish the influence of the trade agreement from other factors. It concluded the trade agreement's negative impact on the environment seems marginal; higher environmental standards imposed through trade with the European Union (as well as United States, Canada and Japan) have helped reduce the pollution intensity of some sectors (George, 2013). In 2016 both the Ministry of the Environment of Chile's Metropolitan Region and the Ministry of Denmark signed a Memorandum of Understanding (MOU) that establishes the terms and mechanisms of cooperation between both countries regarding environmental matters. These matters concern waste management, recycling promotions, environmental audits, biking culture, responsible pet ownership promotions, among others. As for Mr. Mauricio Mena, Environmental Deputy Secretary, he points out that "Chile is moving forward towards a new green growth identity" (OECD, 2016). Germany, an important exporting country with a large manufacturing sector, yet, poor in primary raw materials, has partnered up with several resource-rich countries such as Argentina, Brazil, Chile, Peru or Mexico. The Federal Ministry of Education and Research (BMBF) introduced a formal Science and Technology Cooperation with Chile focusing on three thematic priority areas, namely, climate change and environment, resource efficiency and raw materials, biotechnology and life sciences. Chile has a scientific research and technological development cooperation with Germany since 1970, which was updated in 2012. The agreement resulted in the establishment of a German-Chilean Commission for the Cooperation in Science and Technology, which is meeting

every two years to discuss and develop projects on the priority areas. Besides cooperation in the field of science and technology, in 2013, the German government concluded a raw materials agreement and signing a Memorandum of Understanding between the Federal Ministry of Education and Research and the Chilean Ministry of Mines. Since then, the German ministry has funded 31 projects as of 2015. The German government specifically targets projects for the efficient and sustainable use of natural resources and green economy. The aim is to support and promote efficiency in supply-side countries, R&D along the value chain, scientific excellence via international cooperation and to safeguard the supply of raw materials for the German manufacturers. The Association of German Industries (BDI) ranked Chile among the 12 most interesting growth countries for the German economy. One project between Germany and Chile is on secondary mining of strategic elements from mining dumps at selected Chilean sites. The project is under the coordination of a German university, TU Bergakademie Freiberg. In view of Chile being a market leader in copper production, an important silver and gold exporter, mine dumps contain large strategic elements. The aim of the project is to determine the quantities and to develop concepts for the environmentally friendly storage of the residues (BMBF, 2015).

Green markets in Chile are expanding while the eco-innovation capacity is improving: openness of international trade and a favorable investment environment have eased the penetration of advanced environmental technology – this helped reducing industry’s environmental footprint and expanded solar and wind energy generation; domestic production capacity for green technology is still limited (OECD, 2016). Misun Park et al. (2017) define eco-innovation capacity based on four indicators representing government’s institutional support enabling the environment for eco-innovation, company responses towards regulations and support and mutual relationships in innovation: public R&D expenditure in green industry as well as the implementation of environmental regulations, the maturity of investment setting for green technology industry and investment scale of green technology SMEs (Misun Park et al. 2017). In Chile, the expenditure in research and development targeting the environment grew to 9 per cent of total R&D expenditure in 2012 – one of highest share in Latin America. The

number of patent applications in environment-related technologies increased almost twice as much as that in other domains (ibid.). In order to achieve security of supply, tackle the problem of high energy costs and ensure energy independence, the government has put a policy framework in place, which supports renewable energy and energy efficiency and gives certainty and guidance to investors and businesses. On eco-innovation, Chile demonstrates how to use businesses and especially the mining sector as a strategic anchor in its international relations in order to benefit from collaboration on research and investments. The country shows continuity in its policy decisions, e.g. strong commitment to renewable energy and the revision of the target; it does not have an incumbent sectoral player hindering the promotion and adoption of low-carbon energy; and it shows a great international alignment for eco-innovation.

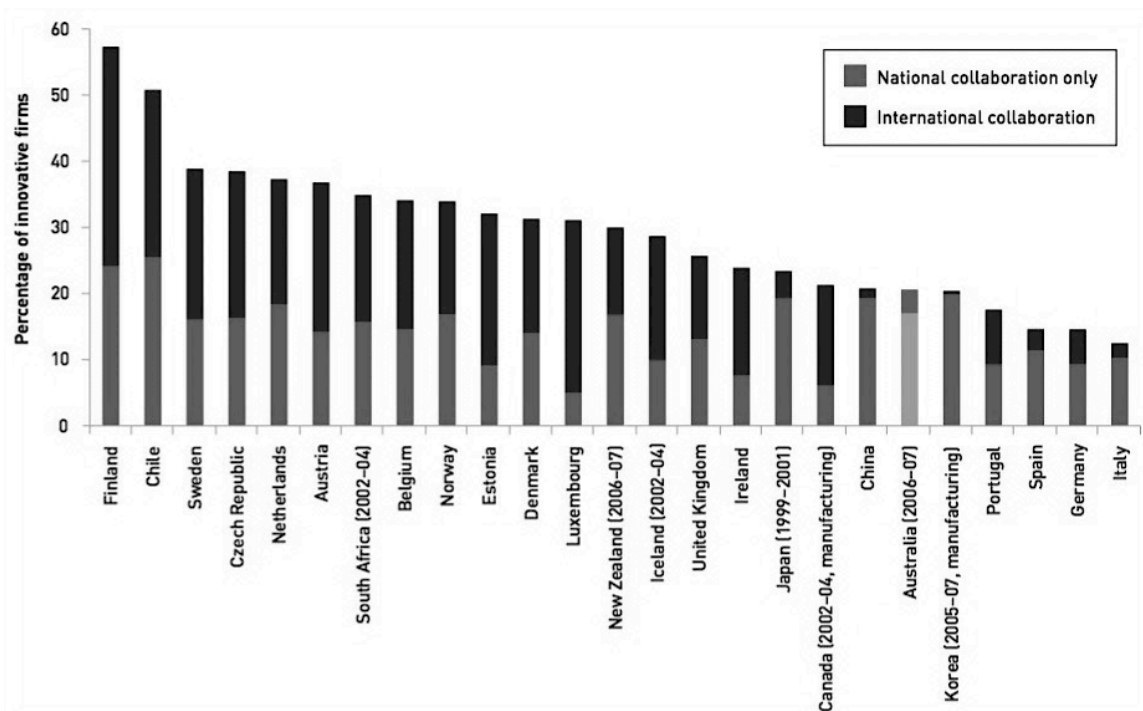
Australia has a number of regional free trade agreements. The one with Canada has a joint work programme on environmental matters. The annex identifies options to facilitate business development and business between the parties in the areas of priority interest, namely environmental technology and services including geosciences. Most of trade agreements Australia has signed include very general environmental provisions and its foreign trade and aid policy focuses mostly on developing small island states in the Pacific (OECD, 2019). The agreement with Chile contains several parts on the environment including cooperation in innovation and research and development. Areas of cooperation also include science, agriculture including the wine industry, food production and processing, mining, energy, environment, small and medium enterprises, tourism, education, labour, human capital development and cultural collaboration. The environment chapter establishes a new institution called the “Cooperation Committee” for the purpose of coordination and chairing the Institutionalised exchange. Both countries facilitate contacts between scientist and media, joint research programmes, dialogues, conferences and seminars. In fact, during the interviews, many government organisations highlighted the steady and effective exchange of information and cooperation with their Chilean counterparts, especially in the field of mining and environment, whereas in many areas Australian authorities are disconnected from the rest of the world in environmental matters (Interview, 2016, 2017).

This disconnection becomes also evident in other areas of multi- or bilateral cooperation. For instance, the “Policy Dialogue on Natural Resource-based Development” is an initiative that offers an inter-governmental platform for peer learning and knowledge sharing to improve understanding around the implications and impact of policy options in resource-rich countries. OECD and non-OECD mineral, oil and gas producing countries, in consultation with extractive industries, civil society organisations and think tanks, work together to craft innovative, collaborative and mutually beneficial solutions for natural resource governance and development (OECD, 2016). The initiative aims at addressing common challenges such as the lack of mutual trust, asymmetry of information and insufficient collaboration and co-ordination among all actors involved creating major barriers to value creation. The initiative wants to enhance the understanding of how different stakeholders can work together and leverage the extractives sector to catalyse long-term, competitive, diversified and, sustainable development. In 2015, a multi-stakeholder drafting committee established consisting of Liberia and Norway as co-chairs, Germany, Switzerland, South Africa, the African Union Commission, Anglo American, Antofagasta Minerals, the Chilean Mining Council, the Columbia Center on Sustainable Investment, Eni, Exxon Mobil, the International Council on Mining and Metals (ICMM), the International Petroleum Industry Environmental Conservation Association (IPIECA), Shell, Social Clarity, Total and UNDP was established without the participation of a single Australian stakeholder neither from the public sector nor from the private – despite the fact that Australia is a traditional mining country and one of the oldest OECD members. In an interview an OECD official highlighted the fact that the Australian government was invited to participate but that the invitation was declined due to cost concerns and geographic distance (Interview, 2017). The OECD would be a useful platform to learn from others and to share experience.

Compared with Chile, Australia also has a low share of international collaboration on innovation between 2004 and 2006 as a percentage of innovative firms. In Australia, mining is the sector that collaborated most with universities and other higher education institutions. 60 per cent of large innovation-active mining companies registered

cooperations with universities. The Australian Government supported international collaboration through the International Science Linkages (ISL) Programme and the Australia-India Strategic Research Fund (AISRF). These programmes provided an important platform for international collaborative research at government-to- government and researcher-to-researcher level. In 2008 and 2009, ISL supported 576 international collaborative activities, including research projects with China, France, the USA, Singapore, Brazil, Germany, the UK and Japan.

Figure 16. Firms with national/ international collaboration on innovation between 2004 and 2006 as a % of innovative firms (Australian Innovation System Report, 2011)



It is striking that Australian firms have a lower share of international cooperation, while Chile is among the best performers. In 2009, Chile launched a call for the establishment of International Centres of Excellence (ICEs) in the country. ICEs are joint R&D institutions, bringing together cutting-edge international players with local partners. Their aim was to facilitate easier access to international resources, skills and technology, while promoting a local environment for innovation, building local skills and strengthening links between research and Chilean businesses (OECD/ECLAC, 2016). By early 2015, 13

ICEs had been established, including for activities related to green growth. The German Fraunhofer Institute, for example, jointly operates the Centre for Solar Energy Technologies with the Catholic University of Santiago. It was inaugurated in May 2015. Supported by CORFO with US\$ 12 million over eight years, the centre will conduct applied research on solar electricity generation, solar heat for industrial use and solar water treatment; test high radiation solar technologies; and provide quality assurance (i.e. standards and certification). The Chilean government also approved an ICE on marine energy in mid-2015, with the French-based DCNS Group and several Chilean institutions as executing partners. With US\$ 13 million of co-financing from the Chilean Economic Development Agency (CORFO), the project is expected to be funded with US\$ 20 million over eight years.

To conclude, the global climate change agreement and trade and cooperation agreements have unfolded eco-innovation effects in terms of policy and practice in Chile, which has led to the country undertaking a rapid catch up in international collaborations on eco-innovation. This has been partly driven by international actors, whose economic interests are well aligned with those of domestic players. Chile capitalises on its renewable energy potential using the global decarbonisation agenda to its advantage by facilitating access to finance and mobilising foreign investment. This can be seen in line with rational choice institutionalisms in terms of convergence of preferences between the domestic level and the international one. In contrast, Australia lacks continuity and determination in political will to transform its policies based on an active participation at the global level, seeking alliances with actors with whom win-win situation could be created in terms of creating new business models and achieving access to finance for the transition. From a rational choice perspective the reasons stem from existing domestic vested interests pulling in one direction, hindering at the same time justified interests to cope with climate change impacts and develop innovations.

4.2. Domestic policy and institutional framework

As discussed in the analytical framework, one important causal mechanism for strong eco-innovation outcomes could be a robust policy framework based on inter-institutional coordination, consistency and continuity, which reduces uncertainty and supports investments in eco-innovation. Strong institutions supported by horizontal coordination across government and introducing consistent policy roadmaps create a level playing field for private sector actors making cost and risk calculations more predictable, reducing transaction and influence costs, thus incentivising investments for eco-innovation. The following section contrasts the different policy and institutional frameworks of Australia and Chile, highlighting the lack of clear coordination in energy, climate and water policy in Australia, as one possible reason for the less promising eco-innovation policy outcomes – compared to Chile, which has several horizontal coordination mechanisms, contributing to policy certainty, consistency and coherence.

In Australia, the main horizontal coordination mechanism for environmental policies is the Council of Australian Governments (CoAG), which was established for the review of Commonwealth-state roles and responsibilities, paving the way for the incoming review of national environmental legislation, which would culminate in the Environment Protection and Biodiversity Conservation (EPBC) Act 1999, which is until today the primary environmental legislation in Australia. The government created with A\$ 1.25 billion a Natural Heritage Trust, which was an ambitious programme dedicated to the conservation and restoration of Australia's natural resources. In 1999, the government introduced one major environmental reform which was the EPBC Act, following three main goals: define clearly state powers over the environment in terms of jurisdiction; embed sustainable development principles in environmental management practices; and promote efficiency and certainty in Australian environmental legislation. The government emphasised that EPBC would “promote, not impede, ecologically sustainable development”, and that it would “include express recognition of the precautionary principle and the other principles of ecologically sustainable development” in environmental decision-making (CoA 1998). However, the legislation was contentious from the beginning. It defined the role of the federal government in environmental assessment.

Environmental protection is a Commonwealth concern, while “biodiversity is of special concern”, which is reflected in the EPBC Act (Interview, 2016). Only matters of national environmental significance are regulated at Commonwealth level, i.e. waters or land. The development of coal seam gas, an unconventional natural gas sourced from coal deposits, has become political and controversial because of potential damages to the environment, e.g. the contamination of surface water but also underground aquifers through hydraulic fracturing, creating some exceptions for Commonwealth intervention. Even though water is state competence, in the case of coal seam gas “water trigger” applies, which means that water issues in the context of coal seam gas are dealt with at the Commonwealth level. The EPBC Act, which is Australia’s only national environmental law, describes water resources as a matter of national environmental significance in relation to coal seam gas and large coal mining developments. This means that coal seam gas and large coal mining projects require federal assessment and approval if they are likely to have a significant impact on water resources. The EPBC Act was amended in June 2013 to provide that water resources are a matter of national environmental significance in relation to coal projects. The “water trigger” amendment was introduced to guarantee proper scrutiny and to control inter-state competition and a race to the bottom. The amendment commenced on 22 June 2013 and allows the impacts of proposed coal seam gas and large coal mining developments on water resources to be comprehensively assessed at a national level. An independent review of the water trigger must be carried out. The independent review also serves as the post-implementation review, a requirement of Australian Government policy, as set out by the Office of Best Practice Regulation (OBPR) guidelines (Interview, 2016).

Rosemary Crowley, a Labour senator commented in 2002 on the EPBC, saying: "With this legislation, Australian environmental policy seems to have completed a full circle. It arose from a barely recognised area of state jurisdiction in the late 1960 and 1970s to a national-level political and policy prominence in the 80s. It faltered at this level in the early 1990s, and now has been devolved, and is probably in decline, back to a largely state-level responsibility". Several scholars argue that the delegation of major

environmental responsibilities to the state level represented a decline in standards (Economou, 1999; McIntosh and Wilkinson, 2005).

Water governance is a “multi-jurisdiction” policy field, which creates challenges due to the lack of coordination. Water governance in Australia is market-based and decentralised. States and territories are in charge of the sustainable management of water resources within their jurisdictions. According to the Australian constitution, “the Commonwealth shall not, by any law or regulation of trade or commerce, abridge the rights of a State of the residents therein to the reasonable use of waters of rivers for conservation or irrigation.” States have almost the exclusive competence over water governance and management, being primarily responsible for the allocation of water licenses. The states in Australia granting licenses for the use of water in mining projects do not require companies to prove the efficient use of water. The only requirement is to demonstrate that the mining site is uses the amount it has paid for (Interview 2016). Companies pay for the license, which determines how much they use. If they require more they need to purchase a new license and pay for the additional volumes required including the administrative costs. The overarching framework, enhancing cooperation and coordination across the country was the 2004 National Water Initiative. This initiative resulted in the 2007 Water Act, which strengthened nationally consistent water policy. One of the major aims was to protect the environmental and economic value of surface waters and groundwater in the Murray-Darling-Basin, where many mining and agricultural activities are located. Progress has been made under the National Water Initiative but not followed-up upon. The Water Act was repealed and the National Water Commission linked to it was abolished. The National Water Commission played an important role in the monitoring and auditing of the water reform policy implementation and management nationally since the National Water Initiative was agreed to more than a decade ago. The standing councils created a good opportunity to meet informally to discuss water and environmental challenges during the Council of Ministers and address policy inconsistencies. Yet, there was no official reporting to Council of Australian Governments (CoAG). The 2014 National Water Commission, leading the water reform, was abolished and the sustainable use of water and coordination at the federal level

“disappeared from policy” leading to "backward outcomes" (Interview, 2016). Australia is a dry continent with concrete water supply risks, it needs a coherent, robust, long-term water strategy supported across all states and territories as well as parties. The major impediment for a more sustainable water governance based on inter-state cooperation is the lack of political will, “the politics of it” (Interview, 2016), i.e. the economic reliance on mining and agriculture revenues and competition between the states. In the particular case of South Australia, which has a copper mining target within its economic development strategy, “water is a big constraint for growth”. BHP Billiton is the largest single consumer of water and energy as an individual company due to the Olympic Dam mine project. Yet, that project makes up 70 per cent state revenue (Interview, 2016). There is no water use reduction target in any state despite availability constraints. There is no state policy to incentivise the use of desalination as a potential solution to move away from groundwater use. Due to conflicts with communities and low levels of water availability for big projects like the Olympic Dam mining project, the owner BHP decided to build a desalination plant at its own initiative. The Olympic Dam mine is a large poly-metallic underground mine located in South Australia. It is the fourth largest copper deposit and the largest known single deposit of uranium in the world, although copper is the largest contributor to total revenue.

Almost all states have put in place long-term water rights for consumption. The existing water allocation frameworks allow water to be traded to high-value users, which structurally favours the mining sector over other users (Kiem, 2013). The Minerals Council of Australia, an industry association of mining companies, criticises in its submission on the water use by the extractive industry to the Senate Environment and Communications References Committee (19 January 2018) the legislative amendments to the EPBC Act, giving more powers to the federal level in the approval of water use, particularly with regard to large-scale coal mine and coal seam gas developments. The industry is against the Commonwealth government assuming a stronger role in environmental legislation and calls on the Senate to remove the recently adopted amendments. Industry is often pro deregulation and more self-responsibility, which supports the assertion that the delegation of environmental responsibilities to the state

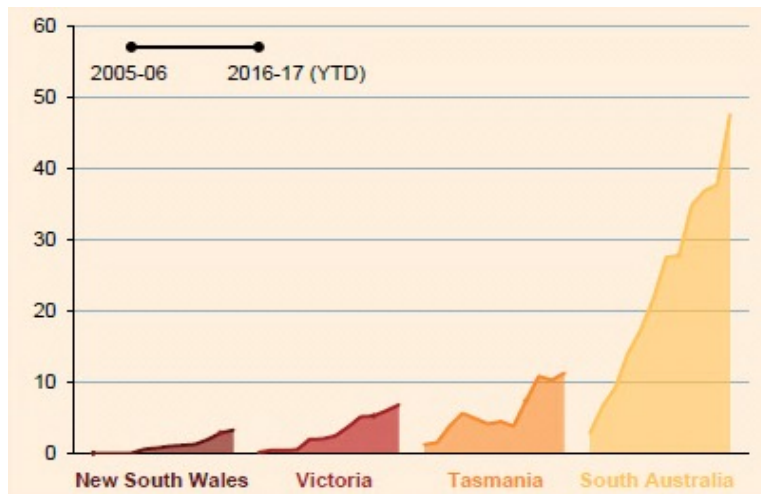
level usually results in a decline of environmental standards and monitoring. The industry criticises the assumption of a greater role by the Commonwealth government as a source of duplication and confusion of responsibilities, while highlighting its relatively small share in overall water consumption vis-à-vis the agricultural sector. While mining consumed between 2015-2016 3.7 per cent of the total water consumed in Australia, agriculture (including fishery and forestry) consumed about 58 per cent water in the same years (Minerals Council of Australia, 2018). In addition, an argument that reoccurs in the discourse of water use in mining is the high economic value-add per unit of water consumption. While the minerals industry generates between A\$ 111 and 127 million of gross value-add per water consumed water unit, agriculture does only generate A\$ 4 million (ibid.). State authorities that were interviewed have also repeated this argument. Due to the relatively lower share of water consumption by the industry and the high economic value add per water used, state authorities do not impose any additional sustainable water use requirements going beyond the rule of paying for the water is being consumed based on acquired water use licenses (Interview, 2016). Also according to the assessments of the Australian Bureau of Statistics, agriculture appears as the largest consumer of water in Australia (Australian, Bureau of Statistics, 2016). In Western Australia, agriculture accounted for over one third (36 per cent) followed by households (24 per cent) and mining (12 per cent). Overall, mining accounts for 2 per cent of total water use in entire Australia (Department of Environment, 2004). Water is not really an environmental concern in relation to mining – “never heard – while agriculture gets a lot of criticism - the debate on the sustainable use of water in Australia is focused on agriculture not mining” (Interview, 2016).

