On the Equilibrium Effects of Nudging

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Abstract

Consumers’ systematic decision biases make them vulnerable to market exploitation. The doctrine of "libertarian paternalism" maintains that this problem can be mitigated by "soft" interventions (nudges) like disclosure or "default architecture". However, the case for nudging is often made without an explicit model of the boundedly rational choice procedures that lie behind consumer biases. I demonstrate that once such models are incorporated into the analysis, equilibrium market reaction to nudges can reverse their theoretical consequences.

KEYWORDS: behavioral industrial organization, nudges, libertarian paternalism, consumer protection, default design, disclosure, bounded rationality, structural models

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1 Introduction

Our everyday thinking about consumer protection relies on some intuitive notion of bounded rationality. A "reasonable" consumer making decisions under normal circumstances is not infallible; he is naturally limited in his computational abilities; his understanding of market regularities is imperfect; he often suffers from attention deficits due to the many tasks he needs to juggle; and he may succumb to temptation, self-delusion or wishful thinking. Since these limitations make him vulnerable to market exploitation, the challenge for economists and legal scholars is how to think about consumer protection in this context. In particular, can regulators minimize market exploitation without resorting to measures that impose limits on contractual freedom (sin taxes, banning contracts ex-ante or voiding them ex-post)?

One school of thought is encapsulated in the words of a former FTC chairman: "Robust competition is the best single means for protecting consumer interests" (Muris (2002)). However, the growing literature on "behavioral industrial organization" (BIO henceforth) does not provide unambiguous theoretical support for this sweeping motto, for a variety of reasons. First, when consumers are diversely sophisticated, stronger competition may impel firms to shift the focus of their pricing strategy toward exploitation of naive consumers (Varian (1980), Spiegler (2011, Ch. 4.2), Armstrong (2014)). Second, in a market for a product of questionable intrinsic value (certain alternative-medicine practices and active money management are often claimed to fall into this category), increased supply may end up raising the fraction of consumers who take the welfare-reducing decision to enter this market (Spiegler (2006a)). Third, firms may respond to stronger competition by intensifying their obfuscation tactics, rather than by offering more attractive products (Spiegler (2006b), Carlin (2009), Chioveanu and Zhou (2013)).

In the last decade, a new school of thought (Thaler and Sunstein (2003), Camerer et al. (2003), Bar-Gill (2012)) has argued for a "third way" that consists of "soft" interventions that assist boundedly rational consumers without
constraining contractual freedom. According to this approach, the regulator can manipulate features of consumers’ choice set that would be irrelevant for a rational decision maker, such as the order in which alternatives are presented, or the specification of a default option. The regulator could also impose user-friendly disclosure requirements that reduce information-processing effort and minimize confusion. Choice architecture and disclosure are indeed the prime examples of this approach, dubbed "libertarian paternalism" or "nudging", which received a major boost by Thaler and Sunstein’s (2008) eponymous best-seller.

The "nudgniks" have been criticized on philosophical grounds. In particular, it has been argued that any governmental manipulation of consumer choice goes against libertarian values, especially when it springs from a paternalistic pretense to know consumers’ "true preferences".\textsuperscript{1} This paper offers a different critique, which targets two characteristics of most discussions of "nudging". First, although proponents of nudging recognized that beneficial effects of nudges may be counteracted by market equilibrium responses (Barr et al. (2008), Bar-Gill (2012, pp. 38-39, 175-176), Baker and Siegelman (2014)), equilibrium analyses of nudges are rare. Second, the literature typically regards consumers’ decision errors and biases as primitive behavioral phenomena, or "black boxes".

For example, Bar-Gill (2012) and Mullainathan et al. (2012) employ models in which rational choice involves trading off costs and benefits according to certain decision weights, and decision biases are captured by wrong weights. Although Mullainathan et al. (2012) allow the weights to be a function of "nudges", they leave this function unspecified. Such "reduced-form" models of consumer biases do not tell an explicit story about the origin of the wrong weights, thus offering little guidance as to how they could be affected by firms’ obfuscation tactics or regulatory interventions. The two characteristics are thus interrelated: the "reduced-form" approach to modeling consumer biases

\textsuperscript{1}Thaler and Sunstein (2008) and Sunstein (2014) discuss and reply to these criticisms.
limits the scope of equilibrium analysis of "nudging".

I challenge the reduced-form approach, by considering a sequence of *market models in which profit-maximizing firms compete for boundedly rational consumers*. In each model, consumers commit a decision error that intuitively calls for nudging. However, the model does not treat the error as a black box, but formalizes a plausible, explicit psychological mechanism that generates it.2 I use each model to address a different "nudge" which seems pertinent given the decision error in question. In each case, I show that once the psychological mechanism behind consumer error and the firms' equilibrium response are taken into account, the theoretical case for the nudge is reversed. Let us preview this sequence of exercises.

**Default architecture and limited comparability (Section 3)**

Decision makers often adhere to status quo or default options, even when there are better alternatives and when the physical cost of switching away from the default is negligible. Such "default bias" leads to social outcomes such as low consumer switching rates in retail banking, or weak participation in retirement-saving and organ-donation programs. Consequently, design of default rules has been a major theme in the "nudge" literature. To evaluate the equilibrium implications of default architecture in consumer-market settings, we should look for the deeper psychological mechanism behind default bias. Introspection and experimental evidence suggest that *complexity of the choice problem* is an important contributing factor to default bias. In a market environment, this complexity is affected by the firms' obfuscation strategies. Adapting a modeling approach originating in a classic paper by Varian (1980) and developed by Carlin (2009), Piccione and Spiegler (2012) and Chioveanu and Zhou (2013), I analyze a two-firm price-competition game, in which firms also choose whether to obfuscate, where obfuscation is simply an action that reduces the probability that consumers are able to make a price comparison (thus increasing the probability they will adhere to their default

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2Rubinstein (1998) refers to such choice models as "procedural".
option, whatever it is). I show that default rules aimed at increasing market participation may end up reducing consumer welfare, as a result of firms’ equilibrium price and obfuscation responses.

*Product-use disclosure and underestimation of future taste for immediate gratification (Section 4)*

A common concern is that when consumers accept long-term service contracts (such as credit cards, mobile phone plans), they systematically underestimate the total amount they will end up paying. It has been argued (Thaler and Sunstein (2008), Bar-Gill (2012)) that regulators can respond by mandating produce-use disclosure. For instance, firms can be required to report the effective price-per-unit induced by the tariffs they offer, calculated according to average consumption in a comparison group of consumers. To evaluate this nudge, I follow Bar-Gill’s (2012) suggestion that excessive payments may originate from consumers’ underestimation of their own future taste for immediate gratification, as captured in an influential model due to DellaVigna and Malmendier (2004). I show that when this model is extended to incorporate product-use disclosure, consumers’ excessive payment is exacerbated, and their ex-ante welfare drops. The reason is that the disclosure effectively impels firms to cater to the consumers’ taste for immediate gratification, rather than their ex-ante preferences.

*Product-attribute disclosure and trade-off avoidance (Section 5)*

Consumers often appear to neglect non-salient product attributes (certain bank fees, contingencies in an insurance contract, add-ons). Firms can take advantage of such neglect and make "shrouded" attributes unattractive for consumers. Moreover, Gabaix and Laibson (2006) argued that market forces need not impel firms to "unshroud" these attributes. A natural regulatory response is to mandate full disclosure of all product attributes, in order to homogenize their salience. I argue that if the deeper psychological force behind consumers’ neglect of attributes is an intrinsic "attention deficit" or aversion to hard trade-offs, disclosure will not turn consumers into rational
"trade-off machines"; instead, they will continue to neglect attributes, albeit less predictably because of the attributes' uniform salience. This lack of predictability weakens competitive pressures and can make consumers worse off. I articulate this point using a recent model due to Bachi and Spiegler (2014).

I wish to make a few comments regarding the methodology of this paper. First, the models I have selected are, in their basic form, among the most well-known in the BIO literature. They are extended to accommodate the nudges, but I have striven to make the extension as minor as possible and I have chosen the models’ simplest possible form to illustrate the nudges’ effects, sacrificing generality for the sake of expositional clarity and simplicity. Thus, one should not expect the theoretical exercises in this paper to be directly applicable to concrete policy issues. Second, I have deliberately chosen to use different models involving different psychological mechanisms to examine different nudges. This will hopefully convince the reader that the "anomalous" equilibrium effects of the nudges are not "cooked", but plausible consequences of taking equilibrium analysis seriously. Some of the models can be used to address multiple nudges, as illustrated in an online appendix. Finally, the scope of my analysis is limited in the sense that it focuses on consumer markets. However, I believe it is relevant to other settings as well. For example, the equilibrium analysis of default architecture sheds light on the role of employers in mediating the interaction between retirement-saving funds and savers: in their absence, default architecture could backfire due to equilibrium effects.

One advantage of thinking about consumers’ decision errors in terms of their deeper procedural origins is that it broadens the range of consumer protection measures that can be studied, and it enables us to make finer distinctions between regulatory environments. In an online appendix, I discuss further implications of the modeling approaches in Sections 3 and 5 for various nudges.
2 Related Literature

The BIO literature forms the backdrop for this paper - see Ellison (2006), Armstrong (2008) and Huck and Zhou (2011) for surveys, and Spiegler (2011) for a graduate-level textbook. The latter provides many theoretical examples of regulatory interventions that seem at first glance to promote consumer welfare (strengthening competition, requiring firms to offer plain-vanilla options) and yet end up harming consumers when their underlying choice procedures and the firms' equilibrium response are taken into account (see Sections 4 and 7, for example). However, since these interventions are not "libertarian-paternalistic", I do not discuss them in detail in this paper.3

A number of recent works examined the equilibrium effects of regulated disclosure, in the contexts of market models in which (some) consumers have various forms of limited attention or awareness. Kamenica, Mullainathan and Thaler (2011) showed that product-use disclosure may have an adverse welfare effect on consumers with limited knowledge of their own tastes, once market equilibrium effects are taken into account. Armstrong and Vickers (2012) discussed disclosure of contingent charges in a model in which some consumers neglect non-salient contingencies. De Clippel et al. (2013) analyzed a model in which consumers rationally allocate their limited attention to individual markets according to the observed prices charged by market leaders. They showed that improving consumers’ attention weakens market leaders’ incentive not to stand out as being too expensive, and this in turn softens competitive pressures and lowers consumer welfare in equilibrium. Grubb (2014) constructed a dynamic consumption model in which consumers have limited ability to monitor their own past consumption, and analyzed disclosure policies that address the "bill shock" problem that arises in such a model. In particular, he showed that policies that prevent bill shock

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can reduce consumer welfare by effectively robbing firms of instruments for discriminating among consumers with different demand.

What distinguishes the present paper from these works? First, it presents the "equilibrium critique of nudging" in a comprehensive and systematic manner. Second, it contains the first theoretical analysis of equilibrium effects of default architecture (together with Bachi and Spiegler (2014)). Finally, most interventions studied in the BIO literature are relevant in models with rational consumers. In contrast, nudges are by definition irrelevant when the consumer is rational. The nudges studied in Sections 3 and 5 can be viewed precisely as external manipulations of the very parameters that define the consumer’s bounded rationality.

Another recent development is the empirical investigation of the equilibrium effects of nudging. Duarte and Hastings (2012) studied the implications of disclosure regulations on the structure of management fees charged by privatized social security funds in Mexico. Grubb and Osborne (2013) estimate a model of the mobile phone market based on Grubb (2014), and use it to assess the welfare effects of product-use regulation in this industry. Handel (2013) estimates a model of health insurance choice with an explicit adverse-selection component and a reduced-form account of consumer inertia, and uses the estimation to argue that nudges can backfire because they exacerbate the adverse-selection problem.

3 Default Architecture

Design of default options is arguably the most influential idea in the "nudge" literature. It is based on the observation that decision makers tend to stick to default or status-quo options (even when the physical cost of switching away is negligible) in a variety of contexts: organ donation, retirement saving, renewing insurance policies, or selecting a provider of retail banking services. This has given rise to the suggestion, eloquently articulated by Thaler and
Sunstein (2008), that policy makers can and should influence decision makers’ choices in such settings by appropriately designing default options. In particular, it has been argued that a switch from "opting in" (a regime in which the default is an outside option) to "opting out" (a regime in which the default is one of the "market" alternatives) will raise participation rates in various programs. Thaler and Sunstein (2008) acknowledged that default bias is not a primitive phenomenon, and that it originates from loss aversion, limited attention or choice complexity. However, neither they nor others integrated these considerations explicitly into an equilibrium analysis of default design.

In this section I attempt such an exercise, in the context of a market model in which profit-maximizing firms compete for consumers who exhibit default bias, and I focus on choice complexity as the source of this bias. This is an extension of a classic model due to Varian (1980), in which firms selling a homogenous product play a price-competition game. Unlike the textbook model of Bertrand competition, not all consumers go for the cheapest market alternative. Instead, a certain fraction $\alpha$ of the consumer population choose randomly one of the firms, independently of their prices. Varian interpreted this behavior as a manifestation of limited information or customer loyalty. More recently, Carlin (2009), Piccione and Spiegler (2012) and Chioveanu and Zhou (2013) reinterpreted Varian’s friction in terms of limited ability to make price comparisons, and extended the model by allowing $\alpha$ to depend on the firms’ endogenous marketing strategies. I extend this tradition by incorporating default architecture.

The model
Consider a market that consists of two profit-maximizing firms and a measure one of consumers. The firms costlessly produce a homogenous product that has a gross value of 1 for consumers, who also have an outside option that gives them zero net utility. The firms play a simultaneous-move game with complete information. Each firm $i = 1, 2$ chooses a pair $(p_i, x_i)$, where $(i)$
$p_i \in [0, 1]$ is the price of the firm’s product, and (ii) $x_i \in \{0, 1\}$ indicates firm $i$’s "obfuscation" strategy, such that $x_i = 1$ ($0$) means that the firm obfuscates (refrains from obfuscation).

The effect of playing $x = 1$ is to lower the probability that consumers are able to make a price comparison between the two market alternatives. Specifically, each consumer makes a comparison with probability $1 - \frac{1}{2}(x_1 + x_2)$. This particular formula is assumed purely for expositional simplicity. It means that when both firms refrain from obfuscation, comparability is perfect, as in the Bertrand model; when both firms obfuscate, the consumer is totally unable to make a comparison; and when only one firm obfuscates, the consumer makes a comparison with probability $\frac{1}{2}$. Whenever a consumer cannot make a comparison, I will say that he faces a "complex choice".

This formulation approximates a variety of real-life forms of obfuscation. For instance, contractual terms can be described in technical or jargon-laden language that requires translation, and the act of translation can result in "gibberish" that prevents comparison. Likewise, prices can be presented in a way that requires the consumer to perform a complex calculation to derive the "bottom line", and the calculation can break down.

I allow for heterogeneity among consumers in terms of their response to complex choices. A fraction $\lambda \in (0, 1]$ of consumers are "decisive" types - they arbitrarily choose a firm (each with probability $\frac{1}{2}$) whenever they cannot make a comparison; the remaining fraction $1 - \lambda$ are "indecisive" types - they respond to complex choices by "deciding not to decide", namely choosing a default option when possible (and when choosing by default is infeasible, they are forced to choose "decisively"). A lower value of $\lambda$ means that the propensity for default bias is more common in the consumer population, and $\lambda = 1$ means that consumers exhibit no default bias. The default regime is designed ex-ante by the regulator. I focus on two default rules. Under "opt in", the default is the outside option. Under "opt out", the default is firm 1 for half the consumer population and firm 2 for the other half (to maintain
the game’s symmetry, for simplicity).4

Let us write down the payoff function in the simultaneous-move game the firms play. Firm $i$’s profit is $p_i \cdot s_i((p_1, x_1), (p_2, x_2))$, where $s_i$ represents the firm’s market share. Under "opt in", $s_i$ is given by

$$s_i((p_1, x_1), (p_2, x_2)) = \begin{cases} \frac{x_1 + x_2}{2} \cdot \frac{1}{2} + \left(1 - \frac{x_1 + x_2}{2}\right) \cdot 1 & \text{if } p_i < p_j \\ \frac{x_1 + x_2}{2} \cdot \frac{1}{2} + \left(1 - \frac{x_1 + x_2}{2}\right) \cdot \frac{1}{2} & \text{if } p_i = p_j \\ \frac{x_1 + x_2}{2} \cdot \frac{1}{2} + \left(1 - \frac{x_1 + x_2}{2}\right) \cdot 0 & \text{if } p_i > p_j \end{cases}$$ (1)

Under "opt out", each firm ends up having half the consumers who are unable to make a comparison (some of them are decisive and choose the firm arbitrarily, while others are indecisive and were initially assigned to the firm as a default). Consequently, the market share function $s_i$ is also given by (1), except that we plug $\lambda = 1$. Thus, as far as firms are concerned, "opt out" is equivalent to "opt in" with $\lambda = 1$. For this reason, I will identify "opt out" with $\lambda = 1$ when I conduct the equilibrium analysis, and return to the distinction between the two default regimes in the welfare analysis.

What is the relation between this market model and the various contexts in which default architecture has been discussed? First, non-market activities such as organ donation are clearly outside the model’s scope. In markets for long-term services (insurance, magazine subscription, mobile phone services), "opt in" may correspond to a regulatory intervention that rules out automatic contract renewals, whereas "opt out" fits an environment in which auto-renewals are the norm. As to 401(k) retirement-saving programs, an important qualification is in order. In reality, funds do not compete directly for savers; instead, the interaction is mediated by the savers’ employers, who shape the set of feasible alternatives and its presentation, and negotiate the management fees. This market is thus effectively regulated by the employers. The analysis in this section can be viewed as an attempt to speculate about

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4The case of $\lambda = 0$ results in multiple Nash equilibria under "opt in", and therefore I rule it out.
the equilibrium effects of default architecture in the absence of such de-facto regulation.

*Comment: "Buridanic" behavior.* The net value that firm $i$ generates for consumers is $1 - p_i \geq 0$. Hence, by assumption, the outside option is inferior to any of the market alternatives, regardless of the firms’ behavior. This is a deliberate modeling choice, designed to ensure that market participation is unambiguously beneficial for consumers. It also means that under "opt in", an indecisive consumer (who clings to the outside option in response to complex choices), ends up being worse off than if he "just did it" and chose an arbitrary market alternative. An indecisive consumer is like the proverbial Buridan’s Ass: unable to rank two attractive market options, he *procrastinates choice*, even though he may recognize that the delay is sub-optimal because *any* of the market products is better than opting out. As a result, for a given time horizon, the effective choice of some of the consumers is not to enter. The psychology behind such behavior is that people generally dislike making an active choice that lacks a good reason (Payne et al. (1993) and Anderson (2003)), and they are willing to delay choice in order to avoid this unpleasant feeling. I believe this behavior is quite common - for "hard" empirical evidence for "Buridanic" behavior in various contexts, see Iyengar et al. (2004), Madrian and Shea (2001) and Beshears et al. (2012).

*Comment: Active choice.* A third default rule that has been discussed in the "nudge" literature is "active choice", namely forcing consumers to make an explicit choice and forbidding them to choose by default. In this case, given that the outside option is clearly inferior to any of the market alternatives, it makes sense to assume that when the consumer faces a complex choice, he behaves as if he were "decisive". Under this assumption, active choice is

5Because the outside option is inferior to the market alternatives, one could argue that the fraction of indecisive types should be lower under "opt in" than under "opt out". However, this criticism is irrelevant for our purposes, because under "opt out", the fraction of indecisive consumers does not matter for firms’ payoffs and consumer welfare.
payoff-equivalent to the case of \( \lambda = 1 \) under any of the other default rules.

**Comment:** *The upper bound on prices.* I have assumed that the upper bound on the firms' prices coincides with the consumers' willingness to pay for the product. This creates some tension with the limited comparability story under the "opt out" rule: if consumers are unable to make a comparison, what prevents firms from raising the price above 1? One answer is that consumers are able to cancel their purchase ex-post, and this ex-post participation constraint prevents over-pricing. Another answer is that consumers do know the utility from their default option, and since they switch away only when having a good understanding of the choice problem, they will never end up paying more than their willingness to pay.

**Symmetric Nash equilibria**

The game between the two firms has no pure-strategy equilibrium, regardless of the default rule. To see why, suppose first that both firms play the same \((p, x)\). If \( p = 0 \), any firm can deviate to \( p' > 0, x = 1 \); as a result, a positive fraction of consumers will be unable to make a price comparison; and because \( \lambda > 0 \), the firm will necessarily have a positive clientele, hence the deviation is profitable. If \( p > 0 \), any firm can slightly undercut the price and play \( x = 0 \); this will necessarily increase the firm's market share by a margin that is bounded away from zero, because the consumer will be able to make a comparison with probability \( \frac{1}{2} \) at least, hence the deviation is profitable.

I now turn to analyzing symmetric mixed-strategy Nash equilibria. A mixed strategy in this model is a joint probability distribution over pairs \((p, x)\) \(\in [0, 1] \times \{0, 1\}\). Every \((p, x)\) in the support of a symmetric equilibrium strategy maximizes a firm's payoff, given that the other firm plays the same mixed strategy. It turns out that there is a unique symmetric equilibrium; the equilibrium strategy exhibits correlation between the firm's pricing and obfuscation decisions. With probability \( \frac{\lambda}{2} \), it charges the monopoly price \( p = 1 \) and obfuscates \( (x = 1) \). With the remaining probability \( 1 - \frac{\lambda}{2} \), the firm randomizes continuously over a range of prices \( p < 1 \) and refrains from
Proposition 1 The game has a unique symmetric Nash equilibrium. With probability \( \frac{1}{2} \), firms play \((p, x) = (1, 1)\). With the remaining probability \( 1 - \frac{1}{2} \), they play \( x = 0 \) and mix over prices according to the cdf

\[
F(p) = M + 1 - \frac{M}{p}
\]

defined over the interval \([\frac{M}{M+1}, 1]\), where

\[
M = \frac{\lambda(2 + \lambda)}{4(2 - \lambda)}
\]

The intuition behind the firms’ equilibrium behavior is as follows. When a firm chooses to charge a high price, it has an incentive to lower the probability of price comparison, and therefore it prefers to obfuscate. In contrast, when a firm chooses low price, it seeks comparison and therefore refrains from obfuscating.\(^6\) An increase in \( \lambda \) leads to less competitive equilibrium behavior, including a higher probability of playing \( p = 1 \) and a higher \( \frac{M}{M+1} \). The reason is that when \( \lambda \) is high, consumers who face a complex choice typically end up choosing one of the firms, independently of the price profile. This means that firms benefit from choice complexity, and so they have a big incentive to generate it by obfuscating and to exploit it by charging a high price.

Welfare analysis
Recall that the outside option generates zero net utility for consumers, while the market alternatives are produced costlessly and generate a gross utility

\(^6\)The cutoff price that separates obfuscatory and non-obfuscatory behavior is \( p = 1 \), and the equilibrium price distribution has an atom on this price. This is a fragile property, due to the extreme assumption of zero comparability when \( x_1 = x_2 = 1 \). If we perturbed the model and assumed a small positive comparison probability in this case, the equilibrium price distribution would have no discontinuous jumps; firms would play \( x = 1 \) over a small range of prices near \( p = 1 \); and the overall probability of \( x = 1 \) would be close to \( \frac{1}{2} \).
of 1 for consumers. Therefore, social surplus is simply equal to the "market participation rate", namely the total fraction of consumers who end up choosing a market alternative. Under "opt out", consumers always end up choosing one of the firms, hence the equilibrium participation rate is 1. To calculate the equilibrium participation rate under "opt in", note first that the fraction of consumers who make a price comparison in the symmetric Nash equilibrium is

\[
(1 - \frac{\lambda}{2})^2 \cdot 1 + 2 \cdot \frac{\lambda}{2} (1 - \frac{\lambda}{2}) \cdot \frac{1}{2} + (\frac{\lambda}{2})^2 \cdot 0 = 1 - \frac{\lambda}{2}
\]

Thus, under "opt in", the equilibrium market participation rate in equilibrium is

\[
\lambda + (1 - \lambda)(1 - \frac{\lambda}{2}) = \frac{1}{2} \lambda^2 - \frac{1}{2} \lambda + 1
\]  

(2)

The reason is that a fraction \( \lambda \) of the consumers end up with one of the market alternatives, regardless of their comparability, whereas the remaining fraction \( 1 - \lambda \) of the consumer population enter only when able to make a comparison. Expression (2) is U-shaped w.r.t \( \lambda \): it attains the maximum of 1 both at \( \lambda = 1 \) and in the \( \lambda \to 0 \) limit (and it attains a minimum of \( \frac{7}{8} \) at \( \lambda = \frac{1}{2} \)). Thus, equilibrium social welfare is non-monotone in consumers’ propensity for default bias; in particular, when virtually all consumers are indecisive, "opt in" and "opt out" induce the same social welfare in equilibrium.

The fact that we have full equilibrium participation when \( \lambda = 1 \) is not surprising, because this is built into the definition of the consumers’ choice procedure. The more noteworthy observation is that the equilibrium participation rate converge to 1 in the \( \lambda \to 0 \) limit. Thus, if the regulator introduces the "opt in" default regime and almost all consumers are indecisive, they end up exhibiting no default bias in equilibrium. The reason is that under "opt in", firms do not benefit at all from default bias when \( \lambda \to 0 \), and therefore they have no incentive to obfuscate. As a result, consumers never face complex choices. This observation illustrates the importance of exploring
equilibrium effects and the psychological mechanism behind decision errors. When the "deep structural parameter" $\lambda$ reflects an extreme propensity for default bias (i.e., $\lambda$ is close to 0), equilibrium effects under "opt in" produce an observed behavior that exhibits virtually no default bias.

Let us now calculate equilibrium industry profits. Suppose that firm 1 considers playing the pure strategy $(p, x) = (1, 1)$. In equilibrium, firm 2 plays the same pure strategy with probability $\frac{1}{2}$. In this case, $x_1 = x_2 = 1$, such that consumers are entirely unable to make a comparison, and each firm gets a fraction $\frac{1}{2}$ of the consumer population. With probability $1 - \frac{1}{2}$, firm 2 plays $p < 1$ and $x = 0$. Since comparison probability in this case is $\frac{1}{2}$, firm 1 gets a fraction of $\frac{1}{2} \cdot \frac{1}{2}$ of the consumer population. Thus, when firm 2 plays the equilibrium strategy, firm’s profit from the pure strategy $(p, x) = (1, 1)$ is

$$1 \cdot \left[ \frac{\lambda}{2} \cdot \frac{\lambda}{2} + \left(1 - \frac{\lambda}{2}\right) \cdot \frac{\lambda}{2} \cdot \frac{1}{2} \right] = \frac{1}{8} \lambda^2 + \frac{1}{4} \lambda$$

(3)

This pure strategy belongs to the support of the symmetric equilibrium mixed strategy. A basic property of mixed-strategy Nash equilibrium is that every pure strategy in the support of the equilibrium strategy is a best-reply. Therefore, each firm earns $\frac{1}{8} \lambda^2 + \frac{1}{2} \lambda$ in equilibrium.

Net consumer welfare in equilibrium is equal to social surplus minus industry profits:

$$\left(\frac{1}{2} \lambda^2 - \frac{1}{2} \lambda + 1\right) - 2 \cdot \left(\frac{1}{8} \lambda^2 + \frac{1}{4} \lambda\right)$$

$$= 1 + \frac{1}{4} \lambda^2 - \lambda$$

This expression is decreasing in $\lambda$. It follows that "opt in" is superior to "opt out" in terms of equilibrium consumer welfare. In particular, in the $\lambda \to 0$ limit (i.e., when the default regime is "opt in" and consumers have an extreme propensity for default bias), consumer welfare reaches the maximal level of 1, because market participation is full and equilibrium prices converge.
The intuition for this result is that in this model, default bias results from the complexity of price comparison. The "opt in" rule restrains firms’ incentive to obfuscate, because they benefit less from choice complexity (compared with "opt out"). In the limit case in which all consumers are indecisive, firms derive no benefit from choice complexity under "opt in" and refrain entirely from obfuscation. This in turn means that price competition is as transparent as in the Bertrand benchmark, such that equilibrium prices reach the competitive level. Thus, paradoxically, once we take the psychological mechanism behind default bias and the firms’ incentives into account, the default rule that seems less conducive to market participation turns out to maximize both participation and net consumer welfare, precisely when consumers’ propensity for default bias is at its extreme.

**Discussion**

The exercise in this section demonstrated the importance of accounting for the psychological origins of consumers’ decision errors. Default bias is not a primitive phenomenon; it is determined at least in part by consumers’ attitude to complex choice problems. I focused on the effect of limited comparability on default bias, and showed that a change in consumers’ default specification affects firms’ incentive to manipulate comparability, which in turn has an effect on competitive pressures.

What are the possible implications of this analysis for some of the real-life examples that motivated our discussion in this section? Recall the interpretation of defaults rules in terms of automatic renewal of long-term services such as insurance or magazine subscription. The equilibrium analysis provides support for the intuition that in these environments, banning auto-renewals leads to higher consumer welfare. It suggests that in response to such a regulation, firms have a weaker incentive to obfuscate, and this in turn can lead to high market participation and low prices.

As to the case of retirement-savings programs such as 401(k), our exercise
highlights the importance of the employer’s role in mediating the interaction between funds and savers. It suggests that the reason that a switch from "opt in" to "opt out" may raise participation rates without harming savers is that the employer acts as a de-facto market regulator. Savers benefit not only from the "soft paternalism" of default architecture, but also from the employer’s "hard paternalism" (to the extent that he can be trusted to serve the savers’ interests).

4 Product-Use Disclosure

Regulation of disclosure is another type of "soft paternalistic" intervention (Bar-Gill (2012) is a useful and comprehensive reference). The literature distinguishes between two subspecies: (1) product-attribute disclosure, aiming to correct biases in how product attributes are perceived and weighted; (2) product-use disclosure, aiming to help evaluating non-linear price plans according to an estimated level of consumption (using the consumer’s own past behavior, or the behavior of other consumers in similar circumstances, as an anchor). This section focuses on the latter.

One reason why consumers may need assistance in evaluating price plans is that they tend to make biased predictions of their own future behavior. Bar-Gill (2012) presented a convincing case that underestimating future taste for immediate gratification may explain why consumers end up paying too much for services such as credit cards or mobile phone services. In particular, he invoked an influential model due to DellaVigna and Malmendier (2004), in which firms compete in two-part tariffs for consumers whose intertemporal preferences display so-called "hyperbolic discounting". In this section I introduce product-use disclosure into a simple version of this model.

The benchmark model

I begin with the basic DellaVigna-Malmendier model without disclosure. There are three time periods, 0, 1, 2. At period 0, two firms that provide
an identical service (credit, mobile telecommunication, etc.) compete for a measure one of identical consumers. Each firm \( i \) simultaneously commits to a non-linear price scheme \( t_i : [0, \infty) \to \mathbb{R} \), where \( t_i(x) \) is the payment the consumer will make to firm \( i \) in period 2 conditional on selecting this firm in period 0 and subsequently choosing the consumption level \( x \) in period 1. Once the consumer chooses a firm at period 0, he is obliged by the firm’s price plan in the next two periods. Following DellaVigna and Malmendier (2004), I restrict \( t_i \) to take the form of a two-part tariff, namely \( t_i(x) = A_i + p_i x \), and identify it with the pair of parameters \((A_i, p_i)\). Both firms face the same constant marginal cost \( c \in (0, 1) \). Firm \( i \)’s profit is zero if it is not chosen by the consumer, and \( t_i(x) - cx \) if the consumer chooses the firm and proceeds to consume \( x \).

Consumers have dynamically inconsistent preferences that take a standard \((\beta, \delta)\) form (a.k.a "hyperbolic discounting") with \( \delta = 1 \). In period 0, when they face the choice of a price plan, their utility from accepting a two-part tariff \((p, A)\) and proceeding to consume \( x \) is \( U(x, p, A) = \beta \ln(x + 1) - \beta(px + A) \). In contrast, in period 1, when they are obliged by the price plan \((p, A)\) and choose the consumption quantity \( x \), their utility function changes into \( V(x, p, A) = \ln(x + 1) - \beta(px + A) \). The parameter \( \beta < 1 \) represents the consumers’ taste for immediate gratification - namely, it measures how they discount all future utility flows against the current utility flow. From the point of view of period 0, both consumption and payment take place in subsequent periods, and therefore both are discounted by \( \beta \); but in period 1, consumption is immediate whereas payment lies in the future, and therefore only the latter is discounted. As a result, the consumer’s trade-off between consumption and payment is dynamically inconsistent. To ensure interior solutions in the sequel, I make the simplifying restriction \( c < \beta \).

The literature makes a distinction between "sophisticated" consumers who correctly predict their future preferences, and "naive" consumers who incorrectly believe that their future preferences will be identical to their cur-
rent preferences. I will focus on the case of naive consumers: in period 0, the consumer will choose a price plan that maximizes $U$, under the incorrect assumption that he will choose $x$ in period 1 to maximize $U$. Firms correctly anticipate that consumers will make consumption decisions in period 1 to maximize $V$, and calculate their profit from any price plan accordingly. The following result, due to DellaVigna and Malmendier (2004) - specialized for this example - analyzes Nash equilibrium in the period 0 game between the firms.

**Proposition 2 ((DellaVigna and Malmendier (2004)))** In symmetric Nash equilibrium, each firm offers a two-part-tariff $t^*$ given by

$$p^* = \frac{c}{\beta}$$

$$A^* = \frac{(\beta - 1)(1 - c)}{\beta}$$

This scheme induces an actual consumption quantity $y^* = \frac{1}{c} - 1$. In period 0, the consumer erroneously predicts that he will consume $y^0 = \frac{\beta}{c} - 1$.

The equilibrium price-per-unit $p^*$ is above marginal cost. Competitive pressures push the firms’ actual equilibrium profits to zero, which means that the lump-sum payment $A^*$ is **negative**. That is, when accepting $t^*$, the consumer expects to consume a relatively small quantity $y^0$, and he is mainly attracted by the lump-sum subsidy. However, having accepted a price plan, his taste for immediate gratification impels him to consume $y^* > y^0$. Since $p^* > c > 0$ while $A^* < 0$, the following inequalities hold

$$\frac{A^* + p^*y^*}{y^*} > \frac{A^* + p^*y^0}{y^0}$$

That is, both total and per-unit payment end up being higher than the consumer anticipates when accepting the equilibrium price plan. The consumer’s
total equilibrium payment is \( A^* + p^* y^* = 1 - c \). If the consumer correctly predicted his actual period 1 behavior, he would evaluate the equilibrium price plan ex-ante at \( U(y^*, p^*, A^*) = 1 + \beta (\ln \beta - 1) + \beta (c - \ln c - 1) \).

**Enter the regulator**

Imagine that in response to this situation, a regulator introduces product-use disclosure. Specifically, for each price plan offered in the market, the regulator mandates the disclosure of the **effective price-per-unit given the historical consumption quantity**. Thus, if the historical consumption quantity is some \( x^* \), each offered two-part tariff \( t \) will be accompanied by the disclosure of the **effective average price** \( t(x^*)/x^* \). I assume that in period 0, the consumer "obediently" chooses the firm with the lowest disclosed effective price (with a symmetric tie-breaking rule). Having selected a price plan \( t \) given by \( (p, A) \), the consumer proceeds in period 1 to choose a consumption quantity \( x \) that maximizes \( V(x, p, A) \). The interpretation is that the three-period interaction is repeated for many rounds; in each round, there is a new generation of consumers who enter the market and make a once-and-for-all decision; and the disclosure is informed by the historical behavior of previous consumer generations. This form of disclosure does not provide new information, and would have no effect on a rational consumer. It is a nudge that manipulates our boundedly rational consumer’s method of evaluating price plans.

I wish to emphasize that introducing product-use disclosure into the DellaVigna-Malmendier model is not an arbitrary idea. Indeed, one of the key applications of DellaVigna and Malmendier (2004) was to credit markets, a context in which product-use disclosure is commonly discussed. And as mentioned above, Bar-Gill (2012) presented the DellaVigna-Malmendier model as an explanation for over-payment patterns (of the type captured by Proposition 2) in the credit-card industry, and recommended product-use disclosure as a potential remedy. This section draws logical consequences from this argument. For this purpose, we need to modify the notion of a stable market outcome; we can no longer model the situation as a game, because
the market agents’ long-run behavior feeds into the firms’ payoff function via the disclosed effective price. We will therefore rely on the following definition.

**Definition 3 (Stable market outcomes)** A triple \( (x^*, p^*, A^*) \) is stable if the following conditions hold: (i) \( x^* = \arg \max_x V(x, p^*, A^*) \); (ii) No firm has an incentive to deviate from \( (p^*, A^*) \) to another price plan, given the consumers’ rule for choosing a price plan in period 0 (where \( x^* \) plays the role of the historical consumption quantity), and their subsequent choice of consumption quantity in period 1 under the price plan they select.

Condition (i) means that in order for the consumption quantity \( x^* \) to persist across generations of consumers, it must be optimal for them (according to their period 1 preferences) given the equilibrium price plan \( (p^*, A^*) \). Condition (ii) reflects the notion that if \( x^* \) is a stable consumption level, it becomes the historical quantity that informs the calculation of the effective price. Suppose a firm deviates from \( (p^*, A^*) \) to some other price plan \( (p, A) \). Then, Condition (ii) requires that either of the following scenarios will be realized: (1) consumers are not attracted to \( (p, A) \) because it has a weakly higher disclosed effective price than the prevailing plan \( (p^*, A^*) \) - that is, \( (A + px^*)/x^* \geq (A^* + p^*x^*)/x^* \); (2) consumers are attracted to \( (p, A) \) because \( (A + px^*)/x^* < (A^* + p^*x^*)/x^* \), but the firm’s deviation fails to raise its profit, given the way consumers actually chooses under \( (p, A) \).

**Proposition 4** There is a unique stable triple \( (x^*, p^*, A^*) \), where \( x^* = \frac{1}{\frac{1}{p^*} - 1} \), \( p^* = c \) and \( A^* = 0 \).

Thus, on the face of it, product-use disclosure is effective in the sense that it induces a competitive stable outcome: firms’ behavior is reduced to linear, marginal-cost pricing. However, if the motivation behind the regulatory intervention was to reduce over-consumption, then the stable outcome
achieves the opposite objective, because $x^* > y^*$. As to the consumer’s welfare, evaluated according to his ex-ante (period 0) perspective, note that $U(x^*, p^*, A^*) = \beta (c - \ln c - 1)$. Given that $\beta < 1$, it is easy to verify that $U(x^*, p^*, A^*) < U(y^*, p^*, A^*)$ - that is, consumers’ ex-ante utility decreases as a result of the regulatory intervention. The consumer’s total payment in the stable outcome is $p^* x^* = \frac{1}{\beta} - c$, which is higher than the total equilibrium payment prior to the intervention.

The intuition for this result is simple. Product-use disclosure causes firms to practice linear pricing, and competitive pressures drive the price-per-unit down to marginal cost. However, since consumer choice given a price plan is determined by the period 1 utility $V$, this means that firms effectively compete the "the wrong self" - namely, the consumer’s taste for immediate gratification. Fostering this kind of competition is the opposite of what the regulation was meant to do, namely protecting the consumer from the market reaction to the consumer’s underestimation of this taste, which manifested itself in over-consumption.\footnote{The stable outcome is the same as the one that would emerge in Nash equilibrium of the original game - prior to the intervention - if firms could use any non-linear pricing scheme, rather than just two-part tariffs (see Spiegler (2011, Ch. 2), based on a model by Eliaz and Spiegler (2006)). Thus, product-use disclosure ends up simulating an environment in which all restrictions on price plans are lifted.}

Note that our welfare analysis relied on the assumption that consumers have dynamically inconsistent preferences. Suppose that consumers did not have distinct period 0 preferences, but simply held the incorrect prior belief that their period 1 preferences would be given by $U$ rather than $V$. This alternative assumption would lead to the same \textit{positive} analysis of the market model (such equivalence would cease to hold if consumers were partially sophisticated - see Spiegler (2011, Ch. 5) for a related discussion), but the \textit{normative} analysis would be different, because there would be no reason to use $U$ as a welfare criterion.\footnote{I thank Oren Bar-Gill for pointing out this consideration.}
5 Product-Attribute Disclosure

Goods and services often have multiple price and quality attributes, and consumers may neglect some of them. For instance, when thinking about the actual cost of a credit card, borrowers may pay more attention to the basic interest rate than to late fees. Headline prices in contracts attract more attention than the small print. Some products have future add-ons that consumers may fail to take into account at the time he purchase (e.g. replacement ink cartridges in printers). Can mandated disclosure of product attributes help consumers making better decisions in this context?

An implicit assumption behind attribute disclosure is that once the consumer becomes fully aware of all attributes, he will execute a rational evaluation. However, suppose that the consumer has a fixed "attention budget", in the sense that he can only take into consideration a subset of attributes; rather than increasing the consumer’s attention budget, disclosure might simply reallocate it among the various attributes. The tendency to neglect relevant attributes can also arise from deeper aversion to difficult trade-offs. For instance, when evaluating retirement saving plans, how does one trade off the bequest motive with ensuring a decent living standard in old age? This is an emotionally inconvenient trade-off, and a natural response is to neglect attributes, thus saving the "mental cost" of dealing with such trade-offs. When one attribute is less salient than another, it is "psychologically easier" to ignore it. Product-attribute disclosure makes all attributes equally salient, thus placing them on an equal footing in this regard.9

What are the implications of product-attribute disclosure under this view of the psychological process that underlies attribute neglect? Will disclosure make consumers better off when equilibrium effects are taken into account? In this section I use a recent model due to Bachi and Spiegler (2014) to capture these considerations. Unlike the previous sections, here none of the

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9For psychological evidence for the phenomenon of trade-off avoidance, see Tversky (1972), Payne et al. (1993), Luce et al. (1999) and Anderson (2003).
results are new; the only novel contribution is their interpretation in terms of product-attribute disclosure. Therefore, I report the results briefly and refer the reader to the original paper for more general statements of the results and their proofs.

Our market will (once again) consist of two identical, profit-maximizing firms that compete for a measure one of consumers by playing a simultaneous-move game. Each firm \(i = 1, 2\) chooses a product that is fully characterized by a quality vector \((q^1_i, q^2_i) \geq (0, 0)\). (I use the language of quality rather than prices for expositional ease.) Firm \(i\)'s profit conditional on being chosen is \(1 - \frac{1}{2}(q^1_i + q^2_i)\). I refer to \(\bar{q}_i = \frac{1}{2}(q^1_i + q^2_i)\) as the "true quality" of the firm's product, where quality is measured in terms of the firms' cost of producing it. Conventionally rational consumers would be endowed with some strictly increasing and continuous function \(u(q^1, q^2)\), and they would always choose the firm that sells the highest-\(u\) product. In Nash equilibrium, both firms would offer quality vectors that maximize \(u\) subject to the constraint that true quality is \(\bar{q} = 1\) (i.e., zero profits).

Now suppose that quality dimension 2 is "shrouded," such that all consumers focus entirely on dimension 1 and choose the firm that offers the highest quality along this dimension (with symmetric tie-breaking). In this case, we have a special case of a well-known model due to Gabaix and Laibson (2006).

**Proposition 5 (Gabaix and Laibson (2006))** When consumers choose entirely according to dimension 1, the game between the two firms has a unique Nash equilibrium: each firm plays \((q^1, q^2) = (2, 0)\).

In equilibrium, competition is effectively restricted to the salient dimension 1, and this enables firms to choose the lowest possible quality along the shrouded dimension 2. Competitive pressure drives quality up along dimension 1, until firms earn zero profits. In terms of average quality, equilibrium products are the same as in the case of conventionally rational consumers.
However, they are "misleading", in the sense that the quality that each consumer perceives according to the dimension he focuses on \((q^1 = 2)\) is higher than the true average quality \(\bar{q} = 1\). In fact, the equilibrium strategy maximizes \(q^1 - \bar{q}\) subject to the constraint that firms earn non-negative profits - in this respect, it is "maximally misleading".

Imagine a regulator who wishes to curb misleading contracts, and responds to this state of affairs by mandating disclosure that will "unshroud" dimension 2. Furthermore, the intervention is successful in the sense that it makes both dimensions equally salient. However, as suggested earlier, suppose that this does not turn consumers into rational "trade-off machines". Instead, it reallocates their "attention budget" between the two dimensions, such that every consumer focuses on either of the two attributes with probability \(\frac{1}{2}\). As a result, when \(q_i^k > q_j^k\) for both \(k = 1, 2\), all consumers choose firm \(i\); but when \(q_i^1 > q_j^1\) and \(q_i^2 < q_j^2\), each firm gets half the consumer population (the case of equality along one or both dimensions is irrelevant for the analysis). What are the equilibrium implications of this intervention?

**Proposition 6 (Bachi and Spiegler (2014))** When each consumer chooses according to a uniformly drawn single attribute, the game between the two firms has a unique symmetric Nash equilibrium: each firm chooses \(q^1 + q^2 = 1\) with probability one, and draws \(q^1\) uniformly from \([0, 1]\).

Thus, in equilibrium, firms offer products of true average quality \(\bar{q} = \frac{1}{2}\), and the breakdown into the two dimensions is random. Each firm earns a profit of \(\frac{1}{4}\) in equilibrium. The intuitive reason for firms' ability to earn positive profits is that they can offer a product with high quality in one dimension and low quality in the other; some consumers will choose the firm because they happen to focus on the dimension in which the firm is relatively attractive, and yet the firm will be able to make a profit thanks to the low quality it offers on the other dimension.
In equilibrium, no market alternative ever dominates the other. In this sense, consumers always face "hard trade-offs" in equilibrium. At the same time, equilibrium pricing is "less misleading" than prior to the intervention: the difference between perceived and true quality (which is $q^1 - \bar{q}$ and $q^2 - \bar{q}$ with probability $\frac{1}{2}$ each) is uniformly distributed over $[-\frac{1}{2}, \frac{1}{2}]$, compared with the deterministic gap $q^1 - \bar{q} = 1$ in the absence of disclosure. While the regulator has succeeded in his mission to curb misleading contracts, this has come at the cost of lowering the true quality of the products that are offered in equilibrium. We see an example of how two desirable criteria for consumer protection, maximizing quality and preventing misleading contracts, can be mutually conflicting.

This exercise provides another demonstration that having an explicit "psychological story" behind observed consumer biases matters for the equilibrium analysis of nudging. When consumers seem to be ignoring certain attributes, it matters whether this is a manifestation of simple unawareness, or a result of deeper psychological forces such as intrinsic attention deficit or trade-off avoidance. When the latter is the case, consumers will continue to ignore product attributes even if the regulator mandates disclosure, but the neglected attributes will be less predictable, and this lack of predictability weakens competitive pressures.

Behavioral-economics models require special caution when it comes to welfare analysis, because of the disconnect between preferences and choices. This was true in the case of the models in Sections 3 and 4, but it holds even more strongly in the present section. The reason is that the consumer’s choice procedure - before and after the intervention - is entirely based on ordinal quality rankings; it reveals nothing about how the consumer "truly" trades-off the two dimensions. For this reason, I refrained from making statements about the consumer’s true welfare in equilibrium, and restricted the discussion to product quality.
6 Conclusion

Nudging is appealing because it seems to offer a "regulatory free lunch": helping boundedly rational consumers without infringing contractual freedom. This paper has demonstrated that theoretically, equilibrium market responses to "nudges" can eat away part of this lunch, and potentially reverse the intended consequences. Moreover, the equilibrium analysis is sensitive to the procedural model underlying the very biases that nudging addresses. Accepting this critique means facing once again the stark dilemma between protecting boundedly rational consumers from market exploitation and maintaining contractual freedom.

At a certain level, the claim in this paper is very familiar to economists: when analyzing theoretical consequences of an intervention, it is useful to think about agents' equilibrium reaction in terms of an explicit "structural" model that accounts for agents' observed stimulus-response patterns. However, the sense in which the present paper is "structural" is unusual. Economists normally reserve the term for rational-choice models that are explicit about agents' preferences and information. In comparison, the models in this paper were explicit about other mental constructs, such as the ability to make comparisons or predict future tastes.

An important implication of this "structural" approach is that there can be a big difference between consumers' underlying potential for bias and the amount of bias we end up observing. The former is determined by "structural features" (e.g. the parameter $\lambda$ in Section 2), while the latter is also governed by firms' equilibrium reaction to the regulatory environment. As a result, naive regulatory response to an observed bias may have unintended consequences. Hopefully, the paper demonstrated that adopting the structural approach enriches the theoretical discussion of consumer protection, even if by its very nature it tends to problematize issues rather than offering easy solutions.
References


Appendix: Proofs

Proposition 1
Consider a symmetric Nash equilibrium strategy. Let $F$ denote the marginal equilibrium distribution over prices. For any $p$ in the support of $F$, define $\sigma_p(x)$ as the probability the equilibrium strategy assigns to $x$ conditional on $p$. I begin with a few preliminary observations. First, note that since $\lambda > 0$, firms can secure a strictly positive profit by charging $p > 0$ and playing $x = 1$. Therefore, $p = 0$ is not in the support of $F$. Suppose that $F$ has an atom on any $p < 1$. If $\sigma_p(0) > 0$, then a firm can profitably deviate to a strategy that consists of the price $p' = p - \varepsilon$ and the mixture $\sigma_p$ over $x$, where $\varepsilon > 0$ is arbitrarily small. If $\sigma_p(1) = 1$, then a firm can profitably deviate to the pure strategy $(p + \varepsilon, 1)$, where $\varepsilon > 0$ is arbitrarily small. Thus, $F$ is continuous over $p < 1$. Note that we cannot rule out the possibility that $F$
places an atom on \( p = 1 \) and \( \sigma_p(1) = 1 \). The reason is that since comparison probability is zero when \( x_1 = x_2 = 1 \), deviating to the pure strategy \((1 - \varepsilon, 1)\) is not profitable for an arbitrarily small \( \varepsilon > 0 \). Finally, the support of \( F \) must be an interval \([p_1, 1]\), where \( p_1 > 0 \) - otherwise, if there is a "hole" \((p, p')\) in the support of \( F \), the strategy consisting of the price \( p' \) and the mixture \( \sigma_p \) over \( x \) generates a strictly higher payoff than \((p, \sigma_p)\), which belongs to the support of the equilibrium strategy, a contradiction.

Let \( p_h(x) \) and \( p_l(x) \) denote the highest and lowest prices \( p \) in the closure of the set \( \{ p \in [p_1, 1] \mid \sigma_p(x) > 0 \} \). Let us show that \( p_l(0) \leq p_h(1) \). Assume the contrary, namely that there exist \( p_1, p_2 \in [p_l, 1] \) such that \( p_2 > p_1 \), \( \sigma_{p_2}(0) > 0 \) and \( \sigma_{p_1}(1) > 0 \). For each \( k = 1, 2 \), \( x = 0, 1 \), the market share that the strategy \((p^k, x)\) generates, denoted \( s(p^k, x) \), is as follows (to simplify the notation, I ignore the possibility of that \( \mathcal{F} \) has an atom on \( p^k \) - to incorporate an atom we would have to replace \( \mathcal{F} \) with left or right limits of \( \mathcal{F} \) - without changing the argument):

\[
\begin{align*}
\sigma(p^k, x) &= \frac{\lambda}{2} \left[ 1 - \int_{p_l}^{p_k} \left( \sum_y \sigma_p(y)(1 - \frac{1}{2}x - \frac{1}{2}y) \right) dF(p) \right] \\
&+ \left( 1 - \frac{\lambda}{2} \right) \int_{p_l}^{1} \left( \sum_y \sigma_p(y)(1 - \frac{1}{2}x - \frac{1}{2}y) \right) dF(p)
\end{align*}
\]

It is now straightforward to verify it is impossible that \( s(p^1, 1) \geq s(p^1, 0) \) and \( s(p^2, 0) \geq s(p^2, 1) \), because \( F \) assigns positive probability to the interval \((p^1, p^2)\).

Suppose that \( p_l(1) < 1 \). We have just seen that \( \sigma_p(1) = 1 \) for every \( p \in (p_l(1), 1) \). Since comparison probability is zero when \( x_1 = x_2 = 1 \), if a firm deviates from a price \( p \in (p_l(1), 1) \) to the pure strategy \( (1, 1) \), its market share does not change and hence its payoff increases. Therefore, \( p_l(1) = 1 \), such that \( \sigma_p(0) = 1 \) for almost every \( p \in [p_l, 1] \). If \( F \) does not place an atom on \( p = 1 \), this means that \( x = 0 \) is played with probability one, and in this
case a firm that charges a price close to 1 will strictly prefer to deviate to $x = 1$. Thus, it must be the case that $F$ places an atom on $p = 1$. Let $\mu$ denote the size of this atom. The following equality must hold:

$$s(1, 1) = \frac{\lambda}{2} \cdot \left[ \mu + \frac{1}{2} (1 - \mu) \right] = \frac{\lambda}{2} \cdot \mu + \left(1 - \frac{\lambda}{2}\right) \cdot \frac{1}{2} \mu = \lim_{\varepsilon \to 0} s(1 - \varepsilon, 0)$$

Otherwise, there would be a profitable deviation either from $(1, 1)$ to $(1, 0)$, or from $(p, 0)$ to $(p, 1)$ for some $p$ sufficiently close to 1. Thus, $\mu = \frac{\lambda}{2}$, such that a firm’s payoff from $(1, 0)$ is $\frac{\lambda}{4} (\frac{1}{2} + \frac{1}{4})$. Since this is the equilibrium payoff, it is the payoff from $(p, 1)$ for every $p \in [p_l, 1)$. Thus, we can write:

$$p \cdot \left[ \frac{\lambda}{2} (1 - F(p)) + \left(1 - \frac{\lambda}{2}\right) \left(\frac{1}{2} \mu + (1 - \mu - F(p))\right) \right] = \frac{\lambda}{2} \left(\frac{1}{2} + \frac{\lambda}{4}\right)$$

and retrieve the expression for $F$, as well as the value of $p_l$, from this equation.

**Proposition 2**

As DellaVigna and Malmendier (2004) show, in this environment the symmetric equilibrium two-part tariff $(p^*, A^*)$ maximizes consumers’ perceived ex-ante net utility $U(x^u, p, A)$ subject to the zero-profit condition

$$A + (p - c)x^v = 0$$

where $x^u = \arg \max_x U(x, p, A)$ and $x^v = \arg \max_x V(x, p, A)$. Since $V$ is concave and twice differentiable in $x$, $x^u$ is simply given by the first-order condition $V'(x, p, A) = \frac{1}{x^u + 1} - \beta p = 0$, hence $x^u = \frac{1}{\beta p} - 1$ (as long as $\beta p \leq 1$). Likewise, $x^v$ is given by the first-order condition $U'(x, p, A) = \frac{\beta}{x^v + 1} - \beta p = 0$, hence $x^v = \frac{1}{p} - 1$ (as long as $p \leq 1$). To find $p^*$, we thus need to find the value of $p$ that maximizes

$$\ln(x^u + 1) - px^u + (p - c)x^v$$

$$= \ln \frac{1}{p} - p(\frac{1}{p} - 1) + (p - c)(\frac{1}{\beta p} - 1)$$

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Solving this maximization problem gives \( p^* = \frac{c}{\beta} < 1 \). Plugging this value into the above equations for \( x^a, x^v \) and \( A \) completes the characterization of equilibrium.

**Proposition 4**

Let us first show that the triple \((x^v, p^s, A^s) = (\frac{1}{\beta c} - 1, c, 0)\) is stable. Suppose that a firm deviates to some other price plan \((p, A)\). In order for consumers to choose \((p, A)\) over \((p^s, A^s)\), it must be the case that

\[
A + p(\frac{1}{\beta c} - 1) < c(\frac{1}{\beta c} - 1)
\]

Consumers who select \((p, A)\) will subsequently choose \(x\) to maximize \(V(x, p, A)\), hence \(x = \frac{1}{\beta p} - 1\). In order for the deviation to be profitable for the firm, we must have

\[
A + (p - c)(\frac{1}{\beta p} - 1) > 0
\]

The two inequalities are clearly contradictory.

Let us now show that there is no other stable pair \((x, p, A)\). Once again, stability requires \(x = \frac{1}{\beta p} - 1\). Let us now show that stability requires firms to earn zero profits - i.e., \(A + (p - c)(\frac{1}{\beta p} - 1) = 0\). If \(A + (p - c)(\frac{1}{\beta p} - 1) < 0\), a firm can deviate to \((p, A')\), \(A' > A\); consumers will not choose the firm, and so it will make zero profits, hence the deviation is profitable. If \(A + (p - c)(\frac{1}{\beta p} - 1) > 0\), a firm can deviate to \((p, A)\), where \(\varepsilon > 0\) is arbitrarily small; all consumers will select the firm because it obviously has a lower effective price, and they will proceed to choose \(x = \frac{1}{\beta p} - 1\) because the price-per-unit has not changed, hence the increase in market share outweighs the slight loss in the profit per customer.

Suppose the triple \((x^v, p^s, A^s) = (\frac{1}{\beta c} - 1, c, 0)\) is unstable. Then, we can
find \((z, p, A)\), such that

\[
A + p\left(\frac{1}{\beta c} - 1\right) < c\left(\frac{1}{\beta c} - 1\right)
\]

\[
A + (p - c)z > 0
\]

where \(z = \frac{1}{\beta p} - 1\). Then, the following inequality must hold:

\[
(p - c)(1 - \frac{1}{\beta p}) < (p - c)(1 - \frac{1}{\beta c})
\]

and it can be easily verified that no \(p\) can satisfy it. Therefore, \((x^*, p^*, A^*)\) is stable.

**Online Appendix: Additional Results**

**Does greater comparability always benefit consumers?**

Consider the model of Section 3. Focus on the case of \(\lambda = 1\) ("opt out", or "opt in" with fully decisive consumers), and modify the comparability structure by assuming that when both firms refrain from obfuscation (i.e., \(x_1 = x_2\)), comparison probability is \(\delta \in (\frac{1}{2}, 1)\). When at least one firm obfuscates, comparison probability is as in the basic model.

This modification clearly weakens comparability. It can be interpreted as a regulatory intervention that lowers comparability standards, creating difficulty of comparison even when firms do not attempt to obfuscate. In this sense, it is the opposite of measures like harmonizing description formats or forcing transparent price disclosure. Nevertheless, Piccione and Spiegler (2012) showed that such a modification would lower expected equilibrium profits, and consequently raise consumer welfare. In this sense, weaker comparability is beneficial for consumers.

The reasoning behind this seemingly counter-intuitive result is as follows. Let \(\beta\) denote the probability that the symmetric mixed equilibrium strategy
assigns to \((p, x) = (1, 1)\). By the same calculation that underlies expression (3), an individual firm’s payoff from playing \((p, x) = (1, 1)\) against an opponent that plays the equilibrium strategy is

\[
\beta \cdot \frac{1}{2} + (1 - \beta) \cdot \frac{1}{4} = \frac{1}{4}(1 + \beta)
\]

Industry profits are thus \(\frac{1}{2}(1 + \beta)\). The change in the comparability structure does not have any direct effect on this expression. However, because comparison probability under \(x_1 = x_2 = 0\) has gone down from 1 to \(\delta\), the market share of a firm that plays \((p, x) = (1 - \varepsilon, 0)\) is higher than prior to the intervention, as long as \(\varepsilon > 0\) is sufficiently small. To restore equilibrium - and in particular the firms’ indifference between the pure strategies \((1, 1)\) and \((1 - \varepsilon, 0)\) - the value of \(\beta\) must go down, and this means that the equilibrium outcome will become more competitive.

The implication for "nudging" is as follows. Suppose that the regulator can shape basic disclosure standards, yet he cannot perfectly constrain description formats, such that firms can obfuscate without violating the regulator’s instructions. The firms’ incentive to obfuscate may weaken if the regulator attenuates the basic disclosure standards. In other words, if the regulator cannot prevent firms from sabotaging comparability altogether, he might prefer not to insist on stringent disclosure standards.

**Different comparability structures**

The model of Section 3 assumed a "monotone" comparability structure: comparison probability decreased whenever an individual firm chose to obfuscate. However, there are other ways to conceptualize endogenous comparability. Indeed, the modeling framework of Piccione and Spiegler (2012) allowed comparison probability to depend in a general way on firms’ individual marketing strategies. For example, suppose that each firm chooses a *unit of measurement* for presenting its price (or some other product-related quantity). The interest rate on a deposit can be stated for various time durations; nutri-
tional content can be presented for various units of volume; energy efficiency can be quantified by various units of power; etc. It is reasonable to assume that consumers are better able to make a comparison between two products when sellers’ descriptions employ the same measurement units. In this case, comparison probability is not "monotone", but depends on whether firms coordinate their choice of units.

To examine the equilibrium implications of default architecture under this alternative account of endogenous comparability, I study the following simple variant on the model of Section 3. As before, assume that each firm $i$ simultaneously chooses a pair $(p_i, x_i)$, where $p_i \in [0, 1]$ is the price of the firm’s product, and $x_i \in \{0, 1\}$. However, now $x_i$ represents the measurement unit the firm employs for describing the time, volume or weight dimension per which its price is presented. Comparison probability is $1(\chi_1 = \chi_2)$ - that is, consumers are able to make a comparison if and only if $\chi_1 = \chi_2$ ($1$ is the indicator function). Each firm $i$ maximizes $p_i \cdot s_i((p_1, x_1), (p_2, x_2))$, where firm $i$’s market share $s_i$ is given by

$$s_i((p_1, x_1), (p_2, x_2)) = \begin{cases} 
1(\chi_1 \neq \chi_2) \cdot \frac{1}{2} + 1(\chi_1 = \chi_2) & \text{if } p_i < p_j \\
1(\chi_1 \neq \chi_2) \cdot \frac{1}{2} + 1(\chi_1 = \chi_2) \cdot \frac{1}{2} & \text{if } p_i = p_j \\
1(\chi_1 \neq \chi_2) \cdot \frac{1}{2} & \text{if } p_i > p_j
\end{cases}$$

The meaning of the parameter $\lambda \in (0, 1]$ is exactly as before.

The game between the two firms has no pure-strategy Nash equilibrium. The following is a characterization of symmetric mixed-strategy Nash equilibrium.

**Proposition 7** There is a unique symmetric mixed-strategy Nash equilibrium. Each firm plays $x = 0$ and $x = 1$ with equal probability, and independently mixes over prices according to the cdf

$$F(p) = 1 - \frac{\lambda}{2} \left( \frac{1}{p} - 1 \right)$$
defined over the interval $\left[ \frac{\lambda}{2+\lambda}, 1 \right]$.

**Proof.** Continue to use the notations $F$ and $\sigma_p(x)$ as in Proposition 1. Using essentially the same arguments as in the proof of Proposition 1, it can be shown that $F$ is continuous and strictly increasing over an interval $[l, 1]$ (there can be no atom on $p = 1$ because, unlike the previous case, comparison probability is positive whenever both firms play the same mixture over $x$).

Let us now show that the overall probability that each $x$ is played is $\frac{1}{2}$. Assume the contrary - w.l.o.g $x = 1$ is played with probability above $\frac{1}{2}$. That is,

$$
\int \sigma_p(0)dF(p) < \frac{1}{2} < \int \sigma_p(1)dF(p)
$$

Note that

$$
\sigma_1 \in \arg \min_{\sigma} \int_{p_1}^{1} \sum_x \sum_y \sigma(x)\sigma_p(y)\mathbf{1}(x,y)dF(p)
$$

$$
\sigma_{p_1} \in \arg \max_{\sigma} \int_{p_1}^{1} \sum_x \sum_y \sigma(x)\sigma_p(y)\mathbf{1}(x,y)dF(p)
$$

Therefore, $\sigma_1(0) = \sigma_{p_1}(1) = 1$. Moreover, by continuity, $\sigma_p(0) = 1$ (0) for every $p$ sufficiently close to 1 ($p_i$). Now consider the highest price $p \in [p_i, 1]$ for which $\sigma_p(1) > 0$. If a firm switches to the pure strategy $(p, 0)$ it necessarily increases its payoff: on one hand, if the rival firm’s realized price is $p' < p$, then by assumption it is more likely to play $x = 1$, such that playing $x = 0$ would induce a lower comparison probability; and on the other hand, if the rival firm’s realized price is $p' > p$, then by the definition of $p$, it plays $x = 0$ with probability one, such that playing $x = 0$ would raise the comparison probability from 0 to 1. In both scenarios, the deviation raises the firm’s market share, hence it is profitable. It follows that both formats are played with probability $\frac{1}{2}$.

Our next step is to show that $\sigma_p(1) = \frac{1}{2}$ for almost every $p \in [p_i, 1]$. 39
Assume the contrary - i.e., w.l.o.g there is a price \( p \in [p, 1] \) for which

\[
\int_p^1 \sigma_p(1) dF(p' \mid p' > p) > \frac{1}{2}
\]

Then, it must be the case that there is such \( p \) satisfying \( \sigma_p(1) > 0 \). Since the overall probability that \( x = 1 \) is played is exactly \( \frac{1}{2} \), it must be the case that

\[
\int_p^1 \sigma_p(1) dF(p' \mid p' < p) < \frac{1}{2}
\]

Therefore, if a firm deviates to the pure strategy \((p, 0)\), the deviation raises (lowers) comparison probability against higher (lower) price realizations of the rival firm, hence it is profitable.

The result that \( \sigma_p(1) = \frac{1}{2} \) for almost all \( p \) implies that for almost any profile of realized prices, the comparison probability is \( \frac{1}{2} \). This enables us to determine \( F \). When a firm charges \( p = 1 \), its payoff is

\[
1 \cdot \frac{\lambda}{2} \cdot \frac{1}{2} = \frac{\lambda}{4}
\]

Thus, for every \( p \in [p, 1] \), a firm’s payoff should satisfy

\[
p \cdot \left[ \frac{\lambda}{2} \left( \frac{1}{2} + \frac{1}{2}(1 - F(p)) \right) + \left( 1 - \frac{\lambda}{2} \right) \frac{1}{2}(1 - F(p)) \right] = \frac{\lambda}{4}
\]

This equation gives us \( F \), and \( p \) is derived from the equation \( F(p) = 0 \). \( \blacksquare \)

The probability of comparison in equilibrium is \( \frac{1}{2} \) for all realized price pairs \((p_1, p_2)\), regardless of the value of \( \lambda \). Thus, \textit{equilibrium choice complexity is invariant to default architecture}. In this regard, the equilibrium characterization departs from Section 3. To see why this invariance is possible in equilibrium (showing its necessity is subtler), note that when firm \( i \) randomizes uniformly over \( x \), the probability of comparison is \( \frac{1}{2} \), independently of firm \( j \)’s choice of measurement unit. As a result, firm \( j \) is indifferent.
between \( x = 0 \) and \( x = 1 \), regardless of the price it considers charging. Therefore, it is consistent with equilibrium for both firms to mix uniformly over \( x \), independently of the prices they charge.

As to the firms’ pricing decisions, the expected equilibrium price (as well as the lower bound on the price distribution) increases with \( \lambda \). Here the intuition is as in the basic model. Under "opt in", when there fraction of decisive consumers goes up, firms benefit more from default bias. They are unable to manipulate default bias because comparison probability is constant at \( \frac{1}{2} \), but they have a greater incentive to exploit it by charging higher prices.

Let us turn to welfare analysis. The equilibrium rate of market participation - which is equal to social surplus - is \( \lambda + \frac{1}{2}(1 - \lambda) \). To calculate firms’ equilibrium profits, note that the price \( p = 1 \) is in the support of the equilibrium pricing strategy. The firm gets a fraction \( \frac{1}{2} \) of the consumers who are unable to make a comparison. Since comparison probability is \( \frac{1}{2} \), the firm’s equilibrium payoff is \( 1 \cdot \frac{1}{2} \cdot \frac{\lambda}{2} = \frac{\lambda}{4} \). It follows that consumers’ net surplus in equilibrium is

\[
\left[ \lambda + \frac{1}{2}(1 - \lambda) \right] - \left[ 2 \cdot \frac{\lambda}{4} \right] = \frac{1}{2}
\]

which is evidently invariant to the default architecture. Thus, in particular, if we shift from "opting in" to "opting out", the gain in consumer welfare due to increased market participation is exactly offset by their welfare loss due to higher prices (which in turn result from the firms’ exploitation of default bias).

This exercise shows that even when we accept the idea that default bias is a function of choice complexity, equilibrium welfare implications of default architecture are sensitive to fine details of how choice complexity depends on firms’ framing strategies. When comparison probability depends on the firms’ individual obfuscation tactics, shifts in the default regime lead to changes in equilibrium choice complexity, and as a result net consumer welfare is sensitive to default architecture. In contrast, when comparability depends on coordination between the firms’ choice of "description formats", equilibrium
choice complexity and net consumer welfare are invariant to the default rule.

**Default architecture in the multi-attribute model**

The model of Section 5 offers a different approach to modeling limited comparability in markets. Here, limited comparability is not determined by marketing strategies that are independent of payoff-relevant product characteristics, but rather by the latter’s internal structure. This turns out to affect the equilibrium analysis of default architecture. Consider the following variation on the model of Section 5. Each firm is initially assigned half the consumers, as in the "opt out" default design described in Section 3. The consumer switches away to the other firm only when it offers a quality vector that dominates the one offered by his default firm.

This market model induces the same payoff function for the firms as the basic model of Section 5 (except for the immaterial case of a tie along one dimension). As a result, symmetric Nash equilibrium is given by Proposition 6. Alternatively, impose an "opt in" policy, where consumers’ default is the outside option. Bachi and Spiegler (2014) show that when almost all consumers are indecisive (and thus stick to the outside option when no market alternative dominates one another), there is a symmetric mixed-strategy Nash equilibrium in which the expected true quality that firms offer is close to 1, but domination occurs with probability $\frac{1}{3}$, such that the overall market participation rate in equilibrium is slightly above $\frac{1}{3}$. Thus, if we measure "true" consumer utility by the average quality of the alternative they end up with, then consumer surplus in this equilibrium is approximately $\frac{1}{3}$. In contrast, consumer surplus in the symmetric equilibrium under the "opt out" rule is $\frac{1}{2}$. In this sense, "opting out" outperforms "opting in", unlike the model of limited comparability analyzed in Section 3. Once again, we see that the equilibrium implications of default architecture are sensitive to the way we model the limited comparability problem underlying default bias.