Contextual Inference in Markets: On the Informational Content of Product Lines

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Abstract

A large literature demonstrates that contexts and frames influence decisions. This malleability of choice is usually invoked as evidence against the assumption that people maximize a stable preference ordering. In a market equilibrium, however, contexts and frames provide payoff-relevant information to consumers: the information implicit in a firm's decision to offer a particular set of goods allows uninformed consumers to infer from the product line which good is optimal for them. Consequently, these consumers rationally violate naïve formulations of standard choice theoretic principles. I identify informational asymmetries under which apparently anomalous behaviors, including the compromise effect, choice overload, and default effects, arise as market equilibria. In addition, I establish that the presence of uninformed consumers may induce firms to reduce the number of varieties they offer or to introduce *premium loss leaders*, i.e., expensive goods of overly high quality that are unprofitable on their own but greatly increase the demand for other products.

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1 Introduction

Numerous studies demonstrate that seemingly irrelevant factors influence people's decisions. Perhaps the best known examples of such influence are *context effects*. A consumer exhibits context effects if her choice between two alternatives systematically depends on the presence of a third option. An extensive literature demonstrates context effects in laboratory settings. One of the most widely studied context effects is the compromise effect (Simonson 1989).[1] The compromise effect refers to the finding that people tend to choose the middle option. More precisely, when three alternatives are available, the middle alternative is chosen more often than when it is paired with only one other option. As an example, Figure 1 shows the compromise effect obtained by Simonson (1989). This tendency to avoid extreme options has been credited with affecting phenomena ranging from the demand for wine (McFadden 1999) to voting (Herne 1997) and investing (Benartzi and Thaler 2002). Even more telling of the importance bestowed on the compromise effect is its didactic use in books such as *101 Ways to Increase Sales* (Van Eetvelde, Geens, and Harrington 2002) and *Information Rules* (Shapiro and Varian 1999). Other anomalous behaviors related to the compromise effect include choice overload and default effects. In choice overload experiments (e.g., Iyengar and Lepper 2000), customers are less likely to purchase a good if more products are added to the choice set. Madrian and Shea (2001) provide an example of a default effect by showing that a firm's decision to automatically enroll new employees in the company 401(k) plan dramatically increases retirement savings even though all employees can easily opt out

[1] Many of the laboratory experiments reported in this paper utilize hypothetical questions. The vast majority of the results, however, have subsequently been replicated using incentive-compatible procedures with real stakes, occasionally in the field (e.g., Doyle *et al.* 1999).

of the default enrollment.

More broadly, marketing research reveals that minor changes in the decision-making environment can have a substantial impact on what people buy. For example, North, Hargreaves, and McKendrick (1997) show that market shares react to the type of music played in the store. In their experiment, customers bought more than three times as many bottles of French as German wine when French music was playing, but German wine outsold French by 150% when music was German.

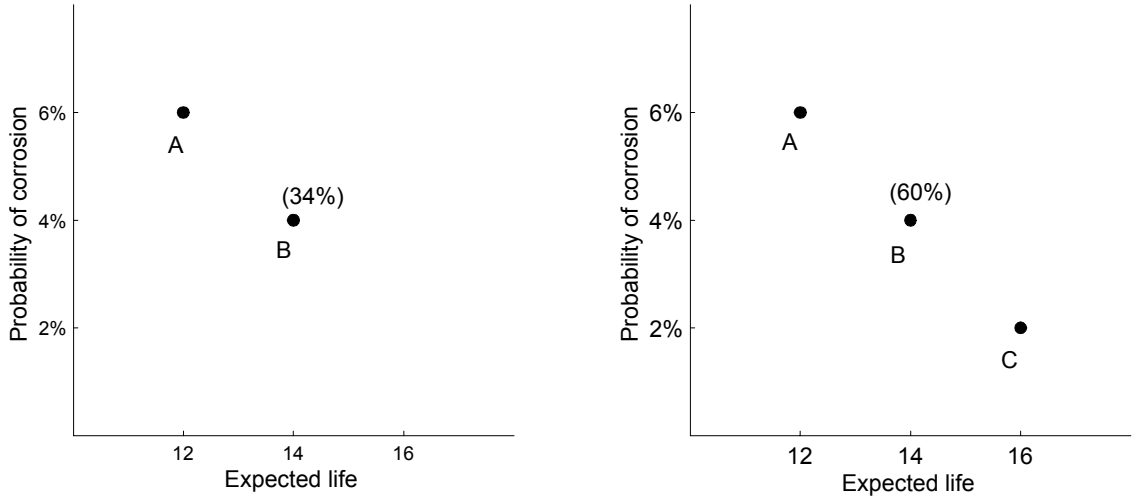

Figure 1: Compromise effect with calculator batteries. Numbers in parentheses indicate percentage of subjects choosing the alternative. The difference is significant at $p < 0.05$. Source: Simonson (1989).