The industry association refers to the fact that water poses a security of supply risk for the business, while not mentioning concrete numbers or measures on supposedly “increased savings and re-use” rates. The same document mentions “research and development of innovative water management strategies (...) significant investment in development and application of new technologies” but it does not give any concrete information or numbers as it does on, for instance, the “economic value-add” of the sector or the overall contribution of the minerals sector to Australia’s GDP, i.e. 6 per cent between 2016-

2017, making it the “fourth largest contributor to the national economy” (Minerals Council of Australia, 2018).

Another important area of “multi-jurisdiction”, creating challenges, is energy governance. In Australia, each state has a different renewable energy target in place exacerbating investor uncertainty, discontinuity and incoherence. New South Wales (NSW) has put public funds in place to support the development of renewable energy to achieve its net zero emissions goal. NSW sources less than 9 per cent of its electricity from renewable energy, half that of Victoria and a quarter of South Australia. West Australia does not have a target. Queensland has a target "but not clear what it is" (Interview, 2017). As a result, as shown in figure 17, the share of renewable energy, here illustrated based on wind energy, differs significantly across the country’s different states.

Figure 17. Share of wind energy in Australia (Wood et al. 2017)



Due to the lack of coordination and long-term strategy, the country's national electricity market faces several challenges (Wood et al. 2017). Even though the federal renewable energy target has supported investment in renewable energy, the 2020 target is because of its short-term focus a source of concern and uncertainty. Investors do not know how each state will support renewable energy in the future and how this might affect investment in the national energy market in a broader sense (Wood et al. 2017; Energetics, 2017). These contribute to the weakening of price signals and uncoordinated government

policies make it very difficult for the markets in terms of predictability. Government policies cause confusion for many reasons. Different states have different targets with different time frames. It is unclear which new support schemes, if any, will be introduced at state and/ or federal level. The government fails “to properly integrate climate and energy policies” (Wood et al. 2017). The electricity sector's contribution to the country's total emissions is 35 per cent. However, current policies lack any effective binding limits on emissions in the power sector and are certainly not linked to Australia’s emissions reduction targets.

The Productivity Commission noted in 2013 that governance arrangements in the National Electricity Markets “are neither efficient nor effective in achieving good outcomes for consumers” (Productivity Commission, 2013). A review of governance in 2015 identified “a strategic policy deficit”, which has led to diminished clarity, coherence and coordination (Vertigan et al. 2015). The Council of Australian Governments' Energy Council is responsible for driving effective market reforms. The review found that the Council and the senior committee officials were lacking effective policy leadership in the energy sector (Wood et al. 2017). The Council of Australian Governments (COAG) Energy Council has to identify the main challenges and focus on the core issues. The Australian Energy Market Commission (AEMC), the rule maker for Australian electricity and gas markets, suggests that after problem definition, it takes too long until the ministers sitting in the Energy Council take these into consideration. The COAG Energy Council could enhance coordination across different states and the federal government to develop a better enabling policy framework, addressing challenges in the energy market more effectively (Wood et al. 2017; Interview, 2016, 2017). Finally, in its 2019 Environmental Performance Review the OECD also stresses the need to “improve coordination and alignment of renewable support programmes across states and territories” along with the development of interconnections among regions and better coordination and planning of grid infrastructure and the geographically balanced deployment of renewables (OECD, 2019).

In conclusion, this research underlines the challenge of “multi-jurisdiction cooperation” as the main impediment for progress in environmental policy, in line with the OECD’s more general findings. The only formal horizontal coordination body on environmental policy is the Natural Heritage Ministerial Boards, consisting of ministers of the environmental and agriculture. Australia should consider strengthening federal horizontal coordination by setting up a coordination mechanism including climate change, energy and water issues to avoid overlap across the country (OECD, 2019). Australia needs to harmonise and streamline regulations in order to address overlaps and existing gaps in legislation. Enhancing vertical coordination mechanisms is an important part of the OECD Council Recommendation on Effective Public Investment across Levels of Government. In its 2007 Environmental Performance Review on Australia, the OECD recommended again the need to strengthen coordination and cooperation across the country. Yet, progress has been rather limited across different policy areas including climate change, energy and water policies. From a rational choice institutionalism point of view, the absence of a consistent, clear policy and regulatory framework due to the lack of horizontal coordination and collaboration towards the common goal of addressing environmental challenges creates loopholes in the system and a lack of exogenous factors conditioning and guiding private actor decisions. A clear policy and regulatory framework that applies to all companies would create same opportunities, such as equal access to financial support, equal obligations to comply with policy objectives and targets, creating ultimately a level playing field minimising first mover risks and investor uncertainty.

Chile, on the other hand, has a four-tier government system comprising the national level, 15 regions, 53 provinces and 345 municipalities but a functioning horizontal coordination mechanism. Regional and provincial administrations, which depend on the presidency, function as branches of the national government. While they have some territorial planning responsibilities, they play a minor role in environmental management. Chile’s institutional framework for environmental governance has undergone significant changes. The 2010 Environmental Quality Law replaced the National Environmental Commission (CONAMA) with now three institutions that have distinct policy-making, environmental

assessment and compliance assurance responsibilities to raise the profile and capacity of each of these important functions. The Ministry of Environment is responsible for policy design, regulatory drafting and information management in all environmental domains and has a strong regional presence. The Environmental Assessment Service is a decentralised technical agency under the Ministry of Environment, based at the regional level, in charge of administering the System of Environmental Impact Assessment, including an information system on environmental permits. The Environmental Superintendence (SMA) is in charge of compliance monitoring and enforcement with respect to activities and projects that are subject to the System of Environmental Impact Assessment or covered by Pollution Prevention and Decontamination Plans, environmental quality or emission standards.

The Council of Ministers for Sustainability, established in 2010, is the main horizontal coordination mechanism. It advises the president on sectoral policies, including draft laws and regulations that concern the environment. It is chaired by the Minister of Environment and comprises Ministers of Agriculture, Finance, Health, Economy, Development and Tourism, Energy, Public Works, Housing and Urban Development, Transport and Telecommunications, Mining and Social Development. There are a number of issue-specific coordination committees at the national and, sometimes, regional level. For example, the Committee on Sustainable Consumption and Production under the Ministry of Environment develops a national programme on these issues. It is made up of over 50 professionals representing 18 public institutions. The Ministry of Environment chairs the Inter-institutional Committee on Environmental Information, which includes representatives of about 50 public agencies and services. Created in 2012, it establishes guidelines and procedures for the collection and management of environmental information, and validates information provided by various public institutions (OECD, 2016).

The difficulty in obtaining fresh water rights, arid conditions in mining areas and continuing drought-conditions, including increasing social conflict in relation to water issues has resulted in mining companies maximising water recycling and re-use in recent

years. As in Australia, the agricultural sector is the main user of water with withdrawals of about 73 per cent, while mining and industrial use has a share of 21 per cent. At the national level, irrigation accounts for most of the water consumption except for the northern part of the country because of the extreme arid conditions. In the northern regions of Antofagasta and Atacama mining accounts for the largest share of water consumption. The Chilean Copper Commission (Cochilco) predicts that despite the industry maintaining its current efficiency path, water use in the mining sector will increase. Therefore, in relative terms, mining is expected to use more water in Chile, while generating at the same time half of Chilean exports. However, since most of the mining activities are concentrated in the dry northern part of the country, even relatively modest water demands put pressure on the regional and national water balance. For this reason, the mining industry has to and has had to invest and innovate to reduce significantly pressure on water use. The lack of water availability has held back many companies in investing in further extraction, particularly lithium and copper miners, not at least to avoid tensions with local communities over water for drinking or sanitation. Since mining operations generate high water demand in Chile's very dry areas where freshwater is no longer available in big quantities, the sector has developed new alternatives. The use of seawater and desalination plants has increased in the past years with significant investments underway. Senior officials in the government highlighted during an interview that the Ministry of Economy is engaged in easing administrative requirements and reducing red tape to improve project assessment and increase investments in water infrastructure. The ministry identified a list of projects that had some troubles in the investment process in order to speed it up. One official underlined though that this does not mean that the "project would jump some legal, social and environmental requirements" but the procedure is applied is a fast track procedure eliminating further requirements going beyond the absolute necessary (Interview, 2018).

Mining operations in Chile are subject to a Strategic Environmental Impact Assessment (SEA/EIA) and are required to conduct an environmental impact assessment study - upon approval, the authority issues a resolution rejecting or approving a project. The project is then authorised to acquire all the other specific permits and authorisations, including in

relation to water. The environmental authority has 60 business days (up to 90 days) to issue a decision, in practice it can take considerably longer (Interview, 2015). The relevant environmental qualification resolution must be obtained before a water right can be applied for. In addition, pending legislation requiring mines to source all their water requirements from the sea has further incentivised mines to minimise their water footprint, which has influenced the industry to act before the legislation (Interview, 2017). The Superintendence of the Environment (SMA) monitors a mining operation's water quality to ensure compliance with legislation. Mining companies are required to self-report on any infringement of environmental regulations to the SMA and are incentivised to do so as SMA may then exempt or reduce the quantum of the fee to be paid. Mining companies are required to file a closure plan for approval by the National Geology and Mining Service (Sernageomin) before mining operations begin. The environmental aspects of the plan will also be evaluated and either approved or rejected during the environmental assessment of a mining project. The 2012 Mine Closure Law required all new mines to get approval for end-of-life closure plans, and more than 1300 such plans were presented to Sernageomin in 2012-13. However, the Mine Closure Law does not apply to existing abandoned mining sites, for which decontamination plans are yet to be developed. The closure plan for new mine sites must be accompanied by a technical report issued by an expert that includes information about: national monuments and archaeological sites; a financial assessment of the cost of mine closure and post-closure, amount of financial assurances to be provided, a community consultation plan, once the mine closure plan has been approved by Sernageomin, it is audited by external auditors, in addition, the closure plan must be audited every five years - financial assurance must be provided to cover the costs of implementing and monitoring closure plan, tailings dam must be shut and the chemical balance of the land restored. The fact that tailings are not allowed for new mining projects incentivises the reduction water consumption in mining processing as there will be no space to store contaminated water. In Chile decision are made mostly in the capital or are made based on horizontal coordination across the regions, creating a level playing field and same obligations for all companies, operating across the country.

There is horizontal coordination across the government and a strong culture of cooperation with the private sector, which is important for eco-innovation in terms of policy consistency and coherence – and non-existent in Australia. Last year in Chile, the government changed but the country's clean energy strategy has not been changed. As the IEA notes in its 2018 report, the ability of the previous government to achieve cross-party consensus and bipartisan support for the energy strategy 2050 has been a major achievement to ensure the adoption of a long-term energy strategy, providing certainty to the market and investors: “A major achievement of the government has been to develop a long-term energy policy for 2050. The Ministry of Energy was put in charge of the planning process, organising nation-wide public consultations, which provided the input for the strategy. The Chilean public was consulted on a broad basis for the first time and the exercise has become an internationally outstanding example for public consultations on energy policy” (IEA, 2018). The strategy document launched by the previous government in 2015 defines four key pillars of energy policy: 1. The quality and security of supply; 2. Energy as a driving force for development; 3. Environment-friendly energy; and 4. Energy efficiency and energy reduction – setting targets for the mid-term 2035 and long-term 2050. The individual 20 per cent target by 2025 set for companies in 2013 was met eight years ahead of time in 2017.

In order to achieve consistency with its international climate commitments, Chile intends to align its energy strategy with emission reduction goals and thresholds. The third principle relates to access to modern, reliable and affordable energy for everyone. In terms of policy coherence, regional and territorial plans as well as land-use instruments should be consistent with the country's energy policy. Being energy dependent, the government wants to achieve price competitiveness and lowest average residential and industrial energy prices and be among the top three among OECD countries. Principle six sets the revised renewable energy target of 70 per cent. 70 per cent of the electricity generated in Chile should come from renewable energy sources. This means that Chile want to achieve a high degree of self-sufficiency and independence from energy imports. The interim target for 2035 is 60 per cent. The 2035 strategy, which represents an interim phase for the longer term 2050 strategy, highlights that Chile wants to reduce its

greenhouse gas emissions by 30 per cent by 2030, mainstream energy efficiency at an industrial scale, targeting specifically transportation and mining and incorporating it into the evaluation process in all tenders for new vehicles and public transportation systems. In line with OECD green growth standards and recommendations, Chile plans to achieve a decoupling of growth of energy consumption from GDP growth, which is currently very much coupled – especially during the times of commodity boom. The higher the GDP growth was, the higher was the growth of energy consumption. There is another reference to the OECD under principle eight, which says that 100 per cent of new buildings should meet OECD standards of efficient construction with intelligent energy control and management systems (IEA, 2018; Government of Chile, 2015). Several clear reference to OECD standards show that Chile aspires to comply with international guidance and benchmarks and global and regional leader in the deployment of clean energy solutions. In 2016, renewable energy accounted for nearly 40 per cent of electricity generated. Geopolitical concerns also play an important role in this trend, which contributed to the alignment of interests (Interview, 2017). Domestic production of fossil fuels is limited, with the majority of the demand being met through imports. Bolivia refuses to sell natural gas to Chile because of an existing border dispute dating back to the 19th century. Similarly, in 2004 Argentina began to steadily cut natural gas exports to neighboring Chile, triggering a major energy crisis (Interview, 2015). In response to Argentina’s export restrictions on natural gas in 2007, Chile has initiated efforts to reduce its dependence on fossil fuel imports and tap into domestic renewable energy sources. Chile imports most oil, natural gas and coal, a situation, which makes the country vulnerable to price volatility and supply interruptions. Energy security remains, therefore, high on the policy agenda. The geographical conditions are suitable, as Northern Chile has the highest solar occurrence in the world or hydropower is the main renewable source for electricity generation, especially in central Chile (Government of Chile, 2015).

Another economic interest, i.e. energy prices, competitiveness concerns, around which different parties and the private sector have aligned themselves, is the aim of entering global green value chains (Interview, 2018). Chile’s solar energy potential coincides with

its metals and minerals in the Atacama Desert – 30 per cent of global copper reserves and significant non-metallic mineral reserves, including lithium, making the mining sector an important supplier for renewable energy technology and consumer of energy – with copper industry alone consuming around 30 per cent of electricity generated. Resource-rich countries have been emphasising the importance of downstream value addition. Economic diversification and value addition is often one of the key policy objectives. Yet, industry strategies and government policies on climate change need to be better aligned with policies to promote local value creation. One of the key economic objectives for minerals producing countries therefore needs to be the use of their strategic mineral endowments to create local value-added activities, by entering new, green value chains and by adapting cutting-edge technologies locally. Chile adopted a strategic approach to using its lithium reserves to fund low-carbon technology research and development, such as electro mobility, as one example of lithium-based value added products, solar energy and low emission mining. Building on its strategic resources and geographical conditions, in its two exploration contracts with international companies exploiting lithium, Chile has included a clause to fund research and development over the next ten years, conducted by a consortium of universities, local firms and global companies. The aim is to move to an economic model with higher diversification and sophistication as well as environmental sustainability by linking knowledge and technology transfer to resource exploitation.

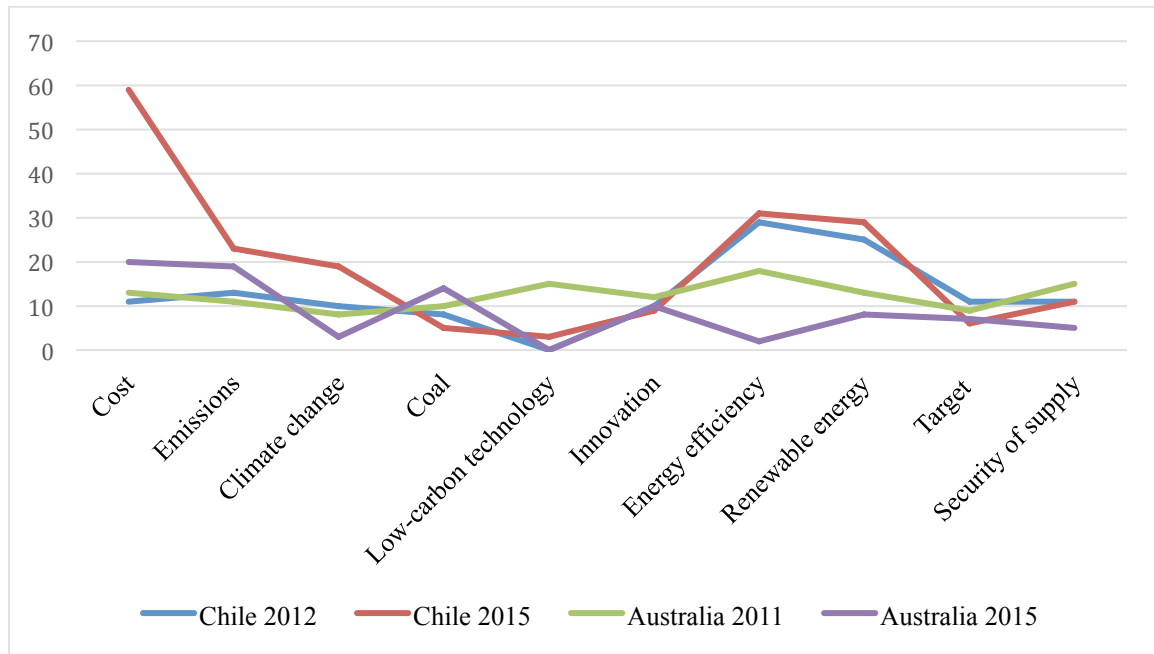
An important factor in support of the development of the renewable energy sector is Chile's enabling policy environment, which sends a strong signal to investors (Alova, 2018). Chile has a de-regulated electricity market, following restructuring reforms in the 1980s. More recently, the government has developed Chile Transforma, a series of strategic programmes aiming to improve productivity of strategic sectors, including mining, and promote innovation, technology adoption and solar energy integration. Unlike Australia, under this framework, Chile has developed a mining technology roadmap 2035 through public-private collaboration based on foresight and industry participation, which explicitly calls for the greater use of renewable energy by companies (Government of Chile, 2015).

Finally, Chile has addressed a significant infrastructure challenge – its national grid expansion had fallen behind renewable energy growth, leading to transmission congestion in the Central Interconnected System (SIC) grid. The grid overcapacity in the northern SIC put downward pressure on the spot market, reducing prices for generator companies up to zero per MWh during daytime hours when solar power generation is at its peak. As a result, the further development of the renewable energy sector was at risk, since low spot market prices had an adverse impact on the bankability of renewable energy projects, increasing their capital costs. To overcome the overcapacity challenges, in 2017 Chile's National Electricity Coordinator (CEN) completed a major infrastructure project to connect SIC with the Great Northern Interconnected System (SING) in the north of the country that services a large share of industrial activities, in particular the mining sector (Alova, 2018). The further successful development of the Chilean renewable energy sector will depend on continued technological advancement, including storage solutions, regional inter-connection with neighbouring countries and effective energy demand management.

In order to illustrate the different trends in energy policy the following section compares Australia's energy strategy with the Chilean energy strategy. For the purpose of comparison, the Chilean National Energy Strategy 2012-2030 (2012), Chilean the Energy 2050 strategy (2015), the Australian Draft Energy White Paper - Strengthening the foundations for Australia's energy future (2011) and the Australian Energy White Paper (2015) were analysed. The same energy codes applied to the sustainability reports of the three mining companies were also applied here. The code "renewable energy" includes solar, wind, and hydro. In the Chilean strategy for 2050 innovation is mentioned in relation to energy efficiency technologies, which is a key theme with a word frequency of more than 30 per cent among all identified codes. Comparing the past and current energy strategy of Chile, it is striking that the issue of cost has become more dominant and important over the past three years. Energy efficiency was also among the top issue in the previous report, but has gained more emphasis in the current strategy. Renewable energy, emissions and climate change have gained more importance, while the frequency of target has dropped. The target has bipartisan support in the country and is a continuation

of the logic from three years ago, that Chile as to reduce dependence of fossil fuel imports and contribute to security of supply. Concerns over dependence and security of supply are the major drivers of public policies supporting renewable energy.

