Choice Complexity and Market Competition*

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Abstract

Consumers often find it hard to make correct value comparisons between market alternatives. Part of this "choice complexity" is the result of deliberate obfuscation by firms. This review synthesizes a theoretical literature that analyzes the role of choice complexity in otherwise-competitive markets. I identify two general classes of models in the literature: (1) firms' obfuscation strategy is an independent "framing device" that affects the probability with which consumers make correct comparisons; (2) market alternatives are multi-attribute objects, and obfuscation is captured by "lopsided" location in attribute space, lowering the probability of being dominated by another market alternative.

I address the following key questions: What determines the amount of choice complexity in market equilibrium? What is the relation between choice complexity and payoff-relevant aspects of the market outcome? What is the role of consumer protection measures? The models surveyed in this review suggest that equilibrium obfuscation and choice complexity increase in response to intensified competition, mitigating the positive effect of competition on consumer welfare. However, equilibrium effects can also attenuate the positive welfare effects of regulatory interventions.

KEYWORDS: limited comparability, bounded rationality, behavioral industrial organization, choice complexity, default bias, framing, competition

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1 Introduction

Consumers in a modern economy regularly face choice tasks of great complexity. In major industries such as insurance, healthcare, money management, retail banking or telecommunications, individual products have elaborate descriptions, while prices are often multi-dimensional and hard to compute. Supermarket shopping is complex for various reasons: large variety of potential substitutes, non-linear and frequently changing prices, or incommensurable measurement units in which quantities are presented. The complexity can be explicit - e.g., elaborate fee structures employed by retail banks, or long service contracts loaded with impenetrable jargon. Yet often the complexity is implicit and unstated - e.g., the reimbursement practice of an insurance company, or patterns in the quality of service offered by an expert.

Clearly, product complexity is hard to avoid in many cases - e.g., when an insurance product targets a risk that results from a specific combination of contingencies. However, there is a common intuition that part of the complexity that consumers encounter in markets is not intrinsic but *strategic*, designed by firms to take advantage of consumers' bounded rationality - specifically, their limited ability to make correct value comparisons. From this point of view, choice complexity is an impediment to effective market competition. Here is a typical quote from a regulator's report:

> "When deciding whether to switch to another bank, consumers need clear, readily available information that they can understand, as well as the financial capability and desire to evaluate it. Ease of comparison will be affected by the structure of current account pricing. The ease with which consumers are able to compare current accounts is likely to affect their desire to do so and thus feed through to the competitive pressures that banks face." (OFT (2008), p. 89)

This review synthesizes a theoretical literature that explores the extent to which choice complexity is an endogenous response of competing profit-maximizing firms to consumers' bounded rationality. Firms may obfuscate to prevent a correct value comparison; they may introduce excessive non-linearity into price plans in order to take advantage of consumers' biased cost-benefit calculations; etc. In all the market models that I shall present, the underlying market environment is fundamentally simple, such that if consumers were fully rational, equilibrium prices and product design could be simple. Choice complexity arises in these models because of consumers' bounded rationality. I address the following questions: What is the relation between choice complexity and payoff-relevant market outcomes? Do competitive forces lead firms to simplify, or rather complicate the description of market alternatives? What is the potential scope of consumer protection measures, e.g. regulating product disclosure or designing default options?

The models in this review are based on explicit descriptions of what makes choice complex and how consumers respond to choice complexity. I identify two broad modeling approaches in the literature. One approach captures obfuscation as a distinct "framing" strategy that affects the probability with which consumers make value comparisons. Another approach defines market alternatives as multi-dimensional objects: a choice situation is complex when no market alternative dominates the others, and obfuscation is captured by "lopsided" location in multi-dimensional space, because this tends to lower the probability of domination. The two modeling approaches tend to fit different scenarios, and thus complement each other. They can also be combined (e.g., when firms use framing to manipulate the relative salience of different product dimensions).

This review illuminates part of a field known as "Behavioral Industrial Organization", which analyzes markets with rational firms and consumers who depart from the standard rational-choice model. My objective is to synthesize the above two strands into a coherent exposition, which hopefully adds value to the collection of individual papers it is based on. In this sense, the review continues my own recent quest for modeling frameworks that could usefully unify some of the main ideas in Behavioral I.O. (see Spiegler (2014a)). The hope is that such frameworks have enough "juice" to whet the appetite of theorists, and that at the same time they will suggest modeling ideas for more empirically inclined I.O. researchers.

This is not meant to be a detailed survey of "behavioral" models of market competition. Also, I do not deal with models of complex pricing strategies in monopolistic settings (Rubinstein (1993), Piccione and Rubinstein (2003), Eliaz and Spiegler (2006,2008), Grubb (2009), Heidhues and Kőszegi (2014)), nor with models of obfuscation that are based on a rational-choice perspective (e.g., Ellison and Wolitzky (2012) regard obfuscation as an attempt to increase the consumer's marginal search cost in an otherwise standard market model with sequential consumer search). Finally, I say little about topics that received extensive treatment in other surveys of behavioral I.O. - e.g., see Armstrong (2015) for a discussion of the externalities that naive and sophisticated consumers exert on each other, or Grubb (2015b) for a discussion of market models with over-confident consumers.[1]

The structure of this review is as follows. I begin each section with a modeling framework, and use it to present a sequence of special cases from the literature. Each case illuminates an economically motivated question regarding the interplay between choice complexity and market competition. I assume throughout that from a rational-choice point of view, products can be ordered vertically, and there is no intrinsic product differentiation or heterogeneity in consumer preferences. For expositional convenience, I refer to all relevant "vertical" dimensions as "quality", but of course the models capture pricing decisions as well. This yields a clear "Bertrand" rational-consumer benchmark, such that all non-competitive aspects of market equilibrium are due to consumers' bounded rationality.

2 Modeling Framework I: Comparability Relations

In this section I present a modeling framework that regards obfuscation as an independent "framing" component in the firm's competitive strategy, which influences the probability that consumers make value comparisons between market alternatives. It is a special case of a more general framework of "competitive framing" due to Spiegler (2014a), and synthesizes ideas from Varian (1980), Carlin (2009), Eliaz and Spiegler (2011a), Piccione and Spiegler (2012) and Chioveanu and Zhou (2013).

2.1 What Makes Comparison Hard?

The following example serves to introduce the modeling framework and show how it can capture various intuitions about what makes it hard for consumers to make value comparisons. Consider a market with two firms, who can provide any number of units of a certain product at zero cost. Each firm simultaneously determines the price or quality of its product. At the same time, each firm chooses a *description format* for presenting the relevant quantity. The firms' selected formats determine the fraction of consumers who are able to make a value comparison between the two firms. When a consumer can make a comparison, he selects the firm that offers the highest-value product. When the consumer cannot make a comparison, he chooses arbitrarily (or by default).

[1] Other recommended reviews of behavioral I.O. are Ellison (2006), Armstrong (2008), Huck and Zhou (2011), Kőszegi (2014) and Grubb (2015a). For a graduate-level textbook treatment, see Spiegler (2011).

The following are two alternative scenarios that illustrate the possible meanings of description formats:

Scenario I: A format is a *measurement unit* for denominating the relevant quantity. For instance, it can be a unit of energy per which the efficiency of an electric appliance is defined, the unit of volume per which the price of a food product is defined, or the time unit per which an interest rate is defined. Some consumers are unable to convert units (because they are ignorant of the conversion rates, or because they lack the numeracy that would enable them to perform the conversion), and therefore unable to make a value comparison.

Scenario II: The firm chooses whether to present the content of its product using a *simple, transparent language* that a layperson would understand, or an *obscure technical jargon* that a non-specialist can understand only when translated into lay terms. The translation can sometimes fail and produce gibberish, in which case the consumer will be unable to make a value comparison.

The two scenarios differ in where they locate the complexity of making value comparisons. In Scenario I, formats do not possess intrinsic complexity; difficulty of comparison arises only when firms employ *different* formats. In contrast, in scenario II formats are ranked according to their intrinsic complexity. As a result, the two scenarios induce different obfuscation incentives. In scenario II, if a firm wants to encourage (discourage) comparison - because it offers a high-value (low-value) product - it will unambiguously prefer to use transparent (obscure) language. In contrast, in scenario I there is no unequivocal preference for either format, because what matters is whether the firms coordinate their formats.

As we shall see later in this section, this distinction has multi-faceted implications for the analysis of market equilibrium and regulatory interventions. Thus, the equilibrium interplay between competition and obfuscation crucially depends on whether we locate choice complexity in the description format employed by the individual firm, or in the relation between the formats employed by two firm.