This malleability of behavior is usually presented as evidence against stability of preferences and as an invitation to consider alternative, psychologically richer, theories of choice (e.g., Slovic 1995). However, a simple recognition that *contexts and frames may contain information* suffices to reconcile these apparent anomalies with standard utility-maximizing behavior. In this paper, I

develop a model where uninformed consumers can learn payoff-relevant information by observing what goods are available. The tendency to select the middle option naturally arises when there are consumers who are unsure which option is best for them, but know their tastes are middlebrow. Choice overload comes as no surprise if excessive product lines reduce consumers' information about which varieties are likely to suit them. A company's decision to make a particular 401(k) option the default clearly may imply that this option is optimal for at least some employees. French music playing in the store might indicate that the store specializes in French vintages. In short, *contextual inference* parsimoniously explains a variety of behavioral anomalies and marketing results.

In examining each incarnation of contextual inference as an apparent behavioral anomaly, I first consider situations where market context, i.e., the product line,[2] arises without the firm's attempt to influence consumers' beliefs. Such a model is appropriate when the number of uninformed consumers is small. The first proposition of the paper identifies the supply-side conditions that are sufficient for the compromise effect to arise as a market equilibrium. The idea is straightforward: in a market setting, a consumer's knowledge of her relative position in the distribution of tastes is sufficient for identifying the optimal good *if* she can observe the entire product line. When fixed costs exclude some goods from the product line, however, the reduced menu provides worse information and forces the consumer to choose based on her prior. This leads to an inconsistency between choices from a smaller and a larger menu. The analysis behind Proposition 1 not only establishes that the compromise effect can arise in equilibrium; it also makes clear predictions on

[2] In accordance with the prevalent use in the existing literature, I use the word "context" throughout the paper to simply mean the set of alternatives available to the agent, i.e., the choice set in the language of decision theory. I reserve the word "frame" for those aspects of the decision-making environment, including the manner of representing the alternatives available, that do not change the underlying choice set.

who should exhibit the effect and *when*.

When many consumers are uninformed, the firm may try to manipulate consumers' beliefs through the set of varieties it offers.[3] Proposition 2 establishes that firms may introduce *premium loss leaders* – expensive goods of overly high quality which, though unprofitable on their own, greatly improve the demand for other products. Section 3 provides anecdotal evidence that supports the existence of premium loss leaders.

Propositions 3 and 4 demonstrate that an uninformed consumer can be better off with a smaller choice set. The logic behind this possibility is as follows. A consumer who does not know which variety she likes must choose randomly among the available varieties. In equilibrium, the most popular goods are introduced, so the average popularity of the available varieties is decreasing in the breadth of the product line. Consequently, the uninformed consumer's surplus is greater when there are fewer options.[4]

In response, as Proposition 5 and Corollary 6 reveal, firms reduce the number of goods they offer in the presence of uninformed consumers. These results on choice overload have implications not only for the theory of product differentiation, but also for the current debate on Social Security reform.

Importantly, the interpretation of context- and frame-sensitivity in terms of inference yields a

[3] Consider a wine column that advises, "If you're on a tight budget, you can always do what economical diners have done for decades: order the second cheapest wine on the list," yet warns, "Just be advised that an old restaurant ploy is to slot an overstocked bottle into the second cheapest position on the list" (Oldman 2004).