Figure 18. Australia and Chile's energy strategies: Energy codes in comparison



In the Chilean energy strategy paper 2050, low-carbon technology is clearly mentioned in the context of clean technology and in the context of future low-carbon economy. It is striking that in 2011 Australia emphasised the importance of security of supply, anticipating the need to promote renewable energy in a scenario in which coal is phased down. The text emphasises the importance of reconciling climate policy objectives with energy security objectives. In line with the propositions of ecological modernisation, the government document stresses the importance of enhancing the “understanding of energy policies, programmes and directions” through the promotion of “cooperation on technology, research and development, deployment and commercialisation”. The strategy document also highlights the importance of exchange of knowledge between business and universities and capacity building. As part of the Clean Energy Future package, a series of measures were introduced to guarantee energy security and market stability by targeting specifically emissions - intensive electricity generators and providing them

support. An Energy Security Fund with A\$ 5.5 billion was established at to assist for the next six years electricity generators strongly affected by the transitional strategy. The Australian Government back then intended the orderly closure of emissions - intensive coal - fired generation capacity by 2020. Some years later two of them were closed. The government also introduced an "Australian Research Council Linkage Programme" aiming at "improving research outcomes and the use of research outcomes by strengthening links within Australia's innovation system (between researchers and between researchers and end users of research) and with innovation systems internationally" (Department of Industry, 2011). The government also encouraged initiatives linking industry and the research community. In 2011, the government decided to allocate A\$ 10 billion and establish the "commercially oriented" Clean Energy Finance Corporation to incentivise innovation through investments in clean energy. The Clean Energy Finance Corporation leverages "private sector financing for renewable energy and clean technology projects, with a focus on renewable energy, energy efficiency and low - emissions technologies, and the transformation of existing manufacturing businesses to refocus on meeting demand for inputs for these sectors". While Chile revised its energy strategy and renewable energy target, Australia still has not. As mentioned above, the target is still at 20 per cent by 2020 and as 2020 is approaching, investors are waiting for a clear policy signal from the states and Commonwealth government. The analysis suggests that renewable energy and eco-innovation have lost relevance in the country's official energy policy, while the emphasis in the recent strategy has clearly been on coal and CCS technology with a declining emphasis on climate change.

In conclusion, Chile has effective horizontal coordination unlike Australia and an inclusive process led to nation-wide renewable energy target with bipartisan support, leading to continuity and certainty despite change in government. The country has favorable conditions to deploy renewables and its supportive regulatory framework has encouraged significant investment in the sector. Australia, on the other hand, suffers from the "challenge of multi-jurisdiction cooperation", which is particularly evident in the field of energy policy, where different states have different targets, distorting the national

energy market. The lack of horizontal coordination and central steer from Canberra is the main impediment for progress in terms of eco-innovation. As presented in the analytical framework, one important causal mechanism for strong eco-innovation outcomes is the existence of a robust policy framework based on inter-institutional coordination, consistency and continuity, which reduces uncertainty and supports investments in eco-innovation. Strong institutions supported by horizontal coordination across government and novel ways to establish consistent policy roadmaps with broad participation of stakeholders create a level playing field for private sector actors in Chile with strategic economic interests, making cost and risk calculations more predictable, reducing transaction and influence costs, thus, incentivising investments for eco-innovation.

4.3. Cooperation between public institutions and the private sector

The following section analyses the role of cooperation between public institutions and the private sector as one important determining factor for successful eco-innovation outcomes. Both the ecological modernisation and eco-innovation literature assert that joint efforts, or coordination, for eco-innovation between inclusive, moderating institutions and private sector actors with strategic economic preferences, such as competitiveness, cost and risk reduction, can lead to overcoming information deficits, and a swifter shift from market failures (environmental pollution, depletion of water resources) to positive externalities, i.e. investments in eco-innovation and the development of new business models. While some mining countries with large fossil fuel deposits face the risk of “stranded assets” and “unburnable carbon”, those countries with minerals that are needed for the low-carbon transition, the global sustainability agenda can be an opportunity not only to export competitive commodities but also to decarbonise their economies. Particularly with regard to energy policy, the transition to clean energy could provide energy security and lower energy costs in the medium term, contributing at the same time to greater competitiveness. Around these goals, the private sector and public stakeholders could converge their preferences and find common solutions.

In Australia, the energy intensity per unit of output has risen by 50 per cent between 1990 and 2006 (Sandu and Syed, 2008; Mason et al. 2013). Compared with other sectors, mining was the fastest growing energy consumer, which was linked to increased demand and declining ore grades. The mining sector's energy demand is the fastest growing one with an average of six per cent (Mason et al. 2013). Chile's energy mix relies predominantly on fossil fuels, which accounted for 68 per cent of total energy supply in 2014. Energy generation from renewable sources has doubled since 2000, but has not kept pace with growth in total energy demand. Energy used by the economy (total primary energy supply) grew by 54 per cent between 2000 and 2014, with rapid economic growth, increased mining and industrial production, and growing transport demand. The mining industry accounts for around 38 per cent of the total electricity consumption, the highest share in the OECD, while the sector consumes 7.5 per cent (IEA, 2018). Therefore, the decarbonisation of the mining sector is crucial and this PhD seeks to assess ongoing efforts through an enabling policy framework and public-private cooperation.

While mining is crucial to the clean energy transition, it also accounts for up to 11% of global energy use. Many mining companies still supply their own electricity with diesel generators. To benefit from the increase in mineral demand and reconcile climate, mining and economic growth objectives, mining countries and companies should be expected to adopt a joint mining practice that minimises carbon and material footprints. Replacing diesel generators with renewable energy has a significant emission and cost savings potential. While many countries could do more to support the decarbonisation of the mining sector, Australia and Chile have made progress in integrating renewable energy in the sector based on enabling policies. After a bipartisan, inclusive process in which also the private sector was extensively consulted, Chile has adopted an ambitious renewable energy (70% by 2050) target and energy efficiency policies including in the mining sector. In Australia, the Australian Renewable Energy Agency (ARENA) played an important role in providing loan-based financial assistance for the integration of renewables in mining operations as well as technical assistance to close knowledge gaps

in the sector – despite the absence of a comprehensive, coordinated and coherent national renewable energy policy framework.

Through its Advancing Renewables Programme, ARENA provides support to the development and early-stage deployment of innovation projects that aim to lower the costs of renewable energy technologies and scale up their uptake. ARENA's team consists of experienced investment and banking specialists – bringing projects to financial closure through expert advice and financial support. The integration of renewables in Rio Tinto's Weipa bauxite mine or the DeGrussa copper mine are directly linked to public-private cooperation and knowledge creation within ARENA's framework. ARENA is probably one of the most important organisations for the integration of renewables in mining based on knowledge creation and exchange between different stakeholders. ARENA is a commercially oriented agency providing co-funding. It was established in 2012 by the Australian Renewable Energy Agency Act 2011 and pursues the goal to improve the competitiveness of renewable energy technologies; increase the supply of renewable energy in Australia. ARENA's timeframe for delivering its objectives is 2022, with intent to provide competitive energy solutions up to 2030-40. The Clean Energy Finance Corporation (CEFC) is an Australian Government-owned Green Bank that was established to facilitate increased flows of finance into the clean energy sector. The CEFC invests in accordance with its legislation, the Clean Energy Finance Corporation Act 2012 (CEFC Act) and the Clean Energy Finance Corporation Investment Mandate. The Australian Government announced on 23 March 2016 its intention to create a new Clean Energy Innovation Fund, to be jointly managed by ARENA and the Clean Energy Finance Corporation (CEFC). The Clean Energy Innovation Fund was formally established in 2016 by amending the CEFC's investment mandate; ARENA and the CEFC jointly manage the CEIF, allocating up to A\$ 100 million each year to commercialise innovative renewable energy projects using equity and debt instruments. ARENA assesses project proposals and makes recommendations for funding to the CEFC for approval.

At the national level, Australia committed over A\$ 80 million to support energy storage projects, ranging from technology development to large-scale deployment. Financial incentives and public financing also have been extended to support the deployment of renewable heat technologies, although there were few new developments in 2015. Australia announced a new grant scheme covering 50 per cent of project costs for renewable heat for industrial processes as one of the focus areas for investment under the Australia Renewable Energy Agency (ARENA). With ARENA Australia has a new grant scheme covering 50 per cent of project costs for renewable heat for industrial processes as one of the focus areas for investment under the Australia Renewable Energy Agency.

ARENA is linked to the Department of Environment, the section of Climate Change and Renewable Innovation. The organisation believes that renewable energy production and diesel, which is volatile in price, are complementary. ARENA promotes the use of renewables in mining and uses a price argument. After a brief period of high levels of initial investment, renewable energy comes with comparatively low operational costs, which creates price certainty for mines and the solar price can be locked in for some time. This approach has been effective in addressing miners, who are vulnerable to diesel price changes. In fact, 26 out of 62 funding requests for individual projects come from mining (Interview, 2016). ARENA does not fund R&D projects but helps existing eco-innovative technology to enter the market. It provides A\$ 100 million per year for over 10 years and supports commercially viable renewable energy use. The renewable energy target is not within mandate of ARENA to avoid "double subsidy" for renewables, as there is also the Safeguard Mechanism, which was introduced after the Agreement, is an emission trading scheme for installations. The price for certificates is linked to the EU Emission Trading Scheme (Interview, 2016).

ARENA operates commercially as a grant-funding body and its mission is to promote the use of renewable energy in Australia. It facilitates regular meetings and information sharing between the mining sector and renewable energy developers. For ARENA knowledge sharing is very important to accelerate the transition across the mining industry, "which is very conservative" (Interview, 2016). Australia is leading in off grid

solar; although it should be noted that recently the enthusiasm for it has slowed down with the decreasing diesel price. Nevertheless, ARENA believes that it is also a great window of opportunity to convince the industry that by locking-in the price for solar energy, the industry would be well prepared for higher diesel prices.

Figure 19. Renewable energy in the mining sector in Australia (own compilation based on TH Energy Consulting, 2017)

		Application	Renewable Energy	Type	Capacity	Year	Comment
1	Mount Cattlin	Lithium (Galaxy Resources)	Wind and solar	Wind-solar-diesel-hybrid	110 kWp solar and 6.4 kW wind	2011	Mine closed in 2013, supported by ARENA
2	DeGrussa	Copper and gold (JuWi)	Solar	PV-diesel hybrid	10.6 MW	2016	Supported by ARENA and CEFC
3	Weipa	Bauxite (Rio Tinto Alcan)	Solar	PV-diesel hybrid	6.7 MW	2015	Supported by ARENA – expansion in discussion to 6.7 MWp PV and storage
4	West Leinster	Nickel (BHP)	Solar	Hybrid PV-diesel-gas	300 kWp	2013	Supported by ARENA, mine closed in 2013

The agency intends to mitigate a first mover risk, which, in line with the eco-innovation framework, can be a barrier due to technical teething problems. Hence, they support an increased supply of renewables and thereby improve the competitiveness of renewable energy technologies. For mining, which is a conservative sector energy procurement is not a core part of business. Miners have been purchasing and using diesel for over 50 years. Renewable energy is perceived as “disturbing” or new and risky. This is where ARENA steps in by providing financial assistance and information with some success. According to a database on solar and wind systems in the mining industry (TH Energy, Sustainable Consulting/ Dr. Thomas Hillig Energy Consulting, 2016), there are worldwide 28 mining sites using renewable energy of which four are in Australia, all funded by ARENA. Two of the renewable energy projects supply active mining sites, while the other two are located on closed mines. ARENA supports all of them financially and technically.

One of them showcases how mining can catalyse the deployment of off-grid solar energy within the framework of public-private collaboration. In Australia, many mines are in remote areas where there is no grid connection. Therefore, they rely on expensive trucked-in diesel fuel. Off grid remote mining projects are particularly vulnerable to oil prices (Mason et al. 2011). Trucking diesel to be used for electricity production can cost a mine about A\$ 200/MWh (Mason et al. 2013). Cost factors create a strong business case for having some additional wind or solar generation capacity at remote mines facing high electricity costs (Sarder, 2010). Yet, the price of high diesel prices is certainly not the only reason why the DeGrussa mine decided to integrate renewables. If high diesel prices were the most important factor, in a country with over 400 mines, the number of renewables in mining would be higher. This, to some extent, indicated a limitation of rational choice institutionalism, which can be explained by acknowledging awareness issues and information deficits and which exactly what ARENA seeks to address. Yet, it takes time to overcome. ARENA played an important role in addressing risk concerns for the financing of this first of a kind project in Australia. Under the supervision of the government, ARENA's governing board, which has the final say over projects to be financed, consists of independent experts with banking and finance backgrounds. ARENA provided A\$ 21 million while the Clean Energy Finance Corporation provided \$ 15 million in loan-based financing. The agency set up meetings on daily, weekly and monthly basis (OECD, 2018), in order to facilitate coordination and transparency (Interview, 2017). The projects success was enhanced by the role the government played in addressing risk concerns and access to finance. In the past, the DeGrussa mine was powered by a 20 MW diesel generation station. In order to reduce costs and the use of diesel, the mine decided to integrate 10.6 MW of solar power and install a 6 MW storage capacity. The DeGrussa mine has today the largest off-grid solar and storage facility on a mine site in the world (OECD, 2018). The mine has a knowledge-sharing plan that aims to release operational performance data summaries to assist mining companies evaluate the risks of integrating renewable energy into diesel plants.

In Chile, private investment in non-conventional renewable energy sources (i.e. excluding large hydro) has increased sharply in recent years, reaching a record high of

about US\$ 2.4 billion in 2015 (BNEF, 2016), and is expected to grow further. Investment has concentrated on wind and solar energy since 2010, reflecting the market competitiveness of these renewables technologies in Chile and an enabling policy framework. The government and its agencies have provided soft loans and other financial incentives that have helped kick-start the financing of renewables projects with the support of international partners. The government has facilitated investment in non-conventional renewable energy sources through a quota obligation, investment in research and development, and promotion of market transparency. The quota obligation, introduced in 2010 and strengthened in 2013, requires electricity companies to gradually increase the share of renewables in their power supply with a view to reach 20 per cent in 2025. In addition, tax and financial incentives have promoted solar thermal systems and other renewables, including in rural areas. The government has also supported investment to improve energy efficiency in the building and government sectors, among others. The enactment of a carbon tax will further support the competitiveness of renewables. In parallel, the Economic Development Agency (CORFO), an autonomous government agency for industrial policy development, and the National Energy Commission (CNE) have developed diverse financial instruments to support investment in renewable energy development. These have helped kick-start the financing of renewables projects in Chile, but finance barriers continue to restrain faster development of renewables capacity. In the solar technology sector, a lack of regulations on certifications or standards for solar modules (which would support longevity, safety and related market guarantees) results in greater risk in terms of guarantees that local Chilean financial institutions often cannot afford (Borregaard et al., 2015). Due to limited local finance, many international organisations like the European Investment Bank, the Inter-American Development Bank or the World Bank have taken the lead in developing projects, notably for larger ones. For example, until recently, most large-scale solar projects were supported through multilateral financing institutions (Borregaard et al., 2015). Private investors from the United States, Europe and China have also been involved (BNEF, 2012).

Since 2008, CORFO has provided in cooperation with the German development bank KfW low-cost funding to commercial banks for lending to non-conventional renewable

energy projects. Today, one-third of operating banks in Chile are actively involved in the financing of renewables projects, including wind, photovoltaic and small hydro (Violic, 2015). The loan programme was extended in 2011 (with US\$ 90 million); three years later, it was expanded to provide targeted support to solar projects (US\$ 133 million). CORFO has also been providing financial support to renewable energy projects in pre-investment stages. In 2005-2009, it subsidised up to half of the total cost of pre-feasibility studies and pre-investment studies, this benefited 217 wind, biomass, biogas, geothermal and small-scale hydro projects (IEA/ IRENA, 2014). Since 2012, the Renewables Energy Center (now CIFES) has developed three new contests to subsidise pre-investment studies of renewable projects with the support of the German development bank KfW. The last three tenders provided co-financing of up to 40 per cent to 121 individual projects mostly wind and solar projects (Ministry of Energy, 2014). Currently, Chile has eleven renewable energy installations linked to mines funded by private investors coming from countries with which Chile has a trade and investment agreement.

Figure 20. Renewable energy in the mining sector in Chile (own compilation based on TH Energy Consulting, 2017)

		Application	Renewable Energy	Type	Capacity	Year	Comment
1	Javiera, Atacama Desert	Copper (Codelco)	Solar	Grid	69.5 MW	2015	SundEdison (US) to deliver electricity for 20 years, TerraForm intends to purchase
2	Chuquica mata	Copper (Codelco)	Solar	Grid	1 MW	2014	Investor: Solarpack (ES) turbines: Yingli (DE)
3	Pozo Almonte, Tarapacá	Copper	Solar	Grid	25.4 MWp	2014	Investor: SolarMax (DE), turbines: Yingli (DE)
4	Sierra Gorda	Copper	Solar thermal	Process heat	27.5 MW	2013	Covers 80% of heat used to refine copper, SunMark A/S (DK)
5	El Tesoro	Gold, copper, molybdenum	Concentrated solar power	Process heat	10 MW	2012	Installer: Abengoa (ES)

6	El Tesoro	Gold, copper, molybdenum	Concentrated solar power	Local grid	64 kWp	2013	Modules: Concentrix (US), installer: Soitec Solar (DE)
7	Calama, Atacama Desert	Copper, Open cast mine	Solar	Grid	1.1 MW	2012	Installer: Solarpack (ES), Modules: Suntech (CN), First Solar (US), Grid-connected, no subsidies
8	Copiapo, Atacama Desert	Iron ore	Solar	Grid	100 MW	2014	Operation, modules, installation: SunEdison (US), covers 15% of the CAP Group's energy demand
9	Andacollo	Gold	Solar	Grid	1.26 MW	2013	Operation, installation: Solairedirect (FR) + Schneider Electric (DE), Modules: Jinko Solar (CN)
10	El Toqui	Zinc, gold	Wind	Wind-hydro-diesel-hybrid	1.5 MW	2011	Seawind, installation, modules: Vergnet (FR)
11	Los Pelambres	Copper	Wind	Grid	115 MW	2014	Siemens, operated by Pattern Energy (US) and Antofagasta Minerals (CL), installation: Pattern Energy and Skanska Chile SA (CL), provides 70% of the electricity goes to Los Pelambres, covering 20% of the needs

Northern Chile has plenty of sunshine and wind. Chile launched its biggest wind farm north of Santiago with fifty wind turbines. It provides energy to the Los Pelambres mine. The farm is a joint venture between Pattern Energy, a US firm, and Antofagasta Minerals, the Chilean-based, London-listed owner of Los Pelambres. It accounts for 20 per cent of the mine's electricity. Further north, in the Atacama Desert, another US company, SunEdison, has built a solar plant for Antofagasta, which provides Los Pelambres with a further 12 per cent of its electricity needs. Antofagasta is not the only miner to be turning to renewables. State-owned Codelco has built wind farm near its Chuquicamata mine. One very good example of how the mining sector and government can work together to support grid connected renewable energy is the Collahuasi mine, which is owned by Anglo American (44 per cent), Glencore (44 per cent) and the Japanese company Collahuasi Resources (12 per cent). The mine had an interest in exploring whether renewable energy would be suitable for their operations, in order to phase out expensive fossil fuel alternatives. This interest converged with the government's interest of expanding renewables in the sector and country and reducing fossil fuel imports. The import dependency and relatively high electricity prices would undermine in the long-term the competitiveness vis-à-vis neighbouring countries such as Peru who pay half of what Chilean mines pay for electricity (OECD, 2018; Alova, 2018; The Economist, 2014). According to predictions of the Chilean Copper Commission Cochilco, the amount of electricity required by Chile's copper mining industry will double by 2025 (Cochilco, 2014). The industry's power demand is predicted to grow by 80 per cent. Energy is one of the industry's major source of costs and seen by many as a major threat to competitiveness compared to its Latin American peers. The leaderships of the mining companies were attracted by the stable price renewables would offer, relatively low operational costs, as well as the environmental benefits of decarbonisation. Hence, the mine signed a 20-year power purchasing agreement with Solar Pack, a Spanish company, which built the plants and took over the operation and maintenance of the renewable energy infrastructure around the mine. The development of the power plants was financed based on a loan by the Inter-American Development Bank and the Canadian Climate Fund for Private Sector in the Americas (OECD, 2018). The solar plants are operational since 2014 and have a power generation capacity of 25 MW, meeting 13 per

cent of the mines power demand. Unlike many other countries, the Chilean government did not provide any subsidies but created an enabling policy framework based on three main factors: 1. bringing in international partners to facilitate the financing; 2. since 2008, the government has introduced short to medium-term targets for the integration of renewables; 3. the government has provided financial support for pre-investment feasibility studies with a budget of US\$ 85 million. The coordination between the mining companies and government was essential to increase overall the availability of renewables in the grid. Determined to approve critical infrastructure projects, the government of Chile has granted 76 concessions for renewable energy projects in northern Chile since 2014, which will add additional capacity to the grid to power dozens of mines (The Economist, 2014).

Furthermore, unlike Australia, Chile benefits from having had until recently a developing country status. It has strong links to partners providing development assistance, in financial and technical terms. Old partnerships remained but have changed in the narrative and structure since Chile joined the OECD and moved up to the category of emerging economies. Development Finance Institutions as well as export credit agencies have played an important role in providing guarantees as credit enhancement, to protect lenders against commercial or political risks in case the guaranteed party fails to repay their debt. In Chile, the European Investment Bank, the Inter-American Development Bank, the German development co-operation agency, GIZ and KfW bank have implemented a number of renewable energy projects, with an increasing focus on the mining sector to promote industrial application of low-carbon energy technologies. When Chilean banks were reluctant to invest in renewable energy projects, KfW co-financed some of the projects through concessional loans. With the increase of renewable energy projects, the domestic financial sector started to better understand potential risk profiles, and became more willing to invest in such projects. This is considered an important contribution of development co-operation to building domestic investor confidence in the Chilean renewable energy sector (OECD, 2016).

To conclude, interestingly and surprisingly, the Australian case shows that despite the influential existence of system incumbents and veto players in the energy sector, which is discussed in detail in the following section, a low-carbon transition and eco-innovation in the mining sector has started, facilitated through a meaningful cooperation between public institutions and the private sector to overcome knowledge gaps and perceived first mover risks linked to investments in untested and new technological solutions. While this is in lines with the assertion made by ecological modernisation and eco-innovation literature, this PhD can trace patterns and put in into the context of other factors. In line with rational choice institutionalism, in both cases, Chile and Australia, access to finance, facilitated by the government, to address such economic risks and costs have unfolded a positive and encouraging effect, supporting the increasing use of renewables in mining. While those activities might be seen as remarkable, they have started later than in other countries and it is still uncertain how they will evolve in the future.

4.4. Domestic veto players

This section looks at the fourth level of analysis and addresses the issue of domestic veto players, which, based on the analytical framework, could provide a strong explanation for resistance to regime change, hence, for explaining the major difference in political outcomes between Australia and Chile. As suggested in the hypotheses, system incumbents who are likely to lose from eco-innovation could act as veto players in the policy change process. The higher the number of incumbents, the less ambitious would be the policy and institutional framework. These could be state institutions with different priorities, such as trade promotion, or significant energy producers as part of fossil fuel based supply systems. This section serves addressing the question of why Australia has a lower level of ambition in terms of eco-innovation and to what extent domestic actors and veto player influence the eco-innovation trajectories of the country.

Climate and environmental policy in Australia is conditioned by the economic fact of its abundance of fossil fuel resources and hence its status as a producer and net exporter of energy. Cheap energy is perceived as a comparative advantage for a successful economic

and trade performance. Low energy prices attract business investments and contribute to economic prosperity. Coal is Australia's highest export earner and provides 80 per cent of the country's electricity, while Chile does not have any fossil fuel resources. Paterson (1996) has identified a clear link between a state's energy base and its climate policy, explaining the success of ecological modernisation in some states than in others. Countries that rely on energy imports tend to generate strong climate policies while those that export fossil fuels tend to generate weaker ones. Abundant coal and gas deposits and substantial carbon exports enhance the power of fossil fuel producing companies, sectoral incumbents, who potentially hinder the development, deployment and diffusion of eco-innovative technologies such as renewable energy technologies (ibid.).

As discussed above in the international organisations and agreements section, strongly diverging domestic preferences in Australia pose an impediment for the unfolding of a significant effect in eco-innovation policies. A well-established, incumbent, coal mining sector with its interest groups form the risk of hindering or slowing down the uptake of eco-innovation and influencing perceptions. The structure of government-business relations is key to sectoral reform and climate policy. In Australia, over time, mutually reinforcing relationships have been developed between major parties and the mining and energy sectors, which ensured enhanced access to government as well as agreements on shared goals and decision-making process. Australian climate policy story highlights significant input of key energy sectors in shaping its direction and in blocking effective sectoral restructuring (Hamilton, 2001; Christoff, 2005; Lowe, 2006), which makes a closer look at domestic veto players and potential "modernisation losers" indispensable.

The analysis reveals that considering Australia's energy-intensive economy, decisive climate action would mean confronting large and powerful sectors. Past governments, however, chose instead to constrain reforms and maintain the energy-status quo. Structural problems remain make eco-innovation politically and economically challenging. Australia's economy derives its comparative advantage from a plentiful, inexpensive supply of energy, particularly coal, and its regional location within a vibrant Asia Pacific energy market. Some industries that are energy-intensive and depend upon

fossil fuels are more difficult to modernise. As Jänicke points out: "an environmental problem, for which we have a marketable technical solution, normally creates less political difficulty than one that requires "negative", restrictive intervention in the established production, consumption, or transport structures" (Jänicke, 2004). Applied to Australian case this means that the modernisation of energy-intensive industries is likely to face resistance from governments and business. Even the win-win solutions of eco-innovation are not sufficient if some sector's inherent logic is responsible for the intensive use of environmental resources when adequate technological solutions are not available or cost-competitive yet, e.g. carbon capture technology (ibid.). A country's economic profile is, therefore, a decisive factor for the pursuit of eco-innovation. Corporate interests influence regional and national institutions and policies, particularly during election times and put effective barriers against such types of eco-innovation that would put their specific assets at risk.

The major industry opponents of the Kyoto Protocol were organisations representing the energy and resources sectors arguing that they would be disadvantaged on the world market if ratification were to occur. The central position occupied by the fossil fuel sector in the Australian economy extends its influence in a variety of ways, including "in bureaucratic arrangements that protect and promote fossil fuel use" as well as generating "direct and personal links between government and fossil fuel interests within the current policy and political elite" (Christoff, 2005). Historical institutionalism would argue that there has been a path dependence and institutional lock-in due to the consistent failures of the Australian government in accepting and contributing to ambitious global climate agreements. Sociological institutionalists would highlight the strong social ties between the conservative party has strong ties to fossil industry as a reason for the lack of commitment. These explanations do not account sufficiently to address some of the changes in political commitment that occurred in the past in Australia. Change comes about with change in domestically predominant interests with specific environmental disasters. In the late 1990s and early 2000s, the government highlighted eco-innovation and introduced measures in support of it, such as the creation of the Australian Renewable Energy Agency. At the national level, Australia faced its most volatile

environmental conflict years, which threatened the stability of development goals and in turn impacted the government's political-electoral objectives due to an increasingly "environmentally literate community" (Curran, 2015). Thus, as rational choice institutionalism asserts, prevailing domestic interests are key and so far most of the time interests related to coal prevailed.

One striking example of such a prevalence of the interests of the fossil fuel industry players is the modelling of the Australian Bureau of Agricultural and Resource Economics (ABARE) on potential or expected Kyoto implementation costs, which was overseen by a steering committee dominated by fossil fuel representatives to the exclusion of many other industries and environmental groups (Hamilton, 2001; Papadakis, 2002; Barnsley, 2006). Participation in the steering committee required a financial contribution of A\$ 50,000 - excluding new and niche businesses, to the advantage of better resourced fossil fuel interests (Papadakis, 2002). The findings were subsequently supported by a 2002 Commonwealth Ombudsman report on the economic modelling process, which recommended that ABARE encourage a more appropriate balance of views and the inclusion of wider array of interested stakeholders (Papadakis, 2002; Barnsley, 2006). ABARE's report concluded that measures such as emission trading or carbon tax would substantially increase costs for emission-intensive industries and hence for the economy overall. What has been overlooked was the provision of subsidies to the fossil fuel sector. Reidy and Diesendorf (2003) point out, "existing financial subsidies and associated incentives to fossil fuel production and consumption provided by governments in most developed countries", of which Australia is a clear example, can have a "distorting effect". These subsidies not only help sustain inefficiencies in emissions-intensive industries, often at the expense of expanding the renewable technologies sector. Jänicke (2004) suggests that one way of achieving ecological modernisation is to reduce or phase out environmentally harmful subsidies, which was not addressed by the ABARE report, as those benefitting most from subsidies had a disproportionate influence on the results of the analysis.

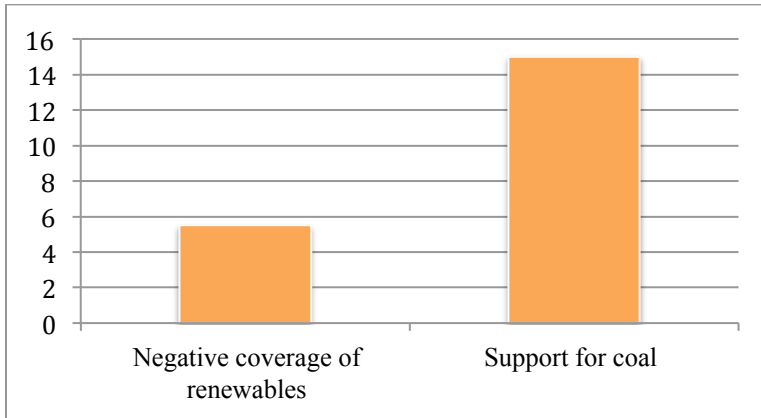
As a reaction to the ABARE report, the Australian Business Roundtable on Climate Change's created its own climate taskforce – members included major corporations: BP Australasia, Insurance Australia Group, Origin Energy, Swiss Re, Visy Industries and Westpac. The aim was to advance the understanding of business risks and opportunities associated with climate change – in the transition to a low carbon future. The roundtable proposed that the economic risks of not acting were far greater than those of acting referring also to risks for insurance and tourism industries stemming from extreme weather events and degradation of ecological assets. The recommendation was to set an aspirational goal to significantly reduce greenhouse gas emissions; prepare more for a low carbon economy; introduce an appropriate market based carbon pricing system; encourage technological and investment innovation; expand fiscal incentives for innovative cleaner technologies; and strengthen research into and capacity for climate change adaptation. The Rudd government tried to follow their call but the following Abbott government took all major reforms back. One might find that decision surprising since a business roundtable made these recommendations. Yet, the stakeholders of the ABARE roundtable were “newcomers” to the energy sector scene in Australia and not incumbents with established influence and specific assets at risk in a low-carbon scenario. The ABARE companies, such as Origin Energy, are stakeholders with economic interests in investing in renewables in Australia but facing major resistance from conservative politicians and system incumbents.

In Australia, the existence of incumbents resisting regime change and their large share of coal in exports slow down the uptake of renewable energy. Jänicke (2004) suggests two options for cleaning these industries: technological innovation or the phase out of entire industries, here coal mining replaced by green energy providers; “dirty industries” represent a structural problem that is not solvable only by means of ecological modernisation. The solution can only be found in a sectoral strategy beyond technological improvements. “Clean coal technologies” such as carbon capture and storage represent the main technological solutions to greening the industry while maintaining the business model – many of these technologies seek to capture carbon emissions from fossil fuel production and then bury them underground (Saddler et al.

2004); others involve the transformation of carbon dioxide into solids that do not require burial – at their heart sits an end-of-pipe, high risk or very weak ecological modernisation logic. Through technological innovation they promise to retain and increase the coal sector while eliminating its greenhouse emissions (Interview, 2016). Given the central position that energy and mining industries occupy in the Australian economy, it is no surprise that such positions are politically influential. In seeking to fight the threat of restructuring, they support across the political spectrum: the conservatives sympathise with the economic credentials of these sectors, while the Australian Labour party has close organisational ties to prominent energy and mining unions (Curran, 2009). Both sides of politics are dependent economically and fiscally on the sector and are sensitive to the unemployment impacts of sectoral restructuring. It, thus, requires committed and ambitious political modernisation agenda to challenge existing sectoral power relations. Ecological restructuring of these industries would demand after all structural transformation of the sector and a re-conceptualisation of its continued place in a country's economic profile – politically risky even in the face of projected economic impacts of accelerating climate change.

How do incumbent veto players exert influence in Australia? One example is the decision of the Australian Coal Association to join the rest of the mining industry in Australia. In August 2013, the Australian Coal Association released a statement announcing it was to be subsumed into the Minerals Council representing the mining companies in Australia. One year later, in April 2014, the Minerals Council of Australia joined the World Coal Association. Experts highlighted during several interviews, that since the coal association joined the Minerals Council, they have been dominating the association's agenda. For the purpose of this PhD research, an analysis of the Council's tweets between March 2016 and March 2017 was conducted, which evaluated the published total of 480 tweets based on their content by specifically searching for the word frequencies of "coal" and "renewables" also taking into account the links around these codes.

Figure 21. Minerals Council tweets between 2016-2017 (%)



The study (figure 21) shows that 36 out of 480 tweets contained scepticism and criticism of renewables (links to subsidies, energy insecurity, supply disruptions etc.), while 72 of them were praising coal as a good case for investment due to anticipated robust demand, for being affordable and providing energy security worldwide.

As part of its public affairs strategy, the Minerals Council communicates that it is “simply common sense” that new coal technologies need to be considered as part of Australia’s efforts to meet its emission reduction target while maintaining affordable and secure energy supply. If the potential of clean coal technology were to be ignored, the reliability of the energy system would be risked (The Australian, 2017). The accession of the Australian Coal Association to the Minerals Council causes a structural problem, as potential modernisation losers and winners are associated with each other in the same organisation, in which the coal industry, which has been described as a modernisation loser by Jänicke, uses channels of the Minerals Council to push forward its own positions and to use the institution for “politics of scale” purposes, hindering opportunities of creating linkages between competitor of coal, namely, clean energy providers, and mining companies with competitive portfolios fit for a low-carbon future. It would require an institutional overhaul to turn such a council into a more SDG-oriented body, which not inconceivable but rather unlikely without political pressure from outside.

Linking to the first level of analysis focusing on international agreements and organisations, the struggle of the Australian government to commit ambitiously to the

global decarbonisation efforts is partially influenced by the existence of fossil fuel producers and their significant economic weight. However, as the analysis of ARENA's role in Australia shows, these dynamics, blocking or slowing down the transition towards a low-carbon economy and eco-innovation can be addressed through an effective cooperation between public institutions and the private sector, aligning their preferences around common goals of reducing costs and enhancing competitiveness. Therefore, even though the analytical and theoretical reflections would suggest the existence of incumbent veto players in the energy sector hindering regime change, the analysis shows the emergence of innovative niches with the potential to challenge the status quo. The power of the incumbents and their effective lobby does not prevent emerging niches to exist and flourish. It is noticeable, however, that rational prospects for water savings are picked up quite slowly. Whether or not such dynamics will be able unfold on a larger scale and are strong enough to challenge an existing regime, thus, remains to be seen.

4.5. Conclusions on Australia and Chile

This chapter tried to answer the question of why Australia and Chile perform differently in reforming their policies and institutions in support of eco-innovation. Our analytical framework has been tested by analysing different levels of analysis and causal mechanisms with a focus on the role of international agreements and organisations, the domestic policy and institutional framework, the structure of collaboration between public institutions and the mining sector, and finally, the role of domestic veto players as a particularly important factor for regime change resistance. The analysis of the international level showed that the global climate change agreement and trade and cooperation agreements have unfolded eco-innovation effects in terms of policy and practice in Chile, which has led to the country undertaking a rapid catch up in international collaborations on eco-innovation. This has been partly driven by international actors, whose economic interests are well aligned with those of domestic players. Chile capitalises on its renewable energy potential using the global decarbonisation agenda to its advantage by facilitating access to finance and mobilising foreign investment. This can be seen in line with rational choice institutionalisms in terms

of convergence of preferences between the domestic level and the international one. Australia, on the other hand lacks continuity and determination in political will to transform its policies based on an active participation at the global level, seeking alliances with potential partners with whom win-win situation could be achieved in terms of creating new business models and access to finance. From a rational choice perspective the reasons stem from existing domestic vested interests pulling in one direction, hindering at the same time justified interests to cope with climate change impacts (e.g. water stress) and develop innovations.

The analysis also revealed that one other important causal mechanism for strong eco-innovation outcomes is a robust policy framework based on inter-institutional coordination, consistency and continuity, which reduces uncertainty and supports investments in eco-innovation. Strong institutions supported by horizontal coordination across government create a level playing field for private sector actors making cost and risk calculations more predictable, reducing transaction and influence costs, thus, incentivising investments in eco-innovation. A striking difference is the emergence of consistent policy roadmaps with strong participatory elements that is quite visible in Chile but significantly less in Australia. Thus, political will and consistency – both often underlined in the policy literature – need an additional analytical element for such transitions, i.e. orientational alignment that could come through policy strategies and roadmaps. The analysis contrasted the different policy and institutional frameworks of Australia and Chile, highlighting the lack of clear coordination in energy, climate and water policy in Australia, as one reason for the less promising eco-innovation policy outcomes – compared to Chile, which has several horizontal coordination mechanisms, contributing to policy certainty, consistency and coherence. Chile has effective horizontal coordination unlike Australia and an inclusive policy making process, which led to a nation-wide renewable energy target with bipartisan support, leading to continuity and certainty despite change in government. The country has favorable conditions to deploy renewables and its supportive regulatory framework has encouraged significant investment in the sector. Australia, on the other hand, suffers from the “challenge of multi-jurisdiction cooperation”, which is particularly evident in the field of energy policy,

where different states have different targets, distorting the national energy market – leading to the missed opportunity to capitalise on its abundance of solar energy potential and potential investments in innovation that would come with such a potential. The lack of horizontal coordination and central steer from Canberra is the main impediment for progress in terms of eco-innovation. Finally, the Australian case shows surprisingly that despite the influential existence of system incumbents and veto players from the fossil fuel sector, eco-innovation in mining, particularly in terms of the integration of renewables, can be achieved based on a meaningful cooperation between public institutions and the private sector to overcome knowledge gaps and first mover risks linked to investments in untested and new technological solutions, as asserted by the analytical framework. In line with rational choice institutionalism, in both cases, Chile and Australia, access to finance, facilitated by the government, to address such economic risks and costs have unfolded a positive and encouraging effect, supporting the increasing use of renewables in mining.

5. The mining sector

In the previous sections the question of to what extent the international level, the national policy and institutional frameworks, the public-private collaboration structures and incumbent veto players have an influence over Australia's and Chile's eco-innovation policies and decisions was addressed. In line with our research objectives and questions, this chapter takes a closer look at the effects of the same analytical levels on the mining sector, focusing on three major companies, which have operations in both countries and are similar in terms of their size, portfolio and sustainability reporting structures, namely BHP, Rio Tinto and Anglo American, in Chile and Australia. Certain environmental investment decisions could be the result of a calculation of transaction costs and risks, as rational choice institutions asserts, or of a socialisation process within an organisation that influences the perception of what is the “appropriate” decision to make. Norm diffusion and sociological institutionalism would suggest similar eco-innovative outcomes in Chile and Australia, if the company is the same and part of the same institutions or international initiatives, forming the corporate identity in a normative way.

Yet, the analysis on the three companies shows differences between the same company's investment decisions and performance in the two countries, which this research aims to explain with some conclusions for the sector. Methodologically, this chapter will apply text coding to analyse the reports from 2014 – 2016, i.e. the years around the Paris Agreement on Climate Change.

5.1. International organisations and agreements

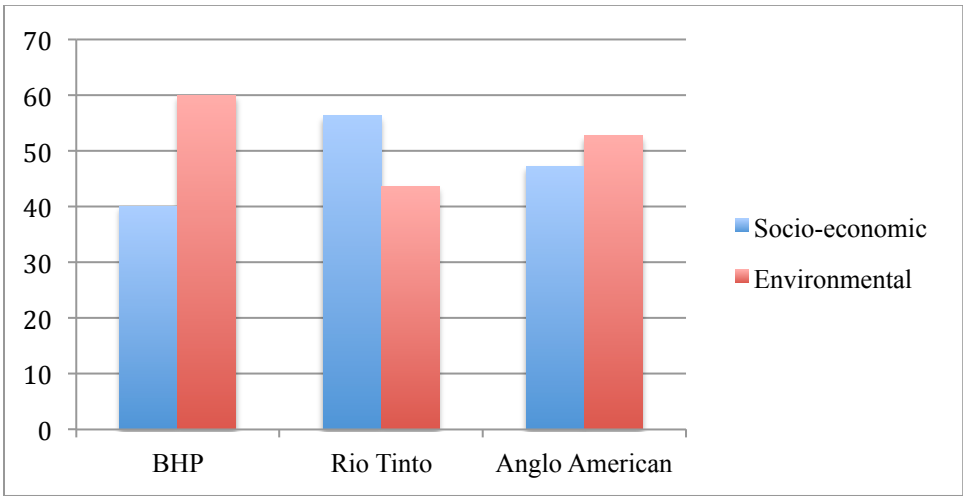
The international policy level works on mining companies to a limited extent. The Paris Agreement has not yet any major impact on everyday operations but rather on long-term portfolio and capital allocation decisions. A large number of countries have committed to the Paris Agreement, determining their own national contributions (NDCs), which is expected to have impact on future demand and commodity markets. Thereby, an increase in demand for minerals for low-carbon technology is expected whereas demand for coal, oil and gas is expected to decline. This agreement has a direct impact on portfolio investments and capital allocation decisions of mining companies. BHP cites explicitly the forecast of the International Renewable Energy Agency (IEA), which increased its forecast for wind and solar contribution to global power generation in 2040 by 12 per cent (BHP, 2016). These have resulted in a comprehensive BHP portfolio analysis published in 2016 based on scenario planning, investment in renewable energy, and a clear commitment to the Paris Agreement.

Ruettinger and Schroll (2017) analyse 42 international standards most of them covering sustainable development and more than one of the dimensions, i.e. environment, social and economic. They conclude that none of them is a game changer or major driver for eco-innovation. They analyse, among others, the International Council on Mining and Metals (ICMM) ten principles, which range from environmental sustainability to human rights to respect for different cultures as well as health and safety. The initiative is not geared towards one topic. Compared with such comprehensive approach, transparency initiatives are more focused and quite effective and successful, as Paul Collier notes (Collier, 2010). Such clear-cut focus has the potential to mobilise actors and be translated

into national legislation. Transparency Initiatives are coordinated covering different elements of the minerals supply chain. While the EU (Directive) and United States (Dodd Frank) regulations impose mandatory reporting on the collection of taxes and royalties, they are supported by the bottom-up work of non-governmental organisations such as the Extractive Industries Transparency Initiative (EITI) or Publish What You Pay (PWYP). National “follow the money initiatives” focus on revenue management and allocation, making sure that the taxes and royalties collected end up in the national budget for saving purposes or spending for the common benefit (Transparency International Australia, 2017). This is rational to counter corruption but our analytical framework would suggest it is not enabling for the eco-innovation agenda since an increasing number of global standards aim at preventing the financing of conflicts through mining and trade in minerals. There is no globally recognised and comprehensive set of standards on the environmental performance of mining companies but rather a wider set of standards including all three dimensions, leading to confusion and lack of clarity. Mining official interviewed highlighted the fact that they have a “very broad” interpretation of what sustainability is. The coding analysis of sustainability reports of the three mining companies (see figure 22 and 23) confirms that there is a strong focus on health and safety and other issues that are not directly linked to environmental sustainability or any transformation ahead.

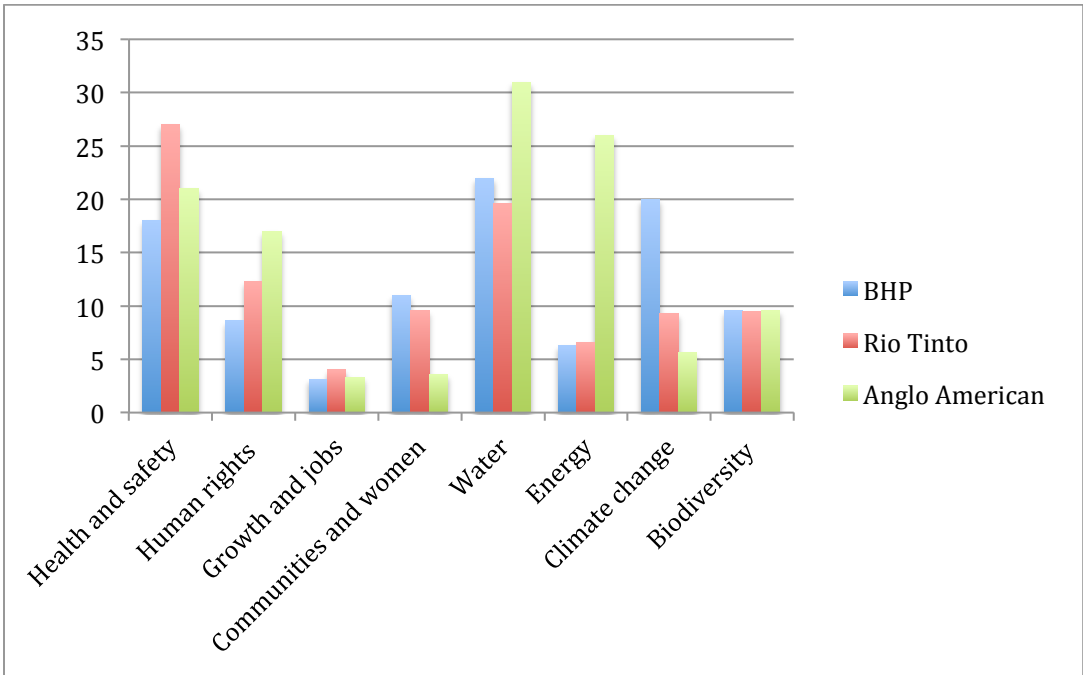
The three mining companies BHP, Rio Tinto and Anglo American design their sustainability reports within the framework of the Global Reporting Initiative. About 1500 organisations from 60 countries use the GRI sustainability reporting guidelines in 2009 to produce sustainability reports. The report is usually structured around a CEO statement, key environmental, social and economic indicators, a profile of the reporting entity, descriptions of relevant policies and management systems, stakeholder relationships, management performance, operational performance, product performance and sustainability overview. The sustainability indicators against which companies are required to report are listed in Appendix III.

Figure 22. Socio-economic and environmental codes in comparison (%)



BHP’s sustainability report consists around 40 per cent of socio-economic issues, whereas Rio Tinto and Anglo American have higher shares, around 56 and 47 per cent, which means that almost half of every sustainability report deals with socio-economic issues. A closer look at the individual codes reveals the frequency of individual codes in the two categories.

Figure 23. Sustainability reporting: Frequency of codes in comparison (%)



The analysis focused on four codes for each category, covering health and safety, human rights, growth and jobs and communities and women under the socio-economic category. Water, energy, climate change and biodiversity were subsumed under the environment category. In the environment category, climate change and water dominate and in the socio-economic category health and safety. For Rio Tinto health and safety is by far the most mentioned topic, while BHP focuses on health and safety, water and climate change almost in a balanced way. Anglo American highlights water, energy and health and safety in its reporting. This patchy picture shows how broadly the industry defines sustainability, which is not very enabling for eco-innovation as discussed for the scope of this PhD thesis.

In fact, the analysis by Ruettinger and Schroll (2017) shows that international mining initiatives covering social aspects have different focal points and varying degrees ranging from stakeholder engagement, avoiding financial conflicts and conflicts with indigenous people. Initiatives specifically geared towards the environmental performance of mining deal with handling residues, acid mine drainage or reducing the use of mercury, which do not relate to eco-innovation or green growth but managing the environmentally damaging “legacy” of mining.

What has the impact of the Paris Agreement been so far? With the increasing global effort to mitigate climate change, greenhouse gas reduction and emissions have become an integral part of the sustainability agenda of mining companies. BHP has two petroleum and potash operations in Australia, two copper mines in Australia and two in Chile, one iron ore operation in Australia, three aluminum mines in Australia and three coal mines in Australia. The company had until 2015 four coal mines in Australia, one of which was sold to a spinoff company called South 32 during a demerger. Its portfolio makes it an important supplier of strategic minerals for the low-carbon future but also one of the potential incumbents showing resistance towards change due to its coal mines. In fact, in its 2014 report, the company stresses that fossil fuels provide access to affordable energy and that under all plausible scenarios they will continue to play an important role in various countries' energy mix.

In 2016, BHP announced they consider it is unlikely that a simple substitution between fossil fuels will achieve the desired results. Complementary to renewables, increasing energy efficiency, BHP counts on solutions aiming to reduce emissions from the extraction and use of fossil fuels through solutions such as carbon capture and storage (CCS), and enabling solutions that have the potential to reduce emissions already in the atmosphere, such as afforestation / reforestation and bio-energy CCS. However, they acknowledge that renewables such as wind and solar have become cost-competitive and that there is a greater potential in these technologies. Nevertheless, they conclude that demand for their energy commodities in the BHP portfolio, including coal, will continue to grow for decades to come, though at a much slower rate than at the peak of the China boom (BHP, 2016). The company's 2014 sustainability report says that fossil fuels provide "access to affordable energy required to continue economic growth" and concludes that "under all plausible scenarios" fossil fuels will continue to be a significant part of the energy mix for decades. The pay back periods for investments are short, as demand is expected to last. Based on this, the portfolio is described as robust, sending a positive and calming signal to the shareholders (BHP, 2014). In the same report, it states that attempts to benchmark energy use and GHG emissions on an intensity basis would not make a meaningful contribution to understanding the company's performance given the diverse range of products across BHP's portfolio (BHP, 2014). Yet, Rio Tinto, for instance, provides product-specific environmental data, which could also be an option for BHP to improve performance through better data and monitoring. Even though the code "emissions" has seen an increase in frequency after the adoption of the Paris Agreement, the company's GHG emissions have almost doubled. This means the company responds to global agreements and cooperation but the effects of the Paris Agreement or Sustainable Development Agenda have not been translated into large-scale, meaningful and effective eco-innovation practices at the level of the company's everyday operations yet. Similarly, Rio Tinto's self-reported environmental performance shows that the company reduced its GHG emissions between 2014 and 2016, while energy consumption went up, and Anglo American has highest scope 3-emission intensity in its production

process despite shareholder pressure and a board resolution on climate resilience (Soliman et al. 2017)

Figure 24. BHP sustainability reporting: Links to "energy" by relevance (%)

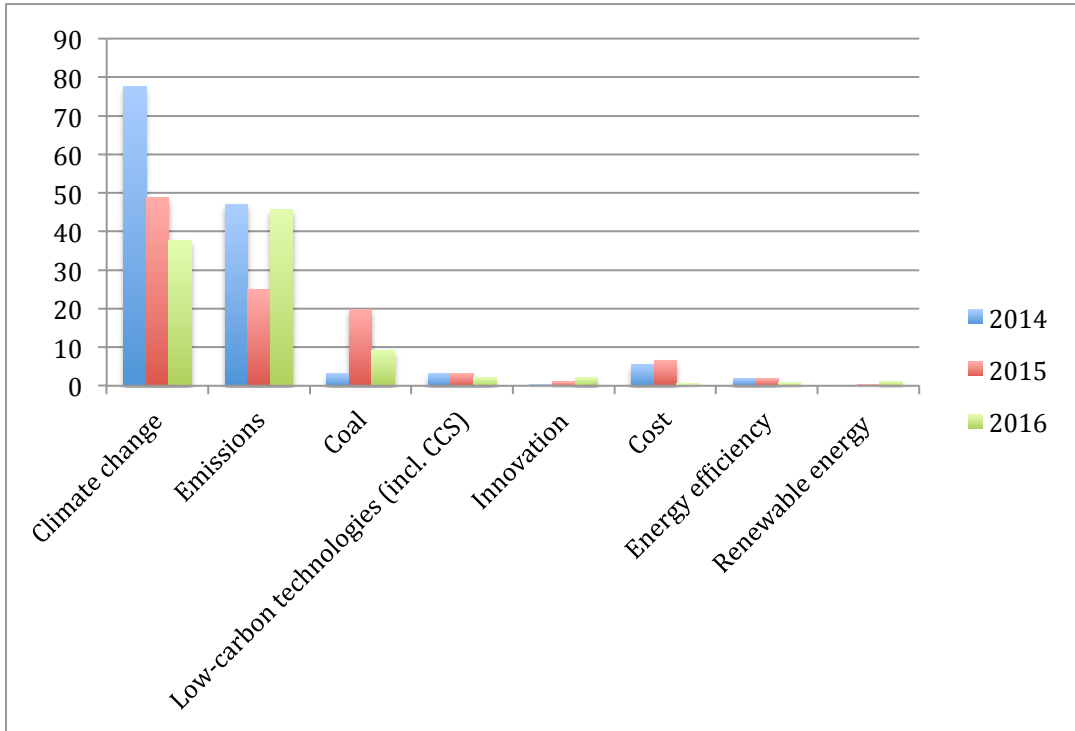
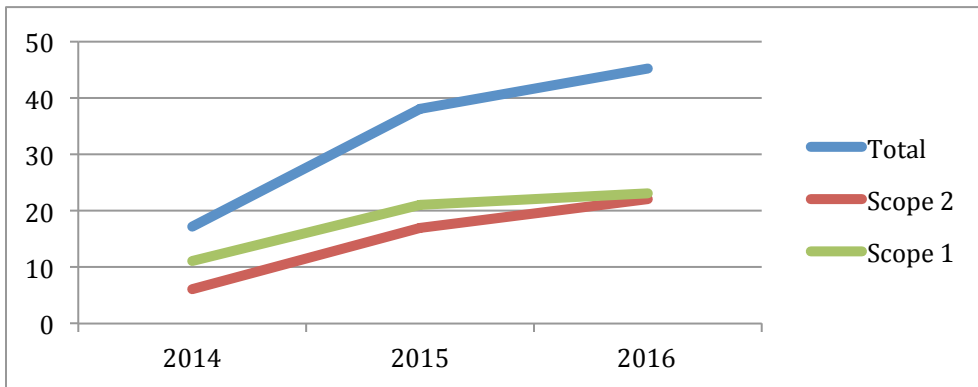


Figure 25. BHP GHG emissions between 2014-2016 (Mt CO₂-e)



The analysis of linkages to the code "energy" show that emissions and climate change considerations play an important role in the company's sustainability reporting. Data in the sustainability reports between 2014 and 2016 shows that BHP uses renewable energy

in its energy mix, with the highest level reached in 2015 followed by a negative trend in 2016. However, the frequency of the code “renewable energy” is increasing. Along with energy efficiency, between 2014 and 2016 there has been a 3 to 4 per cent increase in the frequency. For the first time, in its 2016 sustainability report the company recognised the increasing potential for renewable energy in the resources sector as well as for battery storage solutions at grid scale in order to better manage intermittency and ensure security of supply. The company concludes that these technologies “may transform the way the resources sector access electricity” (BHP, 2016). In the same year, the company decided to invest in the Lakeland Solar Storage Project at a grid-scale in the arid region of Queensland in Australia and to fund a 5-year project in northern Chile with US\$ 14.9 million managed by the Solar Energy Research Centre at the University of Chile.

At the international level, global environmental agreements impact business decisions, particularly sustainability policies and decisions over the company’s asset portfolio, however, being also an important supplier of coal, BHP company still believes in the profitability and robust demand of the coal business and continues to count on fossil fuels as part of their portfolio (BHP, 2016). This position also occurs in the previous reports, published before the Paris Agreement was concluded in 2015. Providing access to affordable energy will be required in view of economic growth and the aspirations to maintaining living standards; "under all plausible scenarios, fossil fuels will continue to be a significant part of the energy mix for decades; pay back periods for most present and future investments in fossil fuels production are relatively short and portfolio remains robust", which means that the company expects robust demand (BHP, 2014).

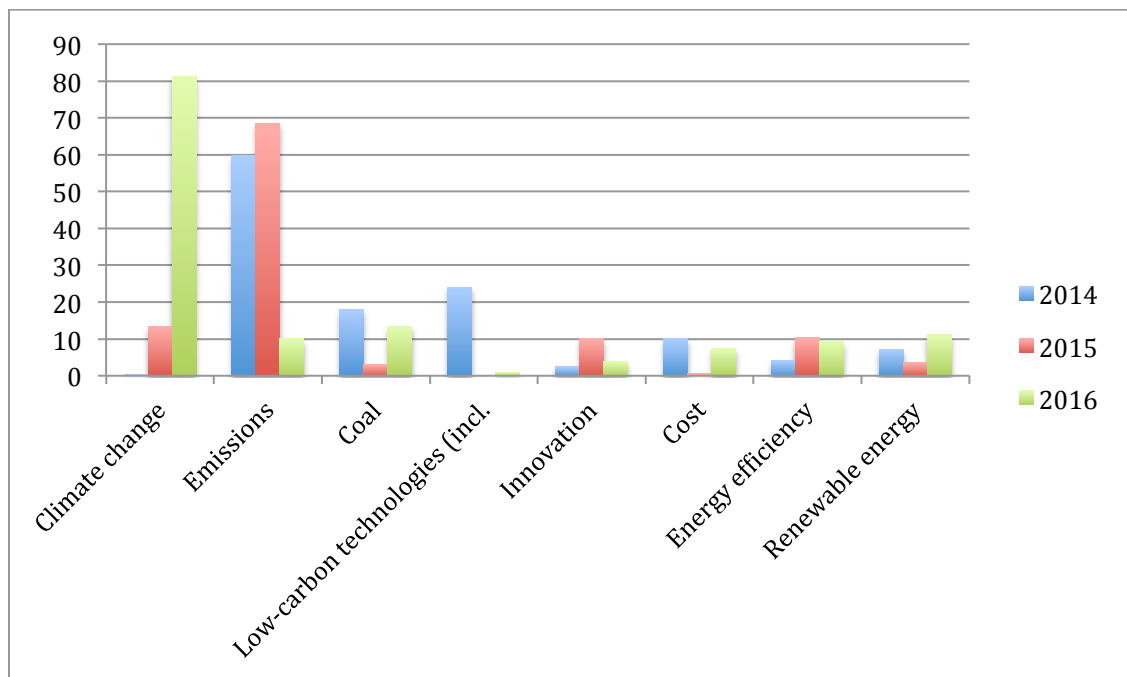
While the 2014 report does not mention the potential of renewables in mining at all, the following two sustainability reports highlight the potential seen in the integration of renewables in the operations. Looking at global markets driven by political decisions, the company refers to the fact that in 2015, renewable energy investments reached a record of US\$ 329 billion. Furthermore, the International Energy Agency (IEA) increased its forecast for wind and solar contribution to global power generation in 2040 by 12 per cent (BHP, 2016). These developments have resulted in a comprehensive BHP portfolio

analysis published in 2016 based on scenario planning, investment in renewable energy, and a clear commitment to the Paris Agreement. The analysis shows that thermal coal contributes 4 per cent to the company's revenue, while metallurgical coal contributes 11 per cent. Both, according to the analysis, are not attractive for investment anymore. Even though coal still remains competitive, any future investments require careful thought for two reasons: one is the global accord, growing regulatory and societal pressures and the other one is the failure in achieving the commercialisation of carbon capture and storage technology (Interview, 2017). Instead, copper (27 per cent of revenue contribution) and gas (10 per cent of revenue contribution) are considered to be competitive. Copper remains attractive due to growing demand driven by growth in renewable energy technology. It is also a substitute for other resources such as aluminium (BHP, 2016). BHP officially recognises in its 2016 reporting the increasing potential for renewable energy to play a significant role in the resources sector and battery storage solutions at grid scale, particularly to manage intermittency of renewable energy and provide security of supply in times of global environmental agreements urging businesses to eco-innovate, reduce GHG emissions and to contribute to the transition to a low-carbon economy with their competitive asset portfolios and cleaner production patterns.

While BHP span-off some of its coal operations to South 32, Rio Tinto has sold A\$ 2 billion worth thermal coal mines in recent years. It is shifting away from coal, selling assets so that earnings exposure to coal will reduce from 4.9 per cent to 2.5 per cent (Soliman et al. 2017). Rio Tinto's energy input stems mostly from coal (30 per cent) with a minimal decrease of 1 per cent, hydro with a slight increase (27 per cent), natural gas (18 per cent), diesel (13 per cent), nuclear (7 per cent) and fuel oil (4 per cent). Between 2014 and 2017, the company's energy mix remained mostly stable with no share of renewable energy. The analysis conducted in NVivo suggests an increase by 10 per cent from 0 per cent in the frequency of the code "renewable energy" between 2015 and 2016. This is likely due to the Paris Agreement and increased global debate on climate change in the year of 2015. In fact in 2016, among all identified codes "climate change" was the most frequent and emphasised one with about 80 per cent. In the 2014 report, Rio Tinto stresses that "renewable energy at a remote site is not an easy proposition even where it is

replacing expensive diesel generation, until economic storage is available, renewable energy is simply replacing the use of diesel, while diesel still remains as a back-up.” The technological and economic stage of battery storage causes concerns over intermittency and security of supply. The coding analysis tells us that coal still played a role in the reporting, as Rio Tinto is the third largest exporter of thermal coal. Coal is mentioned in the context of expected future role in ensuring security of supply and economic growth. The codes “innovation” and “energy efficiency” play a minor role in the report and show a declining trend in the company’s reporting. While the code “emissions” was very frequent, after 2015 it appears to have been replaced by the code “climate change” indicating the strong focus and influence of global debate.

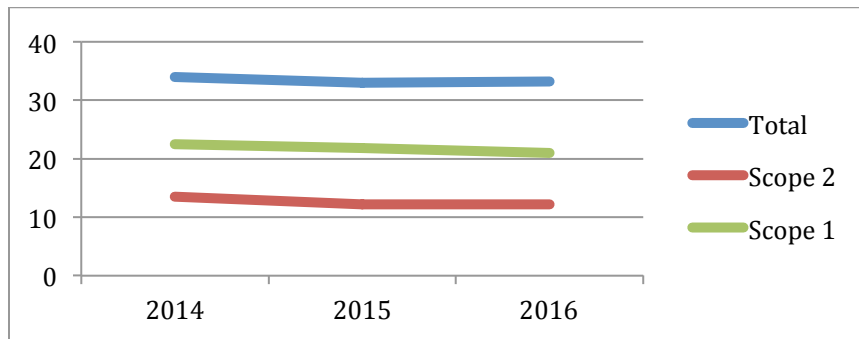
Figure 26. Rio Tinto sustainability reporting: Links to "energy" by relevance (%)



Rio Tinto describes climate change as one of the long-term challenges the industry faces. Therefore, the company takes steps to improve the carbon footprint with a clear focus on energy efficiency. Rio Tinto reports that it has made significant investments to meet its own emissions target set for 2020. According to the company, its own Energy Leadership Program has played a role in emission reduction by 30000 Megawatt/h of electricity and 30500t CO₂ equivalence. Nevertheless, the data reported in the sustainable reports

between 2014 and 2016 show that actually the level of emissions remained quite stable, showing the limited immediate decarbonisation effect of the Paris Agreement on everyday operations.

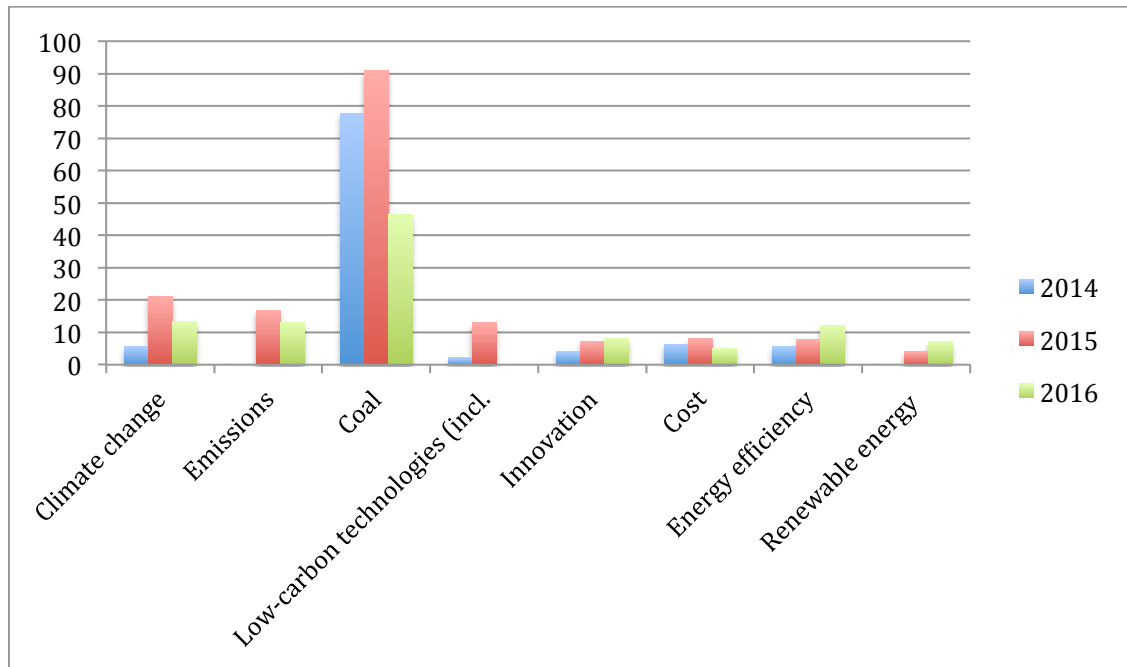
Figure 27. Rio Tinto GHG emissions between 2014-2016 (Mt CO₂-e)



Unlike BHP, however, the company has a greenhouse gas intensity reduction target of 24 per cent by 2020 (Rio Tinto, 2015). Since the company describes climate change as one of the long-term challenges the industry faces and introduces its focus areas for action: energy efficiency, carbon pricing scenarios to inform decisions, including capital expenditure.

The Paris Agreement has also resonated within Anglo American. The company has a climate change strategy to "protect business as well as host communities from climate change risks and contribute to mitigating global GHG" (Anglo American, 2016). The company describes its reaction to climate change as follows: "Anglo American's market risk and opportunities profile as it related to climate change has changed considerably since decision to exit coal mining; the refocused portfolio is well positioned to meet rising demand for copper and platinum, which are critical products for alternative energy technologies". The NVivo exercise shows that there has been an increase in the mentioning of renewable energy but it is still compared to climate change quite low. Climate change is mentioned more often in the context of reducing emissions and contributing to reaching the goals of the Paris Agreement. The code "coal" appears disproportionately high due to the various formulations regarding the intention to divest coal operations and investments.

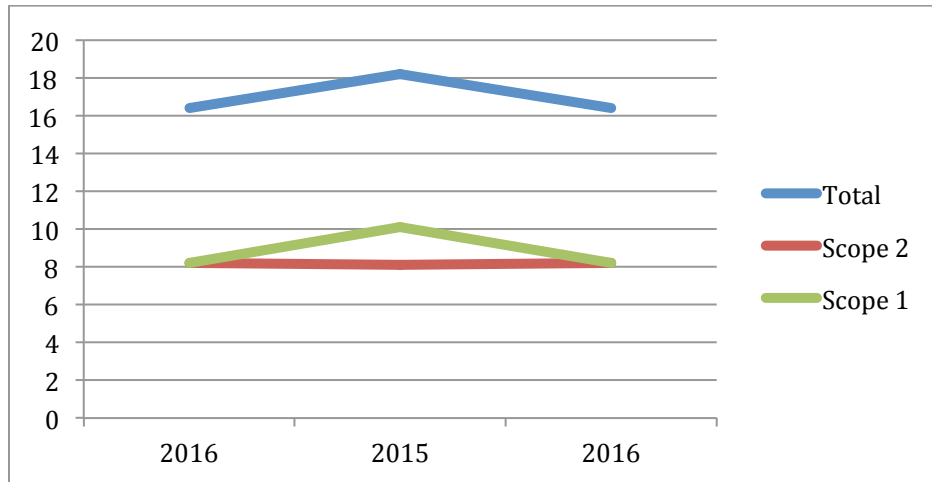
Figure 28. Anglo American sustainability reporting: Links to "energy" by relevance (%)



Anglo American announced plans to sell thermal coal assets to reduce exposure to business risks arising from ownership of these assets (Soliman et al. 2017; Anglo American, 2017). While the company wants to sell its coal assets, it anticipates increasing demand for copper due to its use in several low-carbon technology applications and also platinum, which is important for power stationary and mobile applications. The company mentions explicitly the role it wants to play as a mining company in the transition to a low carbon future: “Anglo American supports constructive efforts to help accelerate mining companies participation in transition to a low-carbon economy; in April 2016 the Anglo American Board supported special resolution proposed by shareholders – resolution in support of strategic climate resilience for 2035 and beyond”, seeking change in company’s disclosure to investors on how they assess climate change risks and opportunities. There should be annual reporting from 2017 on five areas: reducing operational emissions; maintaining portfolio assets resilient to climate change scenarios; supporting low-carbon economy research and development; defining key performance indicators in support of incentives; and defining public policy interventions.

Despite the different pressures and intentions, the company’s GHG emissions remained rather stable, similar to BHP and Rio Tinto, with a slight decline after 2015, when the Paris Agreement was concluded, i.e. between 2015 and 2016 the total GHG emissions were reduced to the level of 2014. The long-term effects of the Agreement need to be seen.

Figure 29. Anglo American GHG emissions between 2014-2016 (Mt CO₂-e)



In conclusion, the overall effect of the Paris Agreement on the three mining companies’ operational environmental performance has been limited. The GHG emissions remained relatively stable with a marginal increase in the aggregated use of renewable energy across different mining projects. Unfortunately, there is no specific mine site data available in the sustainability reports, which would have enabled a more differentiated analysis. Nevertheless, the Paris Agreement has resonated significantly in sustainability reports with a greater mentioning of the importance of making business decisions that are fit for a global low-carbon scenario. Therefore, the major eco-innovative effect of the Paris Agreement has been the beginning of a revision of company portfolios and decisions to divest carbon assets in anticipation of high costs and economic risks in such a low-carbon scenario.

In fact, mining companies such as Anglo American are exposed to a global pressure not only coming from the Paris Agreement but also from organisations such as the Financial

Stability Board (FSB). The Financial Stability Board reiterated its call for additional disclosures on climate risks, which would affect fossil fuel assets worth US\$ 43 trillion (The Daily Telegraph, 2017). If the commitments of the Paris Agreement hold, this would mean that countries like Australia, which is a party to the Paris Agreement, would need to keep about 90 per cent of their coal reserves in the ground unburned (McGlade and Ekins, 2015). The leader of the FSB Climate Taskforce Michael Bloomberg highlights in his interview with The Daily Telegraph that international climate commitments will hit the markets “with a volcanic force throwing up a whole set of winners and losers”. Experts claim that the FSB’s stance represents a radical change in corporate reporting and the concept of material risk and materiality. This impacts shareholder expectations as well, which demand new business strategies in response to international climate policies. Publicly listed companies and those with public debt are obliged to address climate risk in their reporting. The FSB suggests that companies could do more to inform investors and shareholders about potential risks and how they intend to tackle them. This is of crucial importance for companies, as developments in the coal markets have been an indicator of what could happen in the gas and oil sector as well, with much bigger assets and companies, if they do not shift their business strategies.

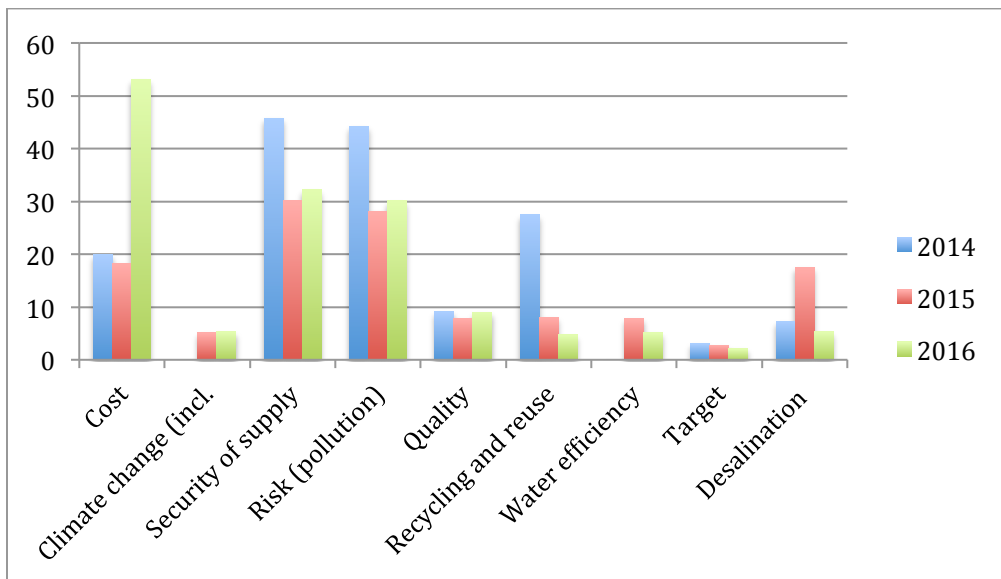
5.2. Domestic policy and institutional framework

In line with the analytical and theoretical framework, the difference in outcome of company decisions with regard to eco-innovation can be best explained based on the policy and institutional framework they operate in. The greater and clearer the exogenous constraints are, the more eco-innovative the company’s decision would be in order to eliminate costs of non-compliance. Therefore, this section analyses the link between Chile and Australia’s domestic policy and institutional framework and the investment decisions of the three mining companies. Furthermore, with a particular focus on water, the following analysis shows the convergence of interests between the Chilean government in enhancing the sustainable use of water resources and the business interest of mining companies to address financial risks arising from water scarcity and security of

supply concerns, which, in turn, had led to an increase in the use of desalinated water supported by enabling administrative procedures.

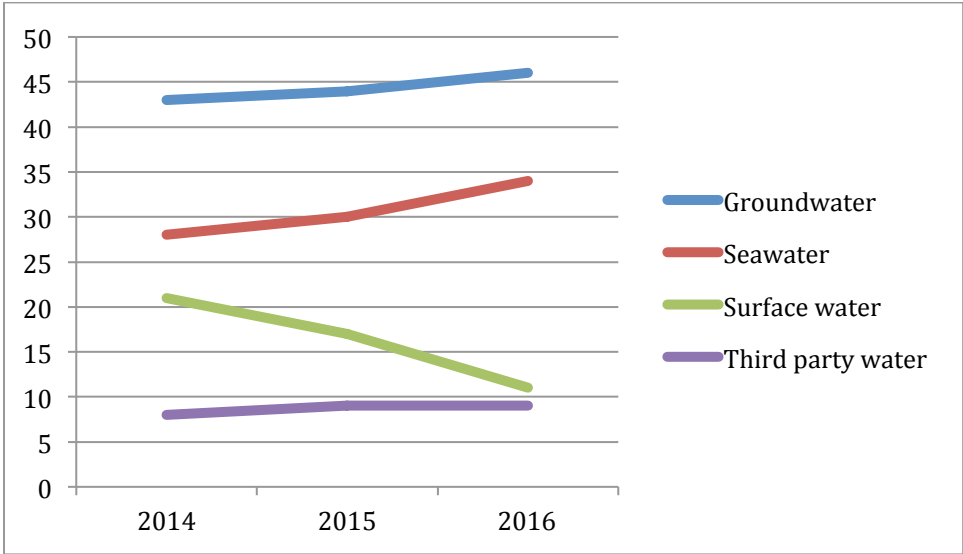
In 2013, BHP introduced a water target, which requires all projects to identify water-related material risks and to implement at least one project to reduce the impact on water and to improve water management. Since 2014, the company reviews once a year water challenges specific to the regions it operates in. With regards to water, the analysis below shows that costs and security of supply are the two main concerns along with concerns over risk of pollution. The biggest concern, however, seems to be the cost of water.

Figure 30. BHP sustainability reporting: Links to "water" by relevance (%)



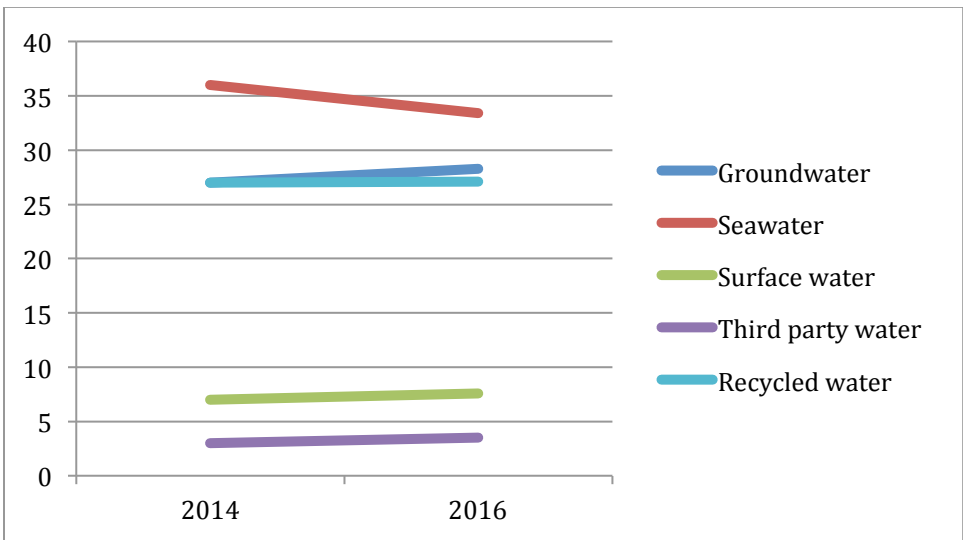
Overall, we see that the company's water consumption between 2014 and 2016 has gone down, while the input of groundwater, seawater and third party water, which comes from the municipality, increased. Yet, the use of surface water was reduced by 10 per cent between 2014 and 2016.

Figure 31. BHP water input by source in per cent between 2014-2016



Rio Tinto's water input by source did not change between 2014 and 2016. Seawater remained the largest input source, with a slight decline of 2 per cent, while groundwater and recycled water use increased by 1 per cent each. The lowest share can be seen in surface water use and third party water use, which is the water taken from the municipality.

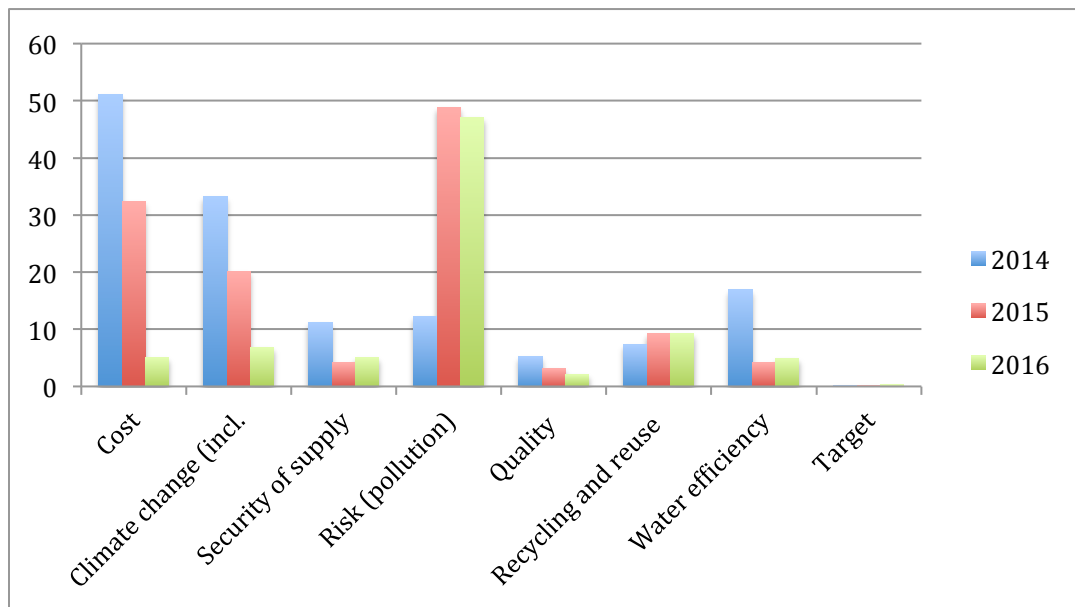
Figure 32. Rio Tinto water input by source in per cent between 2014-2016



In 2014, cost was the biggest concern regarding water, replaced by concerns over risk in 2016. Water reuse and recycling is referred to more often in the 2016 report, compared to

two years ago. Surprisingly, desalination is not mentioned specifically in any of Rio Tinto's sustainability reports between 2014 and 2016.

Figure 33. Rio Tinto sustainability reporting: Links to "water" by relevance (%)



One of BHP and Rio Tinto's largest mines is the Escondida copper-gold-silver mine which is located in the arid, northern Atacama Desert of Chile about 160 km southeast of the port of Antofagasta, at an elevation of 3,050 m above sea level. The mine is a joint venture between BHP (57.5 per cent), Rio Tinto (30 per cent), a Japanese consortium (10 per cent) and the International Finance Corporation (2.5 per cent). It came on-stream in 1990 and its capacity has since been increased by phased expansions to the current level of 230,000t/d ore throughput. The mine employs around 2,200 people. Minera Escondida produces more copper than any other mine in the world. It is a copper porphyry deposit that also produces gold and silver. Its two open-cut pits currently feed two concentrator plants which use grinding and flotation technologies to produce copper concentrate, as well as two leaching operations (oxide and sulphide). Escondida celebrated 25 years of operation during FY2016, having processed more than two billion tons of ore. In 2006, 338.6 million tons were mined (928,000 tons per day), of which 251.5 million tons were waste and oxide ore. Escondida shows how the policy framework and government support can enable large-scale investments in desalination.

In 2014 Chile's lower house members submitted a draft bill aimed to make the use of desalinated water in mining processes mandatory, in an effort to deal with the decreasing supply of the vital element and provide a solution to the industry's mounting power needs. In a press release the lawmakers said the bill would force miners that consume over 150 litres of water per second to incorporate desalinated seawater into their operations. "Communities in Atacama, the world's driest desert, often feel they have to compete with mining companies for their water supply (...) a president who vows to fight for the poorest, cannot sit back and do nothing about it," said a high-level mining industry executive (Mining.com, 2014). This situation has been perceived as a political signal, as the draft law has not been adopted yet. Nevertheless, a number of mining companies have already introduced desalination plants into their operations, including BHP's Escondida and the state-owned company Codelco. As the resource becomes scarce, especially in Chile's arid north where most mining takes place, authorities have begun to look into reforming the country's Water Code, which dates back to the General Augusto Pinochet's 1973-90 military regime. Chile's Copper Commission predicts growing demand for fresh water from the copper sector by 38 per cent by 2021. While the revision of the Water Code reform has not yet entered in force, together with production bottlenecks and growing competition over water with communities, it has stimulated the sector to take action to find eco-innovative solutions (Interview, 2015, 2016). Another enabling factor has been the fast track option for the approval of large infrastructure projects, such as desalination plants, to cut red tape and save time during project approval and implementation. The government aims with that procedural system to support infrastructure projects with broad based benefits for the common good (Interview, 2018). Hence, BHP, Rio Tinto and their two other partners were able to approve quickly an investment of US\$ 1,972 million to sustain operations at Escondida, Chile, by constructing a new 2,500 litre per second seawater desalination facility. The construction of the new desalination facility started in July 2013 and includes the development of two pipelines, four high-pressure pump stations, a reservoir at the mine site and high voltage infrastructure to support the system. "Securing a sustainable water supply in the Atacama Desert is a major priority for all Chilean copper producers, so the

approval of the Escondida Water Supply project is a significant milestone for our business. The new desalination facility will minimise our reliance on the region's aquifers, which will help us to meet our environmental commitments and enable us to achieve our long-term business strategy," said Peter Beaven, President of Copper BHP (BHP, 2013). This quote exemplifies that particular regional and local conditions can be the driver for sustainable and eco-innovative solutions in mining. It addresses local supply concerns and environmental concerns with business opportunities for expansion enabled by additional new sources of water input. Yet, the government's support, facilitating a faster approval process and the threat of introducing a binding quota, which has been a major exogenous factor, for the use of desalination, has been decisive. A senior official from the Chilean Copper Commission (Cochilco) and the former Minister of Mining highlighted during an interview that the sector tries to prove itself as a responsible resource steward, trying to show the government that binding regulatory measures are not needed.

Similarly, Anglo American has also invested in desalination in Chile. Anglo American is one of the world's largest mining companies with five coal mines in Australia and interests in four copper mines in Chile. 70 per cent of Anglo American's operations happen in water-stressed areas (Anglo American, 2014, 2015, 2016). Therefore, the company has introduced water, energy and GHG targets, aiming at reducing water incidents and leading to 69 per cent of operational savings (reused and recycled water) – mostly achieved through investments in advanced technology. Water shortage is one factor that puts investments at risk, creates a serious bottleneck for supply commitments and is of great concern for the ecological balance and livelihood of communities. Therefore, water plays an important role in Anglo American's eco-innovation profile. The company has spent in northern Chile over \$100 Million on a desalination plant and a pipeline to carry to Monteverde mine near Atacama. According to the company, that desalination plant is 30 per cent more efficient than others in the world. Anglo American has also a water strategy, which consists of three phases and stretched over a 10 year period: investing in technology to achieve water reduction target introduced in 2011 –14 per cent by 2020 reduction. The reported numbers show that the consumption of water

went down between 2013-2014 while consumption was rising previously between 2010 and 2013 (Soliman et al. 2017).

Figure 34. Anglo American water input by source in per cent between 2014-2016

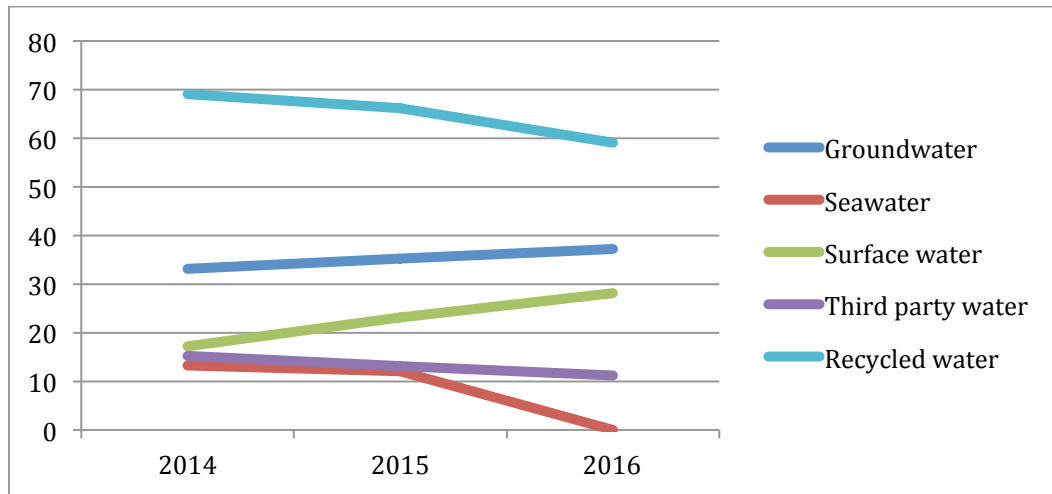
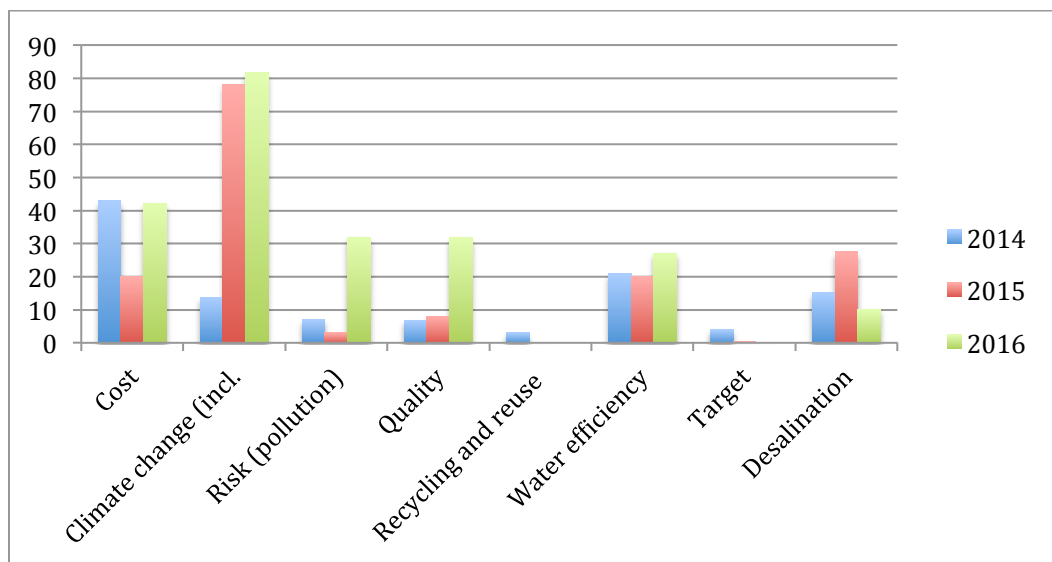


Figure 35. Anglo American sustainability reporting: Links to "water" by relevance (%)



As figure 35 shows, the company stresses most the importance of climate change effects in relation to the availability of water as well as cost concerns and desalination opportunities. Soliman et al. (2017) highlight that the company has the strongest water governance framework and policy compared to its peers. However, the reported numbers

in the company's sustainability reporting between 2014 and 2016 (see figure 34) show an increase in groundwater use, a significant decline in the use of seawater and significant increase in the use of surface water. Despite high ambitions of addressing water stress in its mine sites and investments in desalination, the extent of eco-innovation in relation to the use of water resources seems, therefore, rather modest.

In conclusion, the strong articulation of the Chilean domestic policy focus on water has given incentives to act for companies. Their investment in desalination is a strategic choice and can be seen as a push for eco-innovation in water. It is, however, not yet fully aligned with attempts to produce the energy needed for this technology from renewable sources.

5.3. Cooperation between public institutions and the private sector

Similar to the analysis in the comparative chapter on Australia and Chile, the analysis below illustrates how important the cooperation between public institutions and the private sector are for eco-innovation. Such cooperation can be effective despite deficiencies in the policy and institutional framework, lack of horizontal cooperation and the existence of incumbents from the fossil fuel industry resisting regime change, as the analysis below shows. For a large-scale transition towards eco-innovation, a robust and enabling policy and institutional framework would be clearly indispensable, however, cooperation between public institutions and the private sector can make an incremental, smaller scale contribution towards eco-innovation in the sector, following signals for expected policies.

One of the very first renewable energy projects in mining funded by ARENA is Weipa, a mining project owned by Rio Tinto. Weipa bauxite mine and processing facilities in north Queensland, has to date the largest solar array supporting the mining operation. The project is planned to be extended in its electricity generation capacity and might include battery storage in the next coming years (Interview, 2016). The project provides up to 20 per cent of the mine's energy needs and communities at Weipa, cutting Rio Tinto's diesel

use by around 600,000 litres a year (RenewEconomy, 2015). The Weipa solar PV facility is the first of what is expected to be many mining facilities to turn to solar PV and other technologies for reduce the costs of electricity. The company highlights the difficulties as well and how problems were addressed: "Renewable energy at a remote site is not an easy proposition even where it is replacing expensive diesel generation; until economic storage is available, renewable energy is simply replacing the use of diesel, while diesel still remains as a back-up; cost of building and maintaining renewable energy generation in remote locations is much greater than in urban locations; Rio Tinto Alcon, First Solar, and ARENA reached a joint agreement in 2014 to develop a 1,7 Megawatt solar capacity at Weipa. First solar constructed and operated it - 18000 solar panels, ARENA provided A\$ 3.5 million for 15 year purchase agreement." This is the very first renewable energy project in Australia facilitated by the Australian Renewable Energy Agency for the mining industry.

As discussed in the previous chapters, Australia has a very decentralised energy policy framework and cannot exploit its full potential in terms of the expansion of renewables because of the lack political will and coordination. Systemic problems in the country's energy policy, e.g. lack of interconnectedness with neighbouring states, the absence of a national risk preparedness plan, were particularly evident in South Australia's electricity outage, with some very high costs for the mining projects in the state. The policy failure to address potential energy crises at the national level through better coordination has cost BHP and other mining companies millions of Australian Dollars. In September 2016, South Australia was hit by a storm, which brought down power lines, including major transmission lines, leading to a series of rapid system faults (Wood et al., 2017). During these events, BHP's Olympic Dam mine experienced a five-hour power outage, and was not the only one. BHP faced between 2016 and 2017 a low-production year, in which copper production fell by 16 per cent because of power outages (The Australian, 2017). The electricity outage cost BHP's Olympic Dam mines A\$ 135 million. The deficiencies in the country's policies and institutions have moved BHP to take its own initiative. BHP has provided funding for "knowledge sharing" on a large-scale solar and battery storage project in north Queensland, which has attracted the mining company's interest. BHP is

looking for a suitable technology for its remote and off-grid mine sites. The project, near Lakeland south of Cooktown, will combine 10.4MW of solar PV with 1.4MW/5.3MWh of lithium-ion battery storage, and is being pitched as a world-first for remote, edge of grid technology, and one likely to trigger a host of similar projects across Australia. The German company Conergy, co-funded with A\$ 17.5 million by the Australian Renewable Energy Agency (ARENA), develops the A\$ 42.5 million project. A power purchase agreement with Origin Energy has been signed. That will be Origin's fourth solar project in the last few months, following its deals with Moree, Clare, and the DeGrussa mine facility. Three of these have been co-funded by ARENA, and two of these – Lakeland and DeGrussa – have been paired with battery storage. Being an important producer of coal at the same time, BHP reiterated its call for a climate policy that sets a price on carbon and does not favour one technology, namely renewable energy, over others, but treats carbon capture and storage equally. The company asked the on governments to promote and invest in CCS in order to meet the requirements of the Paris Agreement. “We have seen the successful growth of some low carbon energy sources, such as wind and solar, by incentivising its uptake. (...) To ensure we reduce emissions and maintain energy security, we need a level playing field for all forms of low carbon technology. Without policy parity, CCS will be disadvantaged as it seeks to scale up” (The Australian, 2016). Access to finance provided by ARENA and joining forces with foreign companies enabled BHP to pursue the use of off-grid renewables. Conergy Australia highlights the great opportunity in Australia for the widespread use of utility-scale batteries to store surplus power from additional solar generation it will create a consistent power supply, even during times of lack of sun, and is expected to produce enough electricity to power the equivalent of over 3.000 homes day and night. Other larger solar and storage projects are placed along the main transmission line leading to BHP's Olympic Dam project. Battery storage is an issue that attracts increasing attention of mining companies such as BHP. The head of environment at BHP, Graham Winkelman, highlights in his interview with RenewEconomy (2016) that solar and storage projects may help BHP Billiton reduce its own operating emissions while helping to support energy reliability at some of the more remote operations (RenewEconomy, 2016). The potential of battery storage is recognised as an opportunity for operations in remote areas

with lack of infrastructure and grid connection. The Lakeland Solar and Battery Storage Project is expected to generate knowledge on the performance of solar and storage systems with network and industrial loads. It would be a major step towards energy security and emission reduction on a larger industrial scale. There are now a growing number of solar and storage projects under construction or already running in Australia, including the DeGrussa and Weipa mines, all funded by ARENA.

In conclusion, while the Paris Agreement has not shown any concrete effects on everyday emissions or energy use except for some divestment and plans, which need to unfold their concrete effects yet, other global initiatives related to the environment are too broad and patchy to unfold a significant impact. Eco-innovation in the sector is largely moved by national policies and cooperation between the public and private sector at the national level. The analysis shows again that despite veto players in a country, progress is possible if there is an enabling framework with structures in place to facilitate such a cooperation, particularly helping to overcome knowledge gaps and challenges related to access to finance.

5.4. Conclusions on the mining sector

The data analysis shows that GHG emissions have remained stable and the uptake of renewable energy has been modest, suggesting a limited immediate effect of the Paris Agreement. All three companies' sustainability reporting social and economic topics play a significant role, representing half of the attention given, while the other half is given to environmental issues, covering water, energy, climate change and biodiversity issues. The strong emphasis on human rights as well as health and safety support the proposition that environmental sustainability is mostly restricted to the performance at the local level. This is also clearly linked to the broad focus of international initiatives such as the ICMM's ten principles or the structure of the GRI reporting standards and the absence of a targeted environmental initiative tailored to the sector and supporting eco-innovation. Nevertheless, climate change and emission reduction have become a strong area of attention for the three companies analysed, especially after the conclusion of the Paris

Agreement, which will affect the demand in commodity markets and create economic risks if the portfolios are not revised in line with a global low-carbon scenario.

Furthermore, even though the total use of water has increased in total, the share of recycled water and seawater is also increasing. The analysis of water policies shows that domestic policy and institutional frameworks play an important role for eco-innovation in that area. The case study analysis on Australia shows that water scarcity alone is not sufficient to move the sector towards eco-innovation. Despite water scarcities, the mining sector in Australia does not invest as much as it could in desalination or water efficiency because of the self perception of not being as big of a problem as the agricultural sector, which is the largest user of water in the country. Despite an understanding of water scarcity creating a business risk, the economic value added of every unit of water used in mining is perceived as significant by the public authorities and the sector, which creates a lack of pressure for the sector to do better. The complementary firm-level analysis in the Chilean context shows, on the other hand, that coercive policy signals (here: the threat of introducing a binding target for the use of desalinated water) and enabling administrative support can be a driver for eco-innovative investments in mining, such as investments in desalination, and convergence of strategic preferences such as addressing competitiveness concerns arising from the lack of water supply, creating business risks.

Moreover, similar to the country analyses, the analysis of the mining sector shows the importance of cooperation between public institutions and the private sector for eco-innovation. Such cooperation can be effective despite the absence of targeted environmental initiatives for the sector, deficiencies in the policy and institutional framework, lack of horizontal cooperation and the existence of incumbents from the fossil fuel industry resisting regime change. Cooperation between public institutions and the private sector can make an incremental, smaller scale contribution towards eco-innovation in the sector as the focused analysis on the integration of renewable energy shows. Such small steps to include renewable energy in mining operations together with better water management in Chile, however, will still need to meet the larger challenges ahead for the industry of shifting away from fossil fuels.

6. Conclusions and perspectives

The global low-carbon transition, underpinned by the Paris Agreement and the 2030 Agenda, is an important collective effort to tackle climate change and achieve sustainable development worldwide. This trend will affect developing and emerging economies with large extractive sectors in several ways. While advanced, resource-dependent economies decarbonise progressively, resource-rich countries could be pushed to specialise even further in emission and resource-intensive segments of the global economy, thereby reinforcing the need to address sustainability in the extractive sector in resource-rich economies.

The successful transition to a low-carbon economy and achievement of sustainable development goals will require significant technological change, particularly in the electricity, water and road transportation sectors. These technologies require large amounts of minerals. Low-carbon energy systems are more mineral-intensive than traditional energy systems. The world is relying on low-carbon technologies such as wind, solar and batteries – each of these requiring large amounts of base and specialty or niche minerals. Despite different scenarios based on various assumptions concerning the penetration of low-carbon energy technologies, uncertainty exists on the pace at which options for substitution will become available. Even considering potential substitutes and recycling, there will be a growing demand for primary materials. In the case of several materials, it is necessary to exploit new deposits, which may have lower ore grades than currently available ones. Extracting from ore bodies with lower metal concentrations means that more energy coupled with more emission intensity, water and auxiliary materials will be needed with possibly higher environmental impacts. In this context, this dissertation aimed at contributing to the development of insightful, impact-oriented country-level policy analysis, focusing on the link between resource-based growth and eco-innovation. This research is relevant because it looks at eco-innovation trends in those countries, led by international agreements and organisations, domestic policy and institutional frameworks, and the cooperation between public institutions and the private sector.

This research tried to address the questions of why Australia performs worse in reforming its policies and institutions in support of eco-innovation than Chile despite similar challenges and potentials; what the role of international agreements, institutions and the national policy frameworks are in explaining the differences in eco-innovation trajectories and to what extent the existence of resource scarcity and climate change effects influence policy outcomes in both countries; as well as to what extent domestic actors and veto players influence the eco-innovation trajectories. It also tried to answer the question, why mining companies, operating in both countries and facing similar environmental risks, follow different investment strategies in Chile than in Australia. These questions were guided by the broader interest in answering the question of how eco-innovation in resource-rich countries looks like and what transition pathways lead towards a cleaner and more sustainable growth model and what role institutions and domestic actors play in such a transition.

The research started by identifying gaps in the literature it aimed to address, locating at the same time this PhD research in the wider literature. The literature review provided a detailed discussion of the different strands and concepts related to resource governance and development, identifying the need to align the traditional and predominant literature on resource-based economic growth and development with concepts of resource productivity, ecological modernisation and eco-innovation, which have been mostly focusing on resource-dependent, industrialised countries with a large manufacturing base. It discussed outstanding academic works, which make the case for integrating environmental protection and eco-innovation into the broader academic discussion of resource governance, with which this dissertation aligns itself and aimed to advance as a subject of study in the context of resource-rich countries. While scholars of the resource governance and development strand call for a strong government role vis-à-vis private business in the extractive sector in order to increase the economic benefits of revenues and to ensure the equal distribution of the benefit across the population, they focus solely on extraction-led development models to improve the standard of living within the country. However, they neglect the environmental risks related to water scarcity, climate

change, increasing emissions and energy use due to declining ore grades and increasing demand. The depletion of metal reserves and declining ore grades must be taken into account when evaluating the economic benefits associated with extractivism. At the conceptual level, there was the need to integrate concepts of ecological modernisation and eco-innovation in the influential and interesting strand of the resource governance literature; not only to mitigate potential environmental costs but also to capitalise on the economic benefits of adopting eco-innovative measures, such as enhancing competitiveness, saving costs and benefitting from technology and knowledge transfer based on win-win solutions with international partners. The biophysical data of material intensity and water, energy footprints suggests that if sustainability is not addressed seriously as part of the development agenda, in terms of broader indirect effects, the trade-off between financial incomes and high environmental costs may ultimately lead to a failure to achieve the sustainable development goals. Therefore, the question is how resource-rich countries react to these potential challenges, how they position themselves in terms of public policy and how stakeholders adapt and gear themselves up.

In order to understand how an eco-innovation transition pathway under such specific circumstances could look like, this research decided to analyse two resource-rich countries who are members of the OECD and have undertaken some steps towards eco-innovation – though to different degrees and for different reasons. Methodologically, the comparative case study design in combination with process tracing, semi-structured interviews, document/content analysis and coding have proven to be particularly useful in unpacking the different eco-innovation policy outcomes in Chile and Australia despite various similarities and the reasons behind political choices. The case study design enabled the research to take different variables into consideration and look at historical explanations and complex inter-relation between different prevailing interests and domestic actors. Different sources of documents and regulations were analysed and validated or “saturated” with the help of semi-structured interviews conducted with professionals from academia, government, private sector and civil society. Coding has enabled this research to conduct a structured, standardised analytical exercise, providing further insights on government interests and preferences influencing policy and

institutional decisions. For the detailed exploration of the reasons behind specific eco-innovation investments and priorities of BHP, Rio Tinto and Anglo American, process tracing linked to the different levels of causal mechanisms (international agreements, domestic policy and institutional frameworks and structure and degree of cooperation between public institutions and the private sector) has proven useful. This was methodologically triangulated with semi-structured interviews to validate preliminary conclusions. Coding has proven to be particularly useful to understand how the three large mining companies define sustainability and to conclude implications based on these definitions and perceptions for the overall eco-innovation performance of the sector. NVivo helped analysing positions and preferences, which were gathered through automatised, systemised document search and word frequency analysis. Through query functions the context the codes appeared in were analysed generating interesting insights. Coding has particularly proven useful to understand how the three large mining companies define sustainability and to conclude implications based on these definitions and perceptions for the overall eco-innovation performance of the sector. Coding was complemented with contextual, qualitative detailed document analysis and interviews, which served as an effective validation exercise. The comparative nature of the empirical part, contrasting different effects of different drivers with the help of process tracing, document analysis and semi-structured interviews, taking specific actor preferences as well as domestic policy and institutional framework into account, has helped in deriving policy conclusions for the transition towards eco-innovation in mining countries and understanding the role of institutions and domestic actors in such a transition.

In order to understand the policy and institutional decisions on eco-innovation, this thesis undertook a comparative analysis of Australia and Chile. As outlined above, these two countries represent resource-rich OECD countries with different approaches to eco-innovation despite similar environmental challenges, such as exposure to climate change effects, water scarcity and similar potentials for renewable energy production. Following the outlined analytical framework, the comparative chapter addressed, the questions of why Australia and Chile perform differently in reforming their policies and institutions in support of eco-innovation by analysing different levels of analysis and causal

mechanisms with a focus on the role of international agreements and organisations (level one), the domestic policy and institutional framework (level two), the structure of collaboration between public institutions and the mining sector (level three), and finally, the role of domestic veto players as a particularly important factor for regime change resistance (level four).

As for level one, the research found that global climate change agreement and trade and cooperation agreements have unfolded eco-innovation effects in terms of policy and practice in Chile, which has led to the country undertaking a rapid catch up in international collaborations on eco-innovation. This has been partly driven by international actors, whose economic interests are well aligned with those of domestic players. Chile addresses the need to cope with energy security challenges and capitalises on its renewable energy potential using the global decarbonisation agenda to its economic advantage by facilitating access to finance and mobilising foreign investment. This can be seen in line with rational choice institutionalisms in terms of convergence of preferences between the domestic level and the international one to reduce risks and create economically and environmentally win-win outcomes. On the other hand, the Australian case shows a high degree of lack of continuity and determination in political will to transform its policies based on an active participation at the global level, seeking alliances with actors with whom win-win situation could be created in terms of creating new business models and achieving access to finance for the transition. From a rational choice perspective the reasons stem from existing domestic vested interests pulling in one direction, hindering at the same time justified interests to cope with climate change impacts and develop innovations.

Referring to the second level of analysis, the role of a robust policy framework based on inter-institutional coordination, consistency and continuity, reducing uncertainty and supporting investments in eco-innovation was analysed. Consistent policy roadmaps and strong institutions supported by horizontal coordination across government create a level playing field for private sector actors making cost and risk calculations more predictable, reducing transaction and influence costs, thus incentivising investments for eco-

innovation. The comparative chapter contrasted the different policy and institutional frameworks of Australia and Chile, highlighting the lack of clear coordination in energy, climate and water policy in Australia, as one possible reason for the less promising eco-innovation policy outcomes – compared to Chile, which has several horizontal coordination mechanisms, contributing to policy certainty, consistency and coherence.

From a rational choice institutionalism point of view, the absence of a consistent, clear policy and regulatory framework due to the lack of horizontal coordination and collaboration towards the common goal of addressing environmental challenges creates loopholes in the system and a lack of exogenous factors conditioning and guiding private actor decisions. A clear policy and regulatory framework with shared goals that applies to all companies would create same opportunities, such as equal access to financial support, equal obligations to comply with policy objectives and targets, creating ultimately a level playing field minimising first mover risks and investor uncertainty. The analyses showed clearly that Chile has effective horizontal coordination – unlike Australia – and an inclusive process that together led to nation-wide renewable energy targets with bipartisan support. Such combination of horizontal and foresight coordination has been leading to continuity and certainty despite change in government. The country has favorable conditions to deploy renewables and its supportive regulatory framework has encouraged significant investment in the sector. Australia, on the other hand, suffers from the “challenge of multi-jurisdiction cooperation”, which is particularly evident in the field of energy policy, where different states have different targets, distorting the national energy market. The lack of horizontal coordination and central steer and the lack of a shared viable perspective from Canberra is the main impediment for progress in terms of eco-innovation. As presented in the analytical framework, one important causal mechanism for strong eco-innovation outcomes is the existence of a robust policy framework based on inter-institutional coordination, consistency and continuity, which reduces uncertainty and supports investments in eco-innovation. The research finds that the combination of policy insights, consistent roadmaps and strong institutions supported by horizontal coordination across government create a level playing field for private sector actors with strategic economic interests, making cost and risk calculations more

predictable, reducing transaction and influence costs, thus, incentivising investments for eco-innovation.

The research also addressed the role of cooperation between public institutions and the private sector as one important determining factor for successful eco-innovation outcomes. Both the ecological modernisation and eco-innovation literature assert that joint efforts, or coordination, for eco-innovation between inclusive, moderating institutions and private sector actors with strategic economic interests and fixed preferences, such as competitiveness, cost and risk reduction, can manage expectations, lead to overcoming information deficits, and a swifter shift from market failures (environmental pollution, depletion of water resources) to positive externalities, i.e. investments in eco-innovation and the development of new business models. Such shift can potentially be disruptive for resource-rich countries: While mining countries with large fossil fuel deposits face the risk of “stranded assets” and “unburnable carbon”, if they extended their policies to support fossil fuels, cooperation could also initiate a shift away from fossil fuels towards minerals and diversification. For all resource-rich countries with endowments in minerals that are needed for the low-carbon transition, the global decarbonisation agenda can be an opportunity not only to export competitive commodities but also to decarbonise their economies. Particularly with regard to energy policy, the transition to clean energy could provide energy security and lower energy costs in the medium term, contributing at the same time to greater competitiveness. Around these goals, the private sector and public stakeholders could converge their preferences and find common solutions. In this context, surprisingly, the Australian case shows that despite the influential existence of system incumbents and veto players in the energy sector, a low-carbon transition and eco-innovation in the mining sector can start to emerge. Such novel collaboration is based on a cooperation between public institutions and the private sector, as seen in the case of ARENA and Rio Tinto for example, to overcome knowledge gaps and first mover risks linked to investments in untested and new technological solutions. In line with rational choice institutionalism, in both cases, Chile and Australia, access to finance, facilitated by the government, to address such

economic risks and costs have unfolded a positive and encouraging effect, supporting the increasing use of renewables in mining.

The fourth level of analysis looked into the issue of domestic veto players, which, based on the literature review and theoretical discussion, could have provided a strong explanation for resistance to regime change, hence, for explaining the major difference in political outcomes between Australia and Chile. Theoretical and analytical considerations suggested that the higher the number of incumbents, the less ambitious would be the policy and institutional framework. These could be state institutions with different priorities, such as trade promotion, or significant energy producers as part of fossil fuel based supply systems. The section served addressing the question of why Australia has a lower level of ambition in terms of eco-innovation and to what extent domestic actors and veto player influence the eco-innovation trajectories of the country. Linking to the first level of analysis focusing on international agreements and organisations, the struggle of the Australian government to commit ambitiously to the global decarbonisation efforts is partially influenced by the existence of fossil fuel producers and their significant economic weight. However, as the analysis of ARENA's role in Australia showed, these dynamics, blocking or slowing down the transition towards a low-carbon economy and eco-innovation can be overcome to some extent through an effective cooperation between public institutions and the private sector, aligning their preferences around common goals of reducing costs and enhancing competitiveness. This is a surprising and important insight this research provides. Even though the analytical and theoretical reflections would suggest the existence of incumbent veto players in the energy sector hindering regime change, the analysis showed clearly that incremental changes within are possible and may lead over time to a larger transition; the multi-level analysis that includes corporate actors offers insights into how such transitions might work for resource-rich countries and their vested mining actors.

To conclude on policies, the comparative empirical chapter has come up with responses to the question of why Australia and Chile perform differently in reforming their policies and institutions in support of eco-innovation. The PhD did so by analysing different

levels of analysis and causal mechanisms with a focus on the role of international agreements and organisations, the domestic policy and institutional framework, the structure of collaboration between public institutions and the mining sector, and finally, the role of domestic veto players as a particularly important factor for regime change resistance.

While the comparative country analysis chapter addressed the question of to what extent the international level, the national policy and institutional frameworks, the public-private collaboration structures and incumbent veto players have an influence over Australia's and Chile's eco-innovation policies and decisions, the chapter on mining companies took a closer look at the effects of the same analytical levels on the mining sector, focusing on three major companies, which have operations in both countries and are similar in terms of their size, portfolio and sustainability reporting structures. The chapter aimed at analysing the eco-innovation profiles and how environmental sustainability is perceived by the sector. It also aimed at understanding which one, if any, of the causal mechanisms this thesis identifies, has a significant effect on company performance and decisions related to eco-innovation. It addressed the question of why mining companies, operating in both countries and facing similar environmental challenges, follow different investment strategies in Chile than in Australia. The chapter examined what these different levels of analysis mean for the decision and practices of three mining companies, namely BHP, Rio Tinto and Anglo American, in Chile and Australia. Certain environmental investment decisions could have been the result of a calculation of transaction costs and risks, as rational choice institutions asserts, or of a socialisation process within an organisation that influences the perception of what is the "appropriate" decision to make. Norm diffusion and sociological institutionalism would suggest similar eco-innovative outcomes in Chile and Australia, if the company is the same and part of the same institutions or international initiatives, forming the corporate identity in a normative way. Yet, the analysis on the three companies showed clear differences between the same company's investment decisions and performance in the two countries.

The research found that the initial overall effect of the Paris Agreement on the three mining companies' operational environmental performance has been limited so far. The GHG emissions remained relatively stable with a marginal increase in the aggregated use of renewable energy across different mining projects. Unfortunately, there is no specific mine site data available in the sustainability reports, which would have enabled a more differentiated analysis. Nevertheless, the Paris Agreement has resonated significantly in sustainability reports with a greater mentioning of the importance of making business decisions that are fit for a global low-carbon scenario. Therefore, the major eco-innovative effect of the Paris Agreement is yet to come, and our thesis reveals how new strategies emerge on the revision of company portfolios and decisions to divest carbon assets in anticipation of high costs and economic risks in future low-carbon scenarios. Regarding the sector's sustainability perceptions, the research found that health and safety, human rights and community issues occupy almost half of the topics covered in corporate sustainability reporting, which might represent a "cognitive barrier" to eco-innovation due to the broad definition of sustainability. The strong emphasis on human rights as well as health and safety suggest that sustainability is mostly restricted to the performance at the local level. Yet, despite the focus on local environmental effects, after the conclusion of the Paris Agreement in 2015, climate change and emission reduction have become a strong area of concern for the three companies analysed, proving the importance of global environmental decisions as drivers of eco-innovation.

The research found in line with the analytical and theoretical framework that the difference in outcome of company decisions with regard to eco-innovation can be best explained based on the policy and institutional framework they operate in. The greater and clearer the exogenous constraints are, the more eco-innovative the company's decision would be in order to eliminate costs of non-compliance. Therefore, this section analysed the link between Chile and Australia's domestic policy and institutional framework and the investment decisions of the three mining companies. Furthermore, with a particular focus on water, the analysis showed the convergence of interests between the Chilean government in enhancing the sustainable use of water resources and the business interest of mining companies to address financial risks arising from water

scarcity and security of supply concerns, which, in turn, has led to an increase in the use of desalinated water supported by enabling administrative procedures.

Similar to the analysis in the comparative chapter on Australia and Chile, the analysis illustrated how important the cooperation between public institutions and the private sector are for eco-innovation. Such cooperation can be effective despite deficiencies in the policy and institutional framework, lack of horizontal cooperation and the existence of incumbents from the fossil fuel industry resisting regime change, as the analysis below shows. For a large-scale transition towards eco-innovation, a robust and enabling policy and institutional framework would be clearly indispensable. Without a supporting coherent policy framework a potential upscaling of eco-innovative trends will have its limitations. Nevertheless, cooperation between public institutions and the private sector can make an incremental, smaller scale contribution towards eco-innovation in the sector. As illustrated in the empirical chapter, despite veto players in a country, progress is possible if there are structures in place to facilitate such cooperation to kick-start eco-innovation, particularly helping to overcome knowledge gaps and challenges related to access to finance.

The data analysis on the eco-innovation performance of mining companies showed that GHG emissions have remained stable and the uptake of renewable energy has been modest, suggesting a limited immediate direct effect of the Paris Agreement. All three companies' sustainability reporting social and economic topics play a significant role, representing half of the attention given, while the other half is given to environmental issues, covering water, energy, climate change and biodiversity issues. The strong emphasis on human rights as well as health and safety support the proposition that environmental sustainability is mostly restricted to the performance at the local level. This is also clearly linked to the broad focus of international initiatives such as the ICMM's ten principles or the structure of the GRI reporting standards and the absence of a targeted environmental initiative tailored to the sector and supporting eco-innovation. Nevertheless, climate change and emission reduction have become a strong area of attention for the three companies analysed, especially after the conclusion of the Paris

Agreement, which will affect the demand in commodity markets and create economic risks if the portfolios are not revised in line with a global low-carbon scenario.

Furthermore, even though the total use of water has increased in total, the share of recycled water and seawater is significant and indicates a readiness for strategic changes. The analysis of water policies highlighted that domestic policy and institutional frameworks play an important role for eco-innovation in that area. Water is a global and regional challenge at the same time. From a rational choice institutionalism perspective, due to its immediate regional importance, it is less suitable for free riding; as it is can be the case with global public goods such as climate change. However, the case study analysis on Australia showed clearly that water scarcity at the regional or local level alone is not sufficient to move the sector towards eco-innovation. Despite water scarcities, the mining sector in Australia does not invest as much as it could in desalination or water efficiency because of the self perception of not being as big of a problem as the agricultural sector, which is the largest user of water in the country. Despite an understanding of water scarcity creating a business risk, the economic value add of every unit of water used in mining is perceived as significant by the public authorities and the sector, which creates a lack of pressure to do better as the sector. The complementary firm-level analysis in the Chilean context illustrated, on the other hand, that coercive policy signals as an exogenous constraint (i.e. the threat of introducing a binding target for the use of desalinated water) and enabling administrative support can be a driver for eco-innovative investments in mining, such as investments in desalination, and convergence of strategic preferences such as addressing competitiveness concerns arising from the lack of water supply, creating business risks. Thus, it is the combination of policy signals and business vulnerabilities that seem to create a space for action, and less corporate actors themselves.

Accordingly, similar to the country analyses, the analysis of the mining sector showed the importance of cooperation between public institutions and the private sector for eco-innovation. Such cooperation can even be effective despite the absence of targeted environmental initiatives for the sector, deficiencies in the policy and institutional

framework, lack of horizontal cooperation and the existence of incumbents from the fossil fuel industry resisting regime change. Cooperation between public institutions and the private sector can make an incremental, smaller scale contribution towards eco-innovation in the sector as the focused analysis on the integration of renewable energy shows. Incremental changes supported by financial instruments (e.g. pre-investment subsidies, loan-based financial support) and technical support (e.g. knowledge exchange, active promotion of specific technologies, data and policy foresight) provided by public institutions can encourage a polluting sector such as mining with a comparatively low eco-innovation profile to test cleaner technologies and adopt those at a larger scale, if they prove to save cost, reduce business vulnerabilities and enhance competitiveness.

This leads us to the question to what extent these conclusions on emerging eco-innovation trends and underlying supporting mechanisms in Chile and Australia are transferable in other country contexts and whether Australia and Chile are appropriate benchmarks for other resource-rich countries, particularly developing ones. There are obviously limits to the transferability of the results of this PhD research to other countries since both, Australia and Chile, are members of the OECD with developed institutional capacities. Despite being a “newcomer” to the OECD and not having a long history of environmental policies and institutions, Chile’s the political ambition as well as extent and pace of reform that supports eco-innovation is surprising and remarkable, which can be a source of inspiration and peer learning for other emerging resource-rich economies and even developing ones. In terms of policy process, Chile has shown an internationally outstanding example of an inclusive process based on public consultations to develop an energy policy roadmap including several targets to attract investments and support investor certainty. Without spending large amounts of subsidies, as some European countries with large budgets do, the country provides small-scale financial support for pre-investment feasibility studies to encourage mining businesses to generate knowledge and foresight on the cost effects of adopting alternative renewable technologies. This could be also an interesting policy tool for other mining countries to encourage businesses with small amounts to look into options of replacing diesel generators and other fossil fuel based energy sources with cleaner renewable energy technology. At the

same time, Chile aims to align the global decarbonisation agenda with the national domestic goal of transitioning to an economic model with higher diversification and sophistication that would enable the country to be part of global green value chains. Therefore, Chile has introduced a policy, which makes it mandatory for international businesses to ensure the transfer of technology and knowledge and contribute financially to R&D projects on renewable energy as part of resource exploration contracts. Developing resource-rich countries, such as Gabon with manganese or Bolivia with lithium, could follow a similar model to use their strategic minerals to transition towards a more sustainable and diversified economic model. Finally, despite deficiencies in its institutional and policy framework and existing incumbents, the case of Australia shows that cooperation between public institutions and the private sector can contribute to overcoming knowledge barriers and mutual learning which supports incrementally the adoption of eco-innovation. A close public-private cooperation in developing resource-rich countries could help to align public policy goals of sustainable development with business interests of reducing costs, enhancing competitiveness and addressing challenges related to the security of supply especially regarding the availability of energy and water.

This PhD research concludes with some recommendations and ideas on future research. First, the information provided by mining companies consists of aggregated data, indicating the total water or energy use for all operations. Many mining companies do not have country and operation specific sustainability reporting to illustrate the progress they have made. The aggregated performance data of geographically scattered operations does not provide a detailed picture of company performance in certain geographies and operations. This would help to assess how the same mining company operating internationally responds to different jurisdictions, how they perform in different regions and whether the performance rates are similar or not giving additional insights about diffusion of knowledge and practices within the company across different geographical scales or the lack of it. It would be useful for further research to provide data on separate mining projects to be able to compare different performances across the world or similarities in performance, which would be an indication for within-country technology

and know-how transfer or diffusion. Anglo American, for example, provides mine-specific data on work-related loss of life but not on the company's environmental performance. Rio Tinto provides data on water withdrawal or GHG emissions by location, however, while there is specific data some selected countries (Australia, Canada, France, South Africa, United Kingdom and the United States), the rest of the countries are put together in regions with aggregated data (rest of Africa, Europe, Asia, Central America and South America). Finally, aggregated environmental data might make water savings or recycling as well as emission reductions look more significant than they are. If a company has more than ten operations 21 per cent of total water savings or 19 per cent of emission reduction would be a minimal improvement if broken down to the number of mine projects belonging to the company. Individual, site-specific data would help researchers to identify the specific reasons and conditions for better or worse performance depending on the technological, operational, local or regional context. Future research could focus on data collection and comparisons of the environmental performance of the same mining company in different regions by also analysing the underlying reasons. In this context, given the international agenda of decarbonisation and sustainable development, a focus on specific commodities of relevance for the low-carbon transition and Sustainable Development Goals might be interesting.

Second, countries such as Australia, Brazil or South Africa are net exporters of primary as well as secondary metal commodities with a developed mining sector and metals processing industry. There are also exporters of primary and net importers of secondary metal commodities. These countries have large-scale mining operations in relation to the size of their territory mining metals with comparatively low ore grades: Chile, Jamaica, Indonesia, and Uzbekistan followed by China, Peru, South Africa, and Ghana. Low ore grades mean higher energy and water input as well as higher levels of emissions. Yet, the extractivism literature advocates good governance for resource-based growth, particularly in the poorest and most vulnerable places in the world, without sufficiently addressing environmental and related future economic challenges. These countries can develop a “softer” extraction path that is more focused on commodities relevant for the Sustainable Development Goals and decarbonisation, anticipating a flattening demand and taking into

account new value chains around secondary materials. Future research could also focus on further ways of incorporating environmental imperatives into extractivism at a conceptual and practical level by, for instance, extending the Resource Governance Index and a coherent, coordinated structure for existing international initiatives. Future research could also show possible transition pathways, similar to Chile's energy strategy, based on a nexus approach including water, land, energy, materials and food.

Third, at the national level, a set of metrics could be introduced to monitor the sector's performance and incentivise improvement in order to achieve environmental sustainability and eco-innovation in the mining sector. Government, community and companies can influence the process through cooperation at the international level and between the public and private sector, public policies and regulations. It seems necessary to define sector-specific benchmarks and targets against which mining companies and their operations can be measured. Introducing baseline data and specific targets and objectives for each installation and mine might be an additional source of improvement from an environmental sustainability point of view. Furthermore, governments could introduce technology-specific procurement requirements in order to support the deployment of certain clean technologies and increase the share of their use in the mining sector.

Finally, mining countries could create an "ICMM" or "Mining, Minerals and Sustainable Development Project" for mining countries to establish a structured cooperation based on peer learning and knowledge sharing in the field of resource efficiency, energy and environment. Such a structured cooperation could also serve to harmonise and guarantee standards, exchange best practices and avoid a race to the bottom. Such a cooperation framework could include also resource-dependent demand-side countries and collaboration could include the exchange of best practices and knowledge on eco-innovation along the entire supply chain from extraction to disposal.

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