2.2 General Framework

Consider a market consisting of n identical profit-maximizing firms and a single consumer (equivalently, a continuum of ex-ante identical consumers). Let M be a finite set of "description formats". For now, assume the consumer has no outside option and must choose one of the firms - we will introduce an outside option in Section 4. The firms play a simultaneous-move game with complete information. Each firm $i = 1, ..., n$

chooses a pair (q_i, m_i), where $q_i \in [0,1]$ is the *quality* of its product, and $m_i \in M$ is the format it employs to describe it. I refer to the pair (q_i, m_i) as the "extended alternative" offered by firm i. The firm's payoff conditional on being chosen is $1 - q_i$. The consumer's true utility from a product is equal to its quality, such that total surplus from any firm-consumer interaction is constant and equal to 1. Thus, "quality" is a stand-in for the share in the interaction surplus that the firm offers to the consumer.[2]

Let $\mathcal{R}$ be the set of all symmetric, non-reflexive binary relations over the set $\{1, ..., n\}$. I interpret a relation $R \in \mathcal{R}$ as a "*comparability relation*"; the statement iRj means that the consumer can compare the products offered by firms i and j. The consumer's choice procedure involves two stages:

- First, there is a stochastic mapping $\pi : M^n \to \Delta(\mathcal{R})$. Assume that π is symmetric, in the sense that it is neutral to permutations of $(m_1, ..., m_n)$. Let $\pi_R(m_1, ..., m_n)$ denote the probability of the comparability relation R given the profile of formats $(m_1, ..., m_n)$. We will say that firm i is *maximal* given $(q_1, ..., q_n, R)$ if there exists no $j \neq i$ such that jRi and $q_j > q_i$. Note that there is always at least one "maximal" firm.

- Second, the consumer chooses randomly from among the maximal firms according to a function s, where $s_i(q_1, ..., q_n, R)$ is the probability that firm i is chosen, given that the quality profile is $(q_1, ..., q_n)$ and the comparability relation is R. In particular, all the models that will be examined in this section have the feature that $s(q_1, ..., q_n, R)$ is the *uniform* distribution over the set of maximal firms given $(q_1, ..., q_n, R)$.

The consumer's choice procedure induces the following payoff for firm i:

$$(1 - q_i) \cdot \sum_R \pi_R(m_1, ..., m_n) s_i(q_1, ..., q_n, R)$$

This completes the description of the game.[3]

The crucial feature of this modeling framework approach is that a firm's choice of quality does not restrict its set of available formats - i.e., the substance and framing of

[2] The notion of "true utility" is problematic from a revealed-preference point of view, because the consumer in this model will not behave like a conventional utility maximizer. Spiegler (2011) contains thorough discussions of this common feature of behavioral I.O. models.

[3] Formats are assumed here to be costless. Eliaz and Spiegler (2011a,b) analyze models in which firms take costly actions - e.g., adding "irrelevant alternatives" to their product line - that manipulate consumers' propensity to make comparisons.

a firm's offer are independent. Thus, it cannot capture situations in which the two are inseparable. The primitives M and π can capture various situations. For instance, to accommodate the "measurement units" scenario of the previous sub-section, interpret M as a set of possible measurement units. For $n = 2$, π describes the probability that the consumer can convert m_1 into m_2 (or vice versa). A format can also represent a "language" in which alternatives are described - as in the "technical jargon" scenario of the previous sub-section. In this case, π captures the difficulty of translating statements made in "foreign" languages into a commonly understood, "lay" language. Finally, a format can represent a packaging or positioning decision. For instance, the same yogurt can be positioned as a "fun" product or as a "spiritual" product. This interpretation brings the model quite close to conventional product differentiation, and the distinction between the two emerges from the structure of s, which may be inconsistent with random utility maximization.

The function π captures how firms' choice of formats affects the complexity of consumer choice, as captured by the comparability relation R. A complex choice problem is identified with a distribution that assigns high probability to sparse comparability relations. Rational choice is identified with the special case in which π always assigns probability one to the complete relation (i.e., iRj for every $i \neq j$), such that the consumer always makes value comparisons, regardless of the profile of formats. In this case, firms play $q = 1$ and earn zero profits in symmetric Nash equilibrium.

This modeling approach is closely linked to the choice-theoretic literature on "choices with frames". Masatlioglu and Ok (2005), and later (more generally and systematically) Salant and Rubinstein (2008) and Bernheim and Rangel (2009), enriched the standard choice model and defined the notion of an "extended choice problem" that also specifies the choice problem's frame. The choice function s in the present model is a stochastic version of the choices-with-frames model, where the frame is R. The crucial additional component is the frame's *endogenous determination* of the frame via firms' choice of formats.

The following property turns out to be relevant for equilibrium behavior in this model.

Definition 1 (Enforceable Comparability) *The function π satisfies enforceable-comparability (**EC**) if there exist distributions $\lambda \in \Delta(M)$ and $\sigma \in \Delta(\mathcal{R})$ such that*

$$\sigma(R) = \sum\nolimits_{m_i \in M} \lambda(m_i)\pi_R(m_i, m_{-i})$$

for every m_{-i}.

EC means that an individual firm can unilaterally enforce a given distribution σ over the consumer's comparability relation. Obviously, if π satisfies EC, the distribution σ is unique.[4]

The following are two benchmark cases in which EC holds trivially. First, suppose there is a marketing device m^* that induces the complete comparability relation with probability one, as if it can "switch on a light" that enables perfect comparisons. The behavioral I.O. literature sometimes refers to such an action as "*educating the consumer*" - i.e., transforming him unilaterally into a conventionally rational decision maker. Second, suppose that π is a constant function that assigns probability β to the complete relation and probability $1-\beta$ to the empty relation, regardless of the profile of formats. This specification reduces the framework to Varian's (1980) classic model, which assumed that an exogenous fraction of consumers make a perfect value comparison across all firms and thus choose the best market alternative, while the remaining consumers are entirely unable to make a comparison, and they choose uniformly among all firms, regardless of the value of their products.

2.3 Equilibrium Choice Complexity in the Two-Firm Case

When $n = 2$, there are two possible comparability relations, the complete relation ($1R2$) and the empty relation ($1\not R2$). This specification of the model was analyzed by Piccione and Spiegler (2012). Abusing notation, I identify π with the probability it assigns to the complete relation. Our assumption on s means that when the firms' products are comparable and $q_i > q_j$, the consumer chooses firm i with probability one; and in any other case, he chooses each firm with probability $\frac{1}{2}$.

Recall that by assumption, $\pi(m, m') = \pi(m', m)$ for every $m, m' \in M$. In addition, assume $\pi(m, m) > 0$ for every $m \in M$, to capture the idea that there is a grain of comparability when firms use the same description format. The assumption also ensures that the marginal quality distribution induced by any equilibrium strategy has no mass point on any $q < 1$. In particular, there exist no asymmetric pure-strategy Nash equilibria. From now, we will restrict attention to symmetric mixed-strategy Nash equilibria.

The following is the central question of this sub-section.

[4] Piccione and Spiegler (2012) and Spiegler (2014a) refer to this property as "weighed regularity", because when $n = 2$, π can be reduced to a weighted graph over M (not to be confused with the comparability relation over $\{1, ..., n\}$ in this presentation), such that EC is an extension of the notion of a regular graph.

Question 1: What determines choice complexity in market equilibrium?

Should we expect market competition to minimize the complexity of consumer choice, or perhaps maximize it? To answer this question, we first need to define choice complexity. In the context of the present model, we look for some notion of "average comparison probability". Consider a symmetric mixed-strategy Nash equilibrium strategy $\mu \in \Delta([0,1] \times M)$. The *equilibrium choice complexity* induced by μ is defined as follows:

$$C_{\min}(\mu) = \min_{m \in M} \int_{q,m'} \pi(m, m') d\mu(q, m') \tag{1}$$

What is the interpretation of this measure? Consider the point of view of firm 1, say, when it contemplates offering the monopolistic quality $q_1 = 0$. As we observed above, the strategy μ played by firm 2 does not assign an atom to any $q_2 < 1$, which means in particular that it plays $q_2 > 0$ with probability one. To maximize its market share, firm 1 would choose a format m that minimizes comparability, and $C_{\min}(\mu)$ is *the lowest comparison probability it can attain, given that firm* 2 *plays* μ. Firm 1's profit would be $\frac{1}{2}(1 - C_{\min}(\mu))$. It follows that if $q = 0$ is in the support of the marginal equilibrium quality distribution, industry profits are $1 - C_{\min}(\mu)$. Thus, *equilibrium choice complexity and equilibrium industry profits are closely linked.*

Analysis of symmetric Nash equilibria turns out to hinge on the notion of EC. The meaning of EC in this model is that each firm can randomize over formats so as to implement a constant probability of comparison that is independent of the opponent's behavior. Equivalently, EC means that there exists some randomization over formats that both min-maximizes and max-minimizes the probability of comparison. To see why, consider an auxiliary zero-sum game, in which the payoff for one player (not to be confused with any of the firms in our model) is the probability of comparison. EC means that this zero-sum game has a symmetric Nash equilibrium, and by the Minimax Theorem, the symmetric equilibrium strategy is both a max-minimizer and a min-maximizer. When EC is violated, the zero-sum game has no symmetric equilibrium: max-minimizing comparison probability requires different behavior than min-maximizing it. In other words, a firm that seeks comparison would tend to choose different formats than a firm that eschews comparison.

The following two examples illustrate these ideas. First, suppose that M consists of K formats and comparability depends only on whether firms use identical formats -

i.e.,

$$\pi(m,m') = \begin{cases} 1 & if \quad m = m' \\ 0 & if \quad m \neq m' \end{cases}$$

This specification fits well the measurement-unit interpretation. In this case, π satisfies EC because a firm can randomize uniformly over M and enforce a comparison probability of $\frac{1}{K}$. In contrast, suppose that M is a finite set of real numbers and π is a strictly increasing function. Thus, lower numbers represent formats with greater "intrinsic complexity". This is essentially the specification in Carlin (2009). In this case, EC is violated because each firm can always lower comparability by choosing a lower number. The lesson from these two examples is that EC holds when comparability is a matter of coordination between the formats employed by firms; and EC is violated when comparability is a monotone function of the formats' intrinsic complexity. The "measurement unit" interpretation of the model will typically suggest specifications that satisfy EC, whereas the "jargon" interpretation will typically give rise to specifications that violate EC.

Define C^* to be the min-max comparison probability induced by π, namely

$$C^* = \min_{\lambda \in \Delta(M)} \max_{\theta \in \Delta(M)} \sum_{m} \sum_{m'} \lambda(m)\theta(m')\pi(m,m')$$

The value C^* represents the lowest comparison probability that a firm trying to avoid comparison can enforce. Firms' max-min payoff in this model is $\frac{1}{2}(1 - C^*)$. By definition, $C_{\min}(\mu) \leq C^*$ for any symmetric Nash equilibrium strategy μ.

Proposition 1 *Let μ be a symmetric Nash equilibrium strategy. Then, $C_{\min}(\mu) = C^*$ if and only if π satisfies EC.*

Thus, when π satisfies EC, equilibrium choice complexity is equal to its min-max value in any symmetric Nash equilibrium - hence, firms earn max-min payoffs in equilibrium. Rather than maximizing or minimizing comparison probability, competitive forces *min-maximize* it in this case. In fact, Piccione and Spiegler (2012) show a stronger result: under EC, the probability of comparison is C^* conditional on (almost) any realized quality profile (q_1, q_2). On the other hand, when EC is violated, the equilibrium comparison probability is strictly *below* C^*, such that firms earn profits strictly *above the max-min* level. Note that when M includes a format m^* such that $\pi(m^*, m) = 1$ for every m - i.e., when firms can unilaterally "educate" consumers - $C^* = 1$ and so in symmetric Nash equilibrium firms play $q = 1$ and earn zero profits.

Thus, non-competitive industry profits rely on the impossibility of unilateral "education" of consumers.

The broad intuition for Proposition 1 is as follows. When EC is satisfied, each firm can enforce the constant comparison probability C^*, independently of the quality it chooses. Thus, EC implies a lower bound on the firm's market share conditional on its chosen quality, given the opponent's marginal quality distribution. Since market shares must always add up to one, this implies that the lower bound is almost always binding, and this in turn implies that comparison probability is almost always C^*.

In contrast, recall that when EC is violated, a firm that seeks comparison tends to choose different formats than a firm that eschews comparison. Near the bottom of the quality distribution, firms generally avoid comparison. Therefore, on average firms do *not* randomize over formats as if they try to maximize comparability. From the point of view of a firm that chooses the *lowest* quality level, it faces an opponent that does not go out of its way to enforce comparability, and therefore it can attain a comparison probability below the min-max level C^*. (When EC holds, firms that seek comparison can behave just like firms that try to avoid it. Therefore, the fact that firms near the bottom of the quality distribution try to avoid comparison does not contradict the possibility that on average firms behave as if they max-minimize the probability of comparison.)

Proposition 1 has implications for the two paradigmatic scenarios of Section 2.1. In the "measurement units" case - i.e., when comparability is purely a matter of coordination between the firms' formats - equilibrium choice complexity is equal to the min-max level, and therefore firms earn their max-min payoffs. In contrast, when comparability depends on formats' intrinsic complexity, equilibrium comparison probability is below the min-max level, and therefore firms earn profits above their max-min level.

2.4 The Many-Firm Case

Limited comparability is a force that constrains market competition, partly because firms' endogenous format choices exacerbate the limited-comparability problem. A conventional way to strengthen market competition is to increase the number of competitors. This raises the following question.

Question 2: How does increasing the number of market competitors affect choice complexity?

The case of $n > 2$ introduces additional degrees of freedom, because the set of possible comparability relations grows quickly with n. I will examine two examples from the literature, translated into our modeling framework. Carlin (2009) studies perhaps the simplest extension of the two-firm case. Suppose that π assigns positive probability only to the complete relation (iRj for all $i \neq j$) and the empty relation ($i\not{R}j$ for all $i \neq j$). This specification implies that an individual firm's obfuscation decision can affect the mutual comparability of two other firms. In contrast, Chioveanu and Zhou (2013) adopt a specification that satisfies an independence property: the probability that iRj is purely a function of (m_i, m_j). Both Carlin (2009) and Chioveanu and Zhou (2013) assume further that formats can be ordered unambiguously according to their "intrinsic complexity", such that when a firm chooses a more complex format, it lowers the probability it is comparable to any other firm. Both papers reach the same conclusion: *as $n \to \infty$, the symmetric-equilibrium probability that firms use the most complex format converges to one.*

What is the intuition behind this finding? The underlying "Bertrand" market structure means that firms play a winner-take-all game. If a firm knew for sure that it does not offer the highest-quality product in the market, it would want to obfuscate as much as possible, in order to reduce the chances that the consumer will make a value comparison. When there are many competitors playing a symmetric mixed-strategy equilibrium, any individual firm is unlikely to offer the highest-quality alternative in the market, unless it chooses to be at the very top of the quality distribution. Therefore, it will almost always resort to a maximally complex format. Ironically, it is precisely the intense competitiveness of the market environment that raises the equilibrium complexity of consumer choice to its utmost level.

The implications of this maximal-complexity result for industry profits seem to be more model-specific. In Carlin (2009), industry profits converge to zero when $n \to \infty$, whereas in Chioveanu and Zhou (2013), they converge to a number that is bounded away from zero; moreover, equilibrium industry profits need not decrease monotonically with n.

The specifications of π discussed in this sub-section violate EC. When EC is satisfied, there is always a symmetric Nash equilibrium in which each firm plays the format strategy λ that unilaterally enforces the distribution σ over $\mathcal{R}$ - independently of the number of firms n. In this case, firms' framing behavior in equilibrium is unresponsive to n. Once again, we see that key equilibrium properties rely on whether the comparability structure satisfies EC.

2.5 Consumer Protection: Harmonizing Formats

The previous discussion suggested that a mere rise in the number of competitors may increase the equilibrium complexity of consumer choice, which effectively softens market competition and weakens its beneficial effect on consumer welfare. This raises the following question:

Question 3: Can consumer protection measures reduce equilibrium choice complexity and improve consumer welfare?

To illustrate how the framework can address this question, I focus on the two-firm case and examine one type of intervention: regulating product description by "harmonizing formats" (another regulatory intervention, known as "default architecture", will be discussed in Section 4). The material in this sub-section is based on Piccione and Spiegler (2012).

Regulators often attempt to improve comparability by fighting the multitude of description formats and collapsing them into one standardized format. Clearly, if the regulator could enforce a switch into a regime in which M consists of a single format m^* such that $\pi(m^*, m^*) = 1$, it could enforce perfect comparability and our consumer would act like the conventionally rational consumer in Bertrand competition. A more interesting question is whether partial moves in the general direction of format harmonization monotonically reduce equilibrium choice complexity and raise consumer welfare. Suppose that $\pi(m, m) = 1$ for every $m \in M$. Let $M^* \subset M$ be a subset of formats containing at least two elements, such that for every distinct $m, m' \in M^*$, we have $\pi(m, m') < 1$ and $\pi(m, m'') = \pi(m', m'')$ for all $m'' \notin M^*$. Now consider a switch to another function $\hat{\pi}$, which differs from π only by setting $\hat{\pi}(m, m') = 1$ for every $m, m' \in M^*$. It is as if we collapsed M^* into a single format. The switch from π to $\hat{\pi}$ clearly improves comparability. The question is whether it necessarily decreases equilibrium choice complexity, as defined by (1), in some symmetric Nash equilibrium.

The answer, once again, turns out to depend on the concept of EC. The definition of min-maximization has two immediate implications: (i) $C^*_{\hat{\pi}} \geq C^*_{\pi}$; (ii) equilibrium choice complexity under π is weakly below C^*_{π}. Now, if $\hat{\pi}$ satisfies EC, then by Proposition 1, equilibrium choice complexity under $\hat{\pi}$ is exactly $C^*_{\hat{\pi}}$. This means that the switch from π to $\hat{\pi}$ leads to lower equilibrium choice complexity, hence lower equilibrium industry profits. This is consistent with the intuition that improved comparability resulting from format harmonization leads to a more competitive market outcome.

However, this monotonicity need not hold when $\hat{\pi}$ violates EC. Indeed, Piccione and Spiegler (2012) show how the switch from π to $\hat{\pi}$ can leave C^* unchanged and at the same time increase equilibrium choice complexity. Suppose that M consists of two large classes of formats, M^1 and M^2, such that $\pi(m^i, m^j) = q_{ij}$ for every $m^i \in M^i$, $m^j \in M^j$ (where i and j are possibly identical). Let $1 > q_{11} > q_{12} > q_{22}$. Now suppose that $\hat{\pi}$ differs from π only in that $\hat{\pi}(m, m') = 1$ for every $m, m' \in M^1$. In this example, neither π nor $\hat{\pi}$ satisfy EC, because formats can be unambiguously ordered in terms of their comparability. Formats in M^1 attain higher comparability than formats in M^2 - i.e., they are "intrinsically simpler". Furthermore, $C^*_{\hat{\pi}} = C^*_{\pi} = q_{12}$ (the assumption that both M^1 and M^2 are large plays a role in this observation). And yet, Piccione and Spiegler (2012) show that in the unique symmetric Nash equilibrium, choice complexity and industry profits go up.

The intuition is as follows. In equilibrium, there will be a cutoff q^*, such that when a firm chooses a quality level above (below) q^*, it will adopt formats in M^1 (M^2) in order to maximize (minimize) comparability. As a result of the switch from π to $\hat{\pi}$, when a firm considers offering a quality level *slightly above* q^* and using a format in M^1, it is now more worried about the prospect of facing an opponent who offers a higher quality level, since comparability within M^1 has gone up. At the same time, the switch from π to $\hat{\pi}$ does not change comparability within M^2, or between M^1 and M^2. Therefore, the firm will prefer to switch to the "complex" formats in M^2. In the new equilibrium, this shift translates to a higher probability that firms use M^2, which means that equilibrium choice complexity is higher than prior to the intervention. In other words, the regulator's harmonization of formats that were relatively simple to begin with has an adverse equilibrium effect on consumer welfare. The lesson from this exercise is that a partial move toward format harmonization can be counterproductive, if firms can use more complex formats that are not subjected to the harmonization.

2.6 Summary

This section presented a modeling framework that captures choice complexity by a comparability relation over firms. This relation is endogenously determined by the firms' equilibrium choice of "description formats", via the primitive function π. We saw how this formalism can be employed to analyze three key questions: What is the equilibrium choice complexity that results from market competition? How does it change with the number of competitors? What is the effect of other regulatory interventions? In each case, the notion of enforceable comparability (EC) was crucial for the analysis. In particular, it meant that the analysis is sensitive to whether we conceive of the comparability problem as a matter of "format coordination" among firms (where EC holds), or as a monotone function of the individual formats' "intrinsic complexity" (where EC is violated). In the latter case, firms respond to competitive pressures by obfuscating. As a result, interventions that might seem a priori to foster competition (increasing the number of competitors, harmonizing description formats to improve comparability) end up exacerbating equilibrium choice complexity and possibly harming consumer welfare. In contrast, when EC holds, equilibrium behavior is more "well-behaved" w.r.t these interventions, because equilibrium choice complexity can be invariant to them.

A rational-choice approach to endogenous comparability

The point of view throughout this review is that firms have all the initiative in determining choice complexity, whereas consumers are passive in this regard. A more conventional approach would assume that consumers' ability to make comparisons is a consequence of an earlier information-acquisition decision made by consumers themselves. Fershtman and Fishman (1994) and Armstrong, Vickers and Zhou (2009) implemented this approach in the context of Varian's (1980) model. Take the basic Varian model as described earlier in this section, and adopt the interpretation that there is a continuum of ex-ante identical consumers. Now assume that consumers start out with the empty comparability relation, and each individual consumer can *choose* (simultaneously with the choices made by all other market agents) to switch to the complete relation at a cost. In equilibrium, the consumer's choice is individually rational.

In this environment, if all consumers chose to incur the cost, the equilibrium outcome would be competitive with no quality dispersion, and so investing the cost could not be individually rational for consumers. Therefore, the competitive outcome cannot be sustained in equilibrium. At the other extreme, there is a "Diamond Paradox" equilibrium in which no consumer incurs the cost and firms act monopolistically. However, there is also a "mixed" equilibrium in which a fraction of the consumer population incurs the cost. This equilibrium exhibits interesting features. For instance, introducing a minimum quality standard artificially shrinks the dispersion of quality in the market, and thereby reduce the consumers' incentive to incur the cost, such that in equilibrium fewer of them are able to make a quality comparison. As a result, if the minimum standard is relatively low, consumers can be worse off. This effect is in the same "half measures are worse than no measures" spirit of Section 2.3.

De Clippel, Eliaz and Rozen (2014) analyze a model in which consumers participate in m markets. Each of these markets consists of two firms, a leader and a challenger, who simultaneously choose prices. The consumer observes the prices set by all leaders, but he can only observe some fixed number k of challengers - that is, there is an exogenous constraint on the total amount of attention he can devote to his multi-market environment. Different consumers have different values of k. In market equilibrium, firms in each market effectively play a complex, asymmetric two-firm Varian game, in which the fraction of consumers who make a comparison in the market is given by their attention-allocation decision (conditional on the leaders' prices). As in Fershtman and Fishman (1994) and Armstrong, Vickers and Zhou (2009), the model of de Clippel et al. (2014) exhibits non-trivial comparative statics. In particular, an upward shift in the distribution of k can lead to *higher* equilibrium prices. The reason is that when consumers are partially attentive, leaders have an incentive not to stand out as being too expensive because that would lead the consumer to inspect the challenger, who tends to be cheaper. The incentive "not to stand out" decreases with consumers' attention span, and this in turn softens competition.

The models in this tradition invariably assume that consumers have rational expectations - they fully understand the equilibrium market regularities when choosing their comparability relation. In contrast, the consumers elsewhere in this section are passive, and display no understanding of the equilibrium relation between the formats firms employ and the quality of their products. Constructing models in which both firms and consumers make decisions that affect the comparability relation, where consumers have a *partial* understanding of equilibrium regularities, is an important challenge for future research.

3 Modeling Framework II: Multi-Attribute Products

The modeling framework in Section 2 treated the quality of a firm's product and its description format as two distinct variables, which in principle can be chosen independently. There are situations in which this separation does not make sense. For instance, unusual design of a can of soup can have functional, payoff-relevant implications; but at the same time, it attracts the consumer's attention away from competing brands, and in this sense it is part of the product's "framing". In this case, substance and framing are inseparable.[5]

In this section I take a modeling approach that embraces the inseparability of substance and framing. This approach is based on a strand in the literature, going back to Gabaix and Laibson (2006) and Spiegler (2006), which views alternatives as

[5] Spiegler (2014a) shows how to adapt the formalism of Section 2, and the notion of EC, to accommodate interdependence between these two components of the firm's strategy.

elements in $\mathbb{R}^K$, $K \geq 2$. Alternatives can be multi-attribute objects (such that each dimension corresponds to a different attribute), contingent contracts (such that each component of the vector describes an outcome in a different contingency), or pricing strategies by multi-product firms. A firm's pure strategy consists of a location in $\mathbb{R}^K$.

As in Section 2, the market consists of n identical profit-maximizing firms and a single consumer. Firms play a simultaneous-move game with complete information. Each firm $i = 1, ..., n$ chooses a vector $q_i \in [0, \infty)^K$, where q_i^k is the product's quality along dimension k. The product's "true quality" is defined as its simple average along dimensions, $\bar{q}_i = (\Sigma_k q_i^k)/K$. The firm's payoff conditional on being chosen is $1 - \bar{q}_i$. The consumer's true utility from a product is equal to its true quality. As before, "quality" is a convenient stand-in for any "vertical" dimension, including prices. As before, assume the consumer has no outside option and must choose one of the firms.[6]

In this framework, relaxing consumer rationality means that the consumer employs a different method for aggregating the various dimensions. For example, he may continue to maximize an additively separable utility function, albeit with "wrong" weights; or he may neglect dimensions in which all alternatives have similar quality (as in Rubinstein (1988)). Most reasonable aggregation rules would have the property that when one market alternative strictly dominates all others, the consumer will choose it. Indeed, that would be a "simple choice". Accordingly, in this section *a choice problem is complex when there is no dominant market alternative.*

In the models I examine in this section, I will assume that the consumer focuses on a (possibly random) single dimension, and chooses the firm that performs best along that dimension (with symmetric tie breaking). There can be various reasons for such selective attention. First, consumers may simply fail to notice or think about some relevant product attributes. This is the case when certain attributes are less salient than others (e.g., add-ons and fees that materialize long after they sign the contract). Second, the task of aggregating all dimensions is demanding computationally, and sampling a small subset of attributes is a simplifying heuristic. Finally, trading off various considerations against each other may be emotionally difficult. For instance, how does one justify the trade-off between product safety and price? Or, when comparing retirement plans, how does one trade off one's own disability benefits and their beneficiaries' pension? People may wish to avoid making these emotionally hard choices, by conveniently "forgetting" about some of the relevant attributes. (Choosing by default is

[6] Under the multi-product-firm interpretation, each alternative q_i represents a bundle of K products, such that q_i^k is the quality of product k. This interpretation carries the implicit assumption that the bundles cannot be disentangled - e.g., consumers cannot split their shopping into several supermarkets.

another way to lower this "emotional cost" - see Section 4.)

Obfuscation in this model can be captured by "lopsided" location in $\mathbb{R}^K$, which tends to lower the probability of domination: if alternatives were all located on a single ray from the origin, every pair of distinct alternatives would dominate one another and the consumer's choice problem would be simple. Specifically, we will measure obfuscation by the gap between the quality the consumer perceives in the dimension he considers and the true quality that firms offer. Since this gap can be random, we will be interested in both its mean and its variance - the larger they are, the greater the obfuscation. When true quality falls below what consumers perceive at the time they make their choice, they may end up feeling ripped off, even if the absolute quality they experience is high.[7]

3.1 Two Firms, Two Dimensions

Let us begin with the simplest possible environment, where $n = K = 2$, and assume that the consumer focuses his attention on dimension 1 (2) with probability α $(1 - \alpha)$. W.l.o.g, assume $\alpha \geq \frac{1}{2}$. The interpretation is that the consumer is more likely to sample dimension 1 because it is more salient. This is a slight variation on a model due to Bachi and Spiegler (2015), which has the same equilibrium characterization. When $\alpha = 1$, we have a degenerate case of Gabaix and Laibson (2006), where dimension 2 is a "shrouded attribute" because consumers entirely fail to consider it at the time they choose between the two firms.

Question 4: How are true quality and its distribution across dimensions determined in equilibrium?

The following result characterizes symmetric Nash equilibrium. For brevity, I omit the complete description of the equilibrium, and focus on its essential features.

Proposition 2 (Bachi and Spiegler (2015)) *There is a unique symmetric Nash equilibrium. Each firm earns $\alpha(1 - \alpha)$ in equilibrium. When $\alpha = 1$, firms play the pure strategy $(q^1, q^2) = (2, 0)$. When $\alpha \in [\frac{1}{2}, 1)$, firms play a mixed strategy, such that true quality is distributed over the interval $[1 - \alpha, \alpha]$. The support of the equilibrium mixed strategy consists of all points (q^1, q^2) along the straight line that connects $(0, 2(1 - \alpha))$ and $(2\alpha, 0)$.*

[7] From a revealed-preference point of view, choosing according to a random attribute is consistent with random-utility maximization. However, extensions of the model that involve an outside option will sever this equivalence - see Section 4.

Thus, when $\alpha = 1$, the equilibrium strategy is competitive in the sense that true quality is the same as it would be with rational consumers. At the same time, obfuscation is maximal, as the gap between the quality that the consumer perceives in the dimension he focuses on and the true quality of the product he consumes is $2 - \frac{1}{2}(2+0) = 1$. This is the highest possible gap subject to the constraint that firms earn non-negative profits.

In contrast, when $\alpha = \frac{1}{2}$ - i.e., when both dimensions are equally salient and therefore equally likely to be considered by the consumer - the equilibrium strategy is non-competitive, in the sense that true quality is below 1. Obfuscation is weaker, in the sense that the gap between perceived and true quality is randomly distributed over $[-\frac{1}{2}, \frac{1}{2}]$.

In general, as α goes down toward $\frac{1}{2}$, the expected true quality that firms offer in equilibrium decreases, while the distribution of quality between dimensions becomes more balanced. Thus, competitiveness and obfuscation are *positively* correlated. Note that for every $\alpha < 1$, the support of the equilibrium strategy is a downward-sloping line. Thus, market alternatives never dominate one another in equilibrium, which means that the consumer never faces a "simple choice". In this sense, market competition *maximizes* choice complexity.

3.2 Many Firms, Many Dimensions

Let us now examine the case of an arbitrary number of firms n, and consider the $K \to \infty$ limit. In addition, suppose that the dimension the consumer focuses on is entirely unpredictable. In such an environment, it makes sense to restrict attention to equilibria in which each firm i randomizes independently over every dimension according to the same distribution. The model is then reduced to the following game, which was studied by Spiegler (2006). Each firm i simultaneously chooses a *cdf* F_i over $[0, \infty)$; the consumer draws a random sample point q_i from each F_i, and selects the highest-quality firm in his sample (with symmetric tie-breaking). The true quality of the product offered by firm i is $\bar{q}_i = E_{F_i}(q)$ - i.e., expected quality according to F_i.

This reduced-form model trivializes some aspects of choice complexity and obfuscation. First, the notion of choice complexity as the probability that one market alternative dominates all others becomes irrelevant. Second, by definition, the consumer's sample provides unbiased estimates of the market alternatives' true quality. Hence, the expected gap between true and perceived quality is always zero. We will therefore evaluate obfuscation in terms of the gap between true and perceived quality in *absolute* terms, e.g. as measured by the variance of quality *cdf*s.

Firm i's profit conditional on being chosen is $1 - E_{F_i}(q)$. The consumer chooses firm i with the probability that its quality is the highest in a random sample from $(F_1, ..., F_n)$, with symmetric tie-breaking. When all firms happen to play continuous *cdfs*, firm i's payoff can be conveniently written as

$$\left(1 - \int_0^\infty q dF_i(q)\right) \cdot \int_0^\infty \left(\prod_{j \neq i} F_j(q)\right) dF_i(q)$$

However, the model does not impose the a-priori requirement that firms play continuous *cdf*s.

Proposition 3 (Spiegler (2006)) *There is a unique symmetric Nash equilibrium. Each firm plays the cdf*

$$F^*(q) = \sqrt[n-1]{\frac{2q}{n}}$$

over the interval $[0, \frac{n}{2}]$.

The symmetric equilibrium has several interesting features. Regardless of n, true quality under F^* is $\frac{1}{2}$. Thus, fiercer competition fails to improve true quality. Instead, F^* undergoes a *mean-preserving spread* when n increases, such that the consumer's perceived quality (via sampling) becomes a noisier (unbiased) estimate of true quality. As in the framework of Section 2, the lesson is that stronger competition intensifies obfuscation (suitably defined).

A key step in the proof of Proposition 3 also clarifies the structure of F^*: in equilibrium, each firm faces a linear residual demand - that is, the firm's market share conditional on offering any $q \leq \frac{n}{2}$ is proportional to q. The reason is that if the residual demand were not linear, the firm could deviate to a distribution with the same mean and attain a larger market share, by shifting weight toward the extremes (middle) of intervals in which demand is convex (concave).

When $n > 2$, F^* assigns positive probability to $q > 1$ - i.e. loss-making quality levels. This is similar to the bait-and-switch effect we observed in the two-firm, two-dimension case: high quality realizations are the bait that attracts consumers, whereas low realizations generate profits from customers lured by the bait. The difference is that both the bait and the switch are drawn independently from the same distribution F^*. In equilibrium, consumers end up feeling exploited, in the sense that the perceived quality of the selected firm is on average higher than its true quality. Moreover, this gap increases when n goes up - the reason is that true quality is $\frac{1}{2}$ for all firms and all n, whereas the perceived quality of the selected firm is distributed according to the first-order statistic of n sample points from F^*. This statistic increases with n for two reasons: first, for any fixed distribution, it increases with the number of sample points; and second, the distribution itself undergoes a mean-preserving spread when n goes up. Thus, the consumers' subjective sense of exploitation increases as competition intensifies.

An attractive outside option

An intuitive method for encouraging competitive behavior is to introduce an outside option. Spiegler (2012) extends the many-firm, many-dimension model in this direction. Suppose that consumers have an outside option of quality $q_0 > 0$. The consumer continues to choose the alternative with the highest quality in his sample (which now includes the outside option). If the quality of all market alternatives in his sample is below q_0, the consumer will choose the outside option. It turns out firms respond to this change in their environment in much the same way that they respond to an increase in the number of competitors. The equilibrium quality distribution that firms offer continues to have a mean of $\frac{1}{2}$, and it undergoes a mean-preserving spread relative to the case of $q_0 = 0$.

This extension gives rise to a novel feature. When $q_0 > 0$, there is no reason for firms to assign weight to $(0, q_0)$. Therefore, the equilibrium *cdf* assigns an *atom* to $q = 0$, and a smooth density to the interval $(q_0, \bar{q})$, where both the size of the atom on $q = 0$ and the value of $\bar{q}$ increase with n. When we interpret outcomes as prices rather than quality, $q = 0$ corresponds to a "monopoly price" and $q > q_0$ correspond to "sales prices". This is suggestive of a feature that has been observed in retail markets: recurrent regular prices and fluctuating sales prices.[8]

3.3 Educating Consumers

Unlike the modeling framework of Section 2, the multi-attribute model does not have a rich enough language for expressing the possibility of "educating" the consumer, and we need to augment the model in order to accommodate it. Gabaix and Laibson (2006) examine what happens when firms can unilaterally alert consumers to the shrouded

[8]Heidhues and Kőszegi (2014) survey the relevant empirical literature, and present a different model that generates a similar pattern: a monopolistic firm faces consumers who are loss averse, in the sense that their willingness to pay increases if they expect to buy, and decreases if the realized price is higher than the price they expected to pay.

attribute, and assume that in this case all consumers choose the product that offers the highest true utility. This does not mean that firms will exercise this option. When the ability to "unshroud" attribute 2 is incorporated into the basic model with $n = K = 2$ and $\alpha = 1$, there is an equilibrium in which firms play $(q^0, q^1) = (2, 0)$ and refrain from educating consumers. The reason is that if a firm deviates from this strategy and unshrouds attribute 2, it cannot attract consumers and earn a positive profit at the same time.

Gabaix and Laibson (2006) adopt the interpretation that dimensions 1 and 2 represent the prices of a basic product and an add-on, respectively (one firm's add-on is incompatible with the other firm's basic product). They extend the model by assuming the availability of an exogenous, cheap substitute for the add-on. They also allow for the coexistence of attentive consumers who are aware of both dimensions and inattentive consumers who neglect the add-on. In equilibrium, firms charge a price below marginal cost for the basic product and a monopoly price for the add-on. Attentive consumers switch to the exogenous substitute after buying the basic product. As a result, firms have no incentive to educate inattentive consumers.

Heidhues, Kőszegi and Murooka (2016) draw interesting implications from the possibility of education-free equilibrium in the Gabaix-Laibson model. They assume a floor on the price of the basic product (in the "quality" language of this review, they effectively impose a ceiling on q_2 which is strictly below 2). This prevents the equilibrium outcome in the basic model with $n = K = 2$ and $\alpha = 1$ from being competitive in the zero-profit sense, which means that an individual firm may have a *strict* preference not to educate inattentive consumers. The reason is that an educated consumer will revise his evaluation of the market alternatives downward, and possibly find the true price that the firm charges too high. Now, suppose that there is an ex-ante stage in which one of the firms can *invent* new add-ons and hidden fees. Heidhues et al. (2016) refer to this as "exploitative innovation". They show that if the innovation can be easily copied by competitors, this ensures the existence of an education-free equilibrium in the continuation price- or quality-setting game. In contrast, when the innovation cannot be easily copied, the rival firm's incentive not to educate consumers in the continuation game breaks down, which destroys the incentive for exploitative innovation. This simple model links two aspects of equilibrium choice complexity: the existence of spurious attributes and the firms' incentive to shroud them.

Comment: Does education imply rational behavior?

Our analysis of educating consumers presumed that when a firm calls the consumer's attention to the hidden attribute 2, he automatically turns into a conventionally rational decision maker who correctly aggregates the two dimensions. Spiegler (2014b) argues that this conclusion is questionable, due to the deep psychological factors that underlie the observed failure to perform trade-offs. Even when the consumer is aware of both dimensions, he may find it convenient to ignore one of them. However, the intervention may cause him to treat the attributes more symmetrically - i.e., α will decrease toward $\frac{1}{2}$. In other words, educating the consumer will not raise his "attention budget", but merely reallocate it across dimensions. As we saw, this leads to a less competitive equilibrium outcome. The lesson is that we need to be careful not to identify the act of drawing consumers' awareness to shrouded attributes with the act of eliminating the bounded-rationality element in their decision process.

3.4 Summary

The multi-attribute framework illuminates the relation between choice complexity and market competition from a different angle. The lessons are broadly similar to those obtained in the framework of Section 2, but the details are of course different. Once again, we saw that market competition is a force that may exacerbate choice complexity. In the two-firm, two-dimension case, equilibrium choice complexity - defined in terms of the frequency with which one market alternative dominates the other - is maximized by market competition. In the many-firm, many-dimension case, adding firms increases the variance of the quality distribution they play. In both models, obfuscation takes the form of bait-and-switch tactics, broadly defined. Consumers end up feeling exploited, because the true quality of their chosen product is on average below its perceived quality at the time of choice. The relation between competitiveness of the equilibrium outcome and the amount of obfuscation is subtle. In the two-firm, two-dimension case, the two are positively related (as we modify the parameter that measures the relative salience of the two dimensions). In the many-firm, many-dimension case, obfuscation increases with n, while the competitiveness of the market outcome remains constant.

The Gabaix-Laibson model is the simplest specimen of the multi-attribute framework. Partly for that reason, it has been applied extensively. We have seen how Heidhues et al. (2016) used it as a platform for studying "exploitative innovation". Likewise, Armstrong and Vickers (2012) used it as a basis for modeling retail banks' use of contingent charges (such as overdraft fees). More complex specifications that involve arbitrary n and K - as well as more general methods for aggregating the ordinal quality rankings along the dimensions - remain largely unexplored. Majority auctions, studied by Szentes and Rosenthal's 2003(a,b), can be reinterpreted as an example of such a model. Characterizing equilibria in this more general class of models is an important challenge for future research.

4 An Application: Default Architecture

When consumers face choice problems that are cognitively or emotionally demanding, a natural response for them is to eschew making an explicit choice. This means that when there is an available default option, consumers will have an increased tendency to choose it when facing a complex choice problem. This idea has some experimental and empirical support (Iyengar Huberman and Jiang (2004), Madrian and Shea (2001), Beshears et al. (2012)). However, the models examined in Sections 2 and 3 did not include an explicit default option, and in particular assumed that consumers have no outside option. In this section I enrich the analysis in this direction.

This enrichment enables us to explore theoretically one of the most influential policy ideas that have come out of behavioral economics, namely the design of default options, often referred to as "default architecture" (see Thaler and Sunstein (2008)). By changing the specification of the default option, a regulator can exploit decision makers' default bias to increase participation rates in programs like organ donation or retirement saving. Thaler and Sunstein (2008) acknowledged that default bias is not a primitive phenomenon and that it originates from more fundamental forces, including choice complexity. Bachi and Spiegler (2015) and Spiegler (2014b) integrate these considerations explicitly into an equilibrium analysis of default architecture. To avoid unnecessary tedium, the following discussion is exclusively based on the latter, which makes use of the modeling framework of Section 2. I refer the reader to Bachi and Spiegler (2015) for an equilibrium analysis of default architecture that is based on the model of Section 3.1.

Consider the two-firm case analyzed in Section 2.1, and now assume that the consumer has an outside option that gives him a net payoff of 0. This is an extreme assumption, which means that opting out of the market is always the wrong action for the consumer (except when both firms offer $q = 0$, in which case there is a tie). In addition, assume that when there is an explicit default option and the consumer is unable to make a value comparison between the two market alternatives, he chooses the default option (whatever it is) with probability γ, and each of the two firms with probability $\frac{1}{2}(1-\gamma)$. When there is no designated default option, the consumer is simply not allowed to choose by default and must make an active choice, in which case he chooses each firm with probability $\frac{1}{2}$. The parameter γ thus captures the consumer's *potential* *default bias*. A higher value of γ represents a consumer who is temperamentally less "decisive", or more averse to making arbitrary selections that he cannot justify.

The literature on default architecture distinguishes among the following rules:

Opting in. The default is the outside option.

Opting out. The default is one of the firms (to maintain the model's symmetry, I will assume that both firms are equally likely to play this role).

Active choice. The consumer cannot choose by default.

Given the model's symmetries and the assumption that the outside option is always inferior to the market alternatives, active choice and opting out are payoff-equivalent as far as the firms are concern. Therefore, I will only compare opting in and opting out.[9]

Note that under "opting in", the consumer can make manifestly sub-optimal choices. He may realize that the outside option is his worst choice, but since he cannot compare the two market alternatives and has an aversion to making arbitrary decisions, he may procrastinate and end up with the inferior outside option. In this case the consumer acts like the proverbial Buridan's Ass: unable to choose between two attractive alternatives, he ends up with a third inferior one only because it is the default.

The extended model broadly fits markets for long-term services (insurance, magazine subscription, mobile phone services). In this context, "opting in" may correspond to a regulatory intervention that rules out automatic contract renewals, whereas "opting out" fits an environment in which auto-renewals are the norm. It should be emphasized that a lot of the discussion of default architecture in the literature does not involve competitive consumer markets. Clearly, non-market activities such as organ donation are entirely outside the model's scope. Things are more subtle when it comes to the design of defined-contribution retirement saving programs in the US. In reality, saving funds do not compete directly for savers - the interaction is mediated by the savers' employers, who shape the set of feasible alternatives and its presentation, and negotiate the management fees with the funds. This is a *de-facto-regulated* market, where the employer plays the role of a regulator. In this context, our analysis can be viewed as speculation about the equilibrium effects of default architecture if this de-facto regulation were lifted.

[9] One could argue that forcing consumers to make arbitrary selections makes them incur a psychological cost that choosing by default would save. From this point of view, opting out and active choice are not equivalent for consumer welfare.

What is the effect of default architecture on equilibrium choice complexity and consumer welfare? Once again, EC turns out to be a crucial property. Recall that EC means that each firm can randomize over formats according to some $\lambda \in \Delta(M)$, such that comparison probability is C^*. Thus, whatever the default rule, there is a symmetric Nash equilibrium in which each firm randomizes over formats according to λ, independently of its mixture over q. This means that *equilibrium choice complexity is potentially invariant to the default rule.* (This is a weak statement because I do not know whether symmetric equilibrium is generally unique under "opting in".)

Of course, the firms' equilibrium mixture over quality will *not* be invariant to the default rule. Under "opting in", the consumer adheres to the outside option with probability γ when he is unable to make a comparison. In contrast, under "opting out" he always chooses one of the firms. Thus, market participation rates are higher under "opting out". But at the same time, firms' benefit from lack of comparability is lower under "opting in" (and it vanishes completely when $\gamma = 1$); and as a result, the equilibrium quality distribution is higher under "opting in". When calculating equilibrium consumer welfare, the two effects cancel each other out! To see why, let $C^* < 1$ and consider the point of view of a firm that offers $q = 0$ (which is in the support of the equilibrium quality distribution under both default rules).[10] Under "opting in", the firm's equilibrium profit from this quality choice is

$$(1 - C^*) \cdot (1 - \gamma) \cdot \frac{1}{2}$$

In contrast, under "opting out", the firm's equilibrium profit from this quality choice is

$$(1 - C^*) \cdot \frac{1}{2}$$

Net consumer welfare in equilibrium is equal to the market participation rate minus industry profits. This gives us

$$(\gamma C^* + 1 - \gamma) - 2 \cdot (1 - C^*) \cdot (1 - \gamma) \cdot \frac{1}{2} = C^*$$

under "opting in", whereas "opting out" gives us

$$1 - 2 \cdot (1 - C^*) \cdot \frac{1}{2} = C^*$$

Thus, *when choice complexity is invariant to the default rule, so is consumer welfare.*

[10] When $C^* = 1$, the equilibrium outcome is competitive with full market participation, independently of the default rule.

When EC is violated, equilibrium choice complexity - and therefore net consumer welfare - may be sensitive to the default rule. Take the special case in which formats can be ordered unambiguously in terms of their effect on comparison probability - i.e., in terms of their "intrinsic complexity". Under "opting out", firms benefit from the consumer's default bias and therefore have some incentive to complicate his choice problem. In contrast, under "opting in", firms do not benefit from default bias, and therefore have a weaker incentive to increase choice complexity. When $\gamma \rightarrow 1$ - i.e. when the consumer's *potential* default bias is extreme - firms will choose the simplest format in equilibrium under "opting in". This has several interesting effects. First, equilibrium choice complexity will be as low as possible given the function π, and as a result, the consumer will exhibit high participation rates and little observed default bias in equilibrium. This is superficially paradoxical: observed default bias is at its lowest precisely when the potential for default bias is at its highest. The resolution of the apparent paradox is that under "opting in", firms do not benefit from default bias and therefore refrain from obfuscation, which leads to low choice complexity and therefore low observed default bias. As far as net consumer welfare is concerned, "opting in" may be superior to "opting out".

Let us discuss these effects in terms of the real-life examples of default architecture discussed above. First, consider the interpretation of defaults rules in terms of *automatic renewal* of long-term services. The equilibrium analysis provides qualified support for the intuition that in these environments, banning auto-renewals leads to higher consumer welfare. When EC does not hold and formats can be ordered unambiguously in terms of their intrinsic complexity, firms respond to the ban on auto-renewals by obfuscating less, and this can have a beneficial effect on consumer welfare that outweighs the ban's direct negative effect on market participation rates. As to retirement saving, the analysis highlights the importance of the employer's active role as a de-facto regulator of the interaction between funds and savers. In its absence, the switch from "opting in" to "opting out" might incentivize funds to obfuscate and raise management fees. Savers benefit not only from the "soft paternalism" of default architecture, but also from the employer's "hard paternalism" (to the extent that it can be trusted to serve the savers' interests).

5 The "Wrong Weights" Approach

The modeling frameworks presented in Sections 2 and 3 are based on the notion of *limited comparability*: under some conditions, consumers are unable to make a value comparison between market alternatives, and respond by choosing arbitrarily or by default. In this section, I briefly discuss a line of research that shares with the framework of Section 3 the idea of obfuscation as lopsided location in multi-attribute space. However, it does not share the limited-comparability aspect; instead, it assumes that consumers are always able to make a comparison using a linear utility function, except that the modeler judges the weights they apply to various product dimensions to be wrong. The wrong weights may be due to an inherent bias or the firms' framing devices. Most of the literature in the "wrong weights" category focuses on monopoly pricing. In this section I describe a few works that applied the approach to competitive market models.

The dividing line between the two classes of models is somewhat blurred - some versions of Gabaix and Laibson (2006) and Bachi and Spiegler (2015) fit both. Other models examine choice procedures that mix ordinal and cardinal elements. Bachi (2015) studies unidimensional competition when consumers cannot perceive small differences. Papi (2014) studies multi-dimensional competition when consumers can perform trade-offs over a restricted number of dimensions, and firms use marketing to influence the set of dimensions they focus on.

5.1 Non-Linear Pricing under Biased Beliefs

Recall that one of the interpretations of the multi-attribute model is that each dimension corresponds to a contingency. The contingency can be a state that determines the consumer's willingness to pay for the firm's product. This suggests the following two-period variant on the multi-attribute model. In period 1, each firm offers a price plan $t : \mathbb{R}_+ \to \mathbb{R}$, where $t(x)$ is the total payment if the consumer chooses consumption quantity x. The consumer then decides whether to choose one of the offered contracts or opt out. In period 2, having selected one of the contracts, the consumer is obliged by it and proceeds to select a quantity x that carries the payment $t(x)$. The consumer's outside option gives him a fixed payoff normalized to 0. His utility from second-period consumption is quasi-linear, $\theta u(x) - t(x)$, where u is an increasing function. However, θ may be random, and consumers have idiosyncratic prior beliefs regarding θ, which potentially differ from the prior common to all firms.

The multiple dimensions in this model correspond to the consumer's second-period preference state. The firms' prior over these states is considered to be the correct, unbiased belief, and the consumer's prior applies incorrect weights to the states. For instance, the consumer may systematically overestimate his future willingness to pay, such that his subjective prior over θ first-order-stochastically dominates the true distribution. Eliaz and Spiegler (2008) examine a two-state model of monopoly pricing with this feature. Alternatively, the consumer may be overconfident in his beliefs, in the sense that the true distribution over θ second-order-stochastically dominates the consumer's prior. Grubb (2009) studies a many-states version of such a model. DellaVigna and Malmendier (2004), Eliaz and Spiegler (2006) and numerous subsequent works, assumed that the consumer's preferences are dynamically inconsistent - i.e., he has a distinct first-period preference over his second-period consumption. In this context, an incorrect prior captures the consumer's limited ability to anticipate the change in his future preferences (his "naivete", to use the literature's jargon). The effects I will highlight in this sub-section are independent of this added feature. I refer the reader to Spiegler 2011 (ch. 2-5) and Grubb (2015b) for general reviews of pricing models in which consumers have biased beliefs regarding their future preferences.

Complexity in this context can be viewed as an "overly" non-linear price plan. For instance, consider a two-state model with rational consumers and concave u, where firms simultaneously commit to price plans in period 1. Then, firms choose linear, marginal-cost pricing in symmetric Nash equilibrium. In contrast, when consumers have biased prior beliefs, competition generates non-linear price plans that exploit the difference between consumers' and firms' beliefs. Specifically, firms offer attractive, loss-making prices for quantities that are expected in the state that the consumers deem relatively more likely; firms compensate for this loss with high prices that generate positive profits in the other state. This is analogous to the quasi-bait-and-switch tactics we observed in the models of Section 3. DellaVigna and Malmendier (2004) derive such a result in a model with two competing firms, where firms are restricted to use two-part tariffs and consumers have dynamically inconsistent preferences. Spiegler (2011, Ch. 2) lifts the restriction to two-part tariffs and obtains a result in the same spirit.

What is the role of competition in generating this type of choice complexity? In particular, does competition reduce or rather increase the ubiquity of complex, non-linear pricing? The following argument is made in Spiegler (2011, Ch. 4) in the context of dynamically inconsistent preferences, but it is also applicable when the consumer does not have a distinct first-period preference over second-period consumption. Suppose that the consumer's first-period prior belief is his private information. A monopolistic firm offers a menu of price plans in order to screen the consumer's first-period belief. As usual in price-discrimination models, this may give rise to "bunching" of similar consumer types. In particular, consumers whose prior is relatively close to the firm's belief will be offered the simple contract that the firm would offer to unbiased consumers.

By contrast, in a competitive model where firms simultaneously commit to menus of price plans, the split between consumers who choose simple and complex contracts is determined by the zero-profit condition that all price plans satisfy in equilibrium, and therefore it is insensitive to the distribution of consumers' prior beliefs. Depending on the shape of the distribution of consumer beliefs, it is possible that the switch from monopoly to competition will raise the fraction of consumers who end up with a complex, non-linear price plan. In this sense, competition can increase choice complexity in this setting. Because complex contracts are more exploitative, the conclusion is that competition may harm consumer welfare.

5.2 Endogenous Weights

Just as Heidhues et al. (2016) endogenized the existence of hidden attributes by the idea of ex-ante "exploitative innovation", we may ask whether consumers' wrong weights can be endogenized. Let us return to the static setting in which consumers make a once-and-for-all decision, as in the models of Section 3. However, now assume that the weights that consumers apply to different product dimensions are endogenously affected by the firms' marketing strategies.

Spiegler (2014a) analyzes an example in which two firms simultaneously choose elements in $[0, \infty)^K$ as well as an independent marketing message m. The latter is a suggested vector of weights. The weights that the consumer ends up applying is a simple average of the firms' suggestions. This simple model synthesizes modeling ideas from Sections 2 and 3: on one hand, firms' basic strategy is a location in multi-dimensional space; yet on the other hand, firms also make use of an independent, payoff-irrelevant framing device. Symmetric Nash equilibria have a simple structure: firms mix over quality vectors of the following form: $q^k = K$ for some k and $q^j = 0$ for all $j \neq k$, and thus earn zero profits. The quality vectors are maximally skewed subject to the zero-profit condition. Firms accompany such vectors with a marketing message that assigns all weight to the unique component k for which $q^k = K$. Although both firms suggest maximally skewed vectors of weights, they need not coordinate on the same vector, and as a result the consumer's weights need not be maximally skewed. However, for any realization of the firms' equilibrium mixed strategy, the consumer ends up assigning positive weight to two attributes at most. Thus, when K is large, the consumer's weights are close to being maximally skewed.

Kőszegi and Szeidl (2013) and Bordalo, Gennaioli and Shleifer (2013) construct wrong-weights models of consumer choice in which weights are not determined by an independent "framing" variable, but by the very structure of the firms' location in multi-attribute space. More specifically, the weight consumers apply to an attribute increases with the variation of values it gets in the choice set. For instance, let $n = K = 2$ and suppose that firms offer quality vectors that satisfy $q_1^1/q_2^1 > q_2^2/q_1^2 > 1$. That is, the product of each firm i is comparatively better along dimension $k = i$, yet firm 1's advantage is greater in relative terms. The model of Bordalo et al. (2013) implies that under such a strategy profile, the consumer will assign a larger weight to dimension 1. In equilibrium, both firms choose $q^1 = q^2 = 1$ and earn zero profits. This model of endogenous weights leads to a "maximum simplicity" selection among all competitive market outcomes.

Bordalo, Gennaioli and Shleifer (2014) analyze a sequential-move variant on this model. In the first stage, firms simultaneously commit to a value in one dimension, interpreted as the product quality. In the second stage, having observed their quality choices, they compete along the other dimension, interpreted as the product price. In subgame prefect equilibrium, firms choose identical qualities and identical prices, and earn zero profits. Thus, as in the simultaneous-move version, consumers apply correct weights and there is no choice complexity along the equilibrium path. However, the equilibrium provision of quality is *lower* than in the rational-consumer benchmark, because of the threat of out-of-equilibrium consumer bias resulting from a deviation. Underprovision of quality becomes more pronounced as the consumer's subjective weights become more sensitive to firms' strategy profile.

6 Conclusion

This article reviewed a number of modeling approaches to the question of choice complexity and market competition. Choice complexity can be captured by an incomplete comparability relation over the (labels of) available market alternatives, which is a function of independent "framing" devices; or it can be defined as lack of simple domination between multi-attribute market alternatives; or, relatedly, it can be described by highly non-linear price plans. Despite their differences, these modeling approaches shared a common theme: in the simplest competitive-market environments, consumers' failure to make correct value comparisons is a force that impels firms to introduce choice complexity, in an attempt to exploit consumers' decision errors and soften competitive pressures. As we increase the competitiveness of the market (by switching from monopoly to multi-firm settings, increasing the number of competitors, or introducing an attractive outside option), firms tend to intensify their equilibrium attempts to increase complexity. As a result, greater competition is not unambiguously beneficial for consumers.

Throughout this review, I did not take a stand on whether complex alternatives declare themselves as such. In some cases - e.g., when complexity is defined as jargon-laden verbal descriptions - consumers can recognize which market alternatives are simple and which are complex. In other cases - recall the example of insurance companies' randomization over reimbursement levels - this distinction is hard to make. In yet other cases - e.g., when choice complexity is due to incommensurable measurement units - the distinction is nonsensical. However, when consumers can tell simple alternatives from complex ones - even if they cannot evaluate them - they can follow a natural heuristic: choose simple alternatives over complex ones. This heuristic clearly annuls the forces that this review has emphasized, and pushes the market toward a competitive outcome with simple contracts. See Gaudeul and Sugden (2012) for a formalization of this argument.

The literature faces several interesting challenges. First, at the purely game-theoretic level, we saw non-trivial classes of games that await complete equilibrium characterization. Second, it would be interesting to find properties of individual consumer behavior like EC, which possesses similarly rich implications for market equilibrium. Third, my use of the notion of "true utility" throughout this review has been quite vulgar from a revealed-preference point of view. It is imperative to strengthen the link between the equilibrium market models and the decision-theoretic analysis of consumer behavior. In particular, when we perform welfare analysis in market models, the question is whether it can be grounded in actual or hypothetical consumer choices. The question of welfare identification in the presence of bounded rationality has been discussed in choice-theoretic settings (Berhneim and Rangel (2009), Rubinstein and Salant (2012)), but market settings present interesting challenges in this regard (see Eliaz and Spiegler (2015)).

Finally, although my orientation in this review has been purely theoretical, there are beginnings of an empirical literature that addresses the interplay between complexity and competitiveness. Some of these works use the experimental methodology (e.g. Kalayci and Potters (2011), Crosetto and Gaudeul (2014), Huck, Lünser and Tyran (2015), Kalayci (2015)), while others are in the "empirical I.O." tradition (for discussion of recent examples in Grubb (2015a)). The modeling frameworks introduced in this review may be insightfully adapted for empirical work, as they suggest new unobservables (the function π in Section 2, the parameter γ in Section 4) that can help making sense of data, and generate new predictions that link choice complexity and more traditional market variables.

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