[4] The contrast between the compromise effect and choice overload is worth noting. In the case of the compromise effect, the uninformed consumers know their relative position in the distribution of tastes and their equilibrium strategies resemble a rank-order heuristic. In the case of choice overload, the uninformed do not know their relative position in the distribution of tastes (or goods are not ordered in a suitable way), so they cannot do any better than to choose randomly among the available options. The structure of preferences is not the determining factor: both the compromise effect and choice overload can arise whether product differentiation is horizontal or vertical.

rich set of testable predictions. In Section 4, I discuss existing experimental results that support the inference interpretation of choice overload. Section 5 provides evidence that inference plays a significant role in default effects in 401(k) savings.

Clearly, not every instance of context and framing effects is a consequence of purely rational behavior. Contextual inference may not be the complete story in some examples of context effects,[5] and certain demonstrations of anchoring reveal a framing effect in a setting where information should not play a role (Tversky and Kahneman 1974; Ariely, Loewenstein, and Prelec 2003). In these anchoring experiments, the authors attempt to make it transparent to the subjects that the anchor has no informational value. However, it may be that the inability of the subjects to refrain from reacting as if the frame harbored information speaks to the general importance of inference in decision making, not to its irrelevance. Moreover, there are several advantages to using the contextual inference model: (i) the model parsimoniously explains a wide variety of phenomena; (ii) it permits us to draw on existing notions of equilibrium; (iii) the possibility results are stronger insofar as they do not rely on non-maximizing behavior; (iv) contextual inference provides a rich set of testable implications; and (v) the model allows us to embed context- and frame-dependence into a market setting and study the impact of contextual inference on equilibrium product lines and advertising strategies.

The idea that context effects may stem from rational inference, though largely unexplored, is not new. Luce and Raiffa (1957) and Sen (1993) informally observe that a choice set may contain information. Wernerfelt (1995) argues that the compromise effect in particular may follow from the

[5] Simonson and Tversky (1992) demonstrate that context matters even when subjects assess qualities before making their decisions (inspect the samples of paper towels).

use of an approximately rational rank-order heuristic, while Prelec, Wernerfelt, and Zettelmeyer (1997) experimentally examine this possibility. Most recently, Kalai, Rubinstein, and Spiegler (2002) establish bounds on the size of the implicit state space that is needed to rationalize specific behaviors.[6] In contrast to these papers, I explicity and formally model the informational content of product lines. The formalization yields new insights about choice overload and default effects in addition to context effects and furthermore, it allows me to embed these behaviors in a market setting and analyze the supply side response to consumers' contextual inference.

The results in this paper also build on the industrial organization literature on product selection in general (Hotelling 1929; Chamberlin 1951; Spence 1976) and on the influence of asymmetric information on market structure in particular. Much of the latter literature focuses either on adverse selection (Akerlof 1970) or on the role of signalling in a setting with repeat purchases (Nelson 1974; Schmalensee 1978; Milgrom and Roberts 1986). The analysis in this paper considers neither of these issues but rather examines the impact of the informational content of product lines in a static situation. The well-known insight that informed consumers can exert a positive externality on the uninformed ones (Wolinsky 1983; Salop and Stiglitz 1977; Chan and Leland 1982; Cooper and Ross 1985) plays a central role in the analysis of the compromise effect in Section 3. However, Section 4 reveals a limitation of this intuition and establishes that in the situations with choice overload, uninformed consumers' surplus *decreases* in the number of the informed.

Finally, this paper relates to the work on behavioral or boundedly rational industrial organization.[7] The last two years have witnessed a profusion of papers that analyze the question of how

[6] Harrison, Harstad, and Rutström (2004) and Plott and Zeiler (2005) stress the need to consider inference by subjects in design of experiments.

[7] See Ellison (2005) for a survey.

firms will respond to consumers who exhibit some particular behavioral anomaly (DellaVigna and Malmendier 2004; Schlag 2004; Gabaix and Laibson 2005; Heidhues and Kőszegi 2005a, 2005b; Orhun 2005). In contrast to this line of research, I do not exogenously impose a behavioral bias on consumers but rather derive such behavior as an equilibrium phenomenon that arises under standard preferences. In that vein, Section 4 of this paper is most closely related to concurrent work by Kuksov and Villas-Boas (2005) which also demonstrates that rational consumers can be better off with fewer options.

The remainder of the paper is structured as follows. In Section 2, I develop the general model of contextual inference. Section 3 applies the model to the compromise effect. Section 4 demonstrates that, under an appropriate informational asymmetry, uninformed consumers obtain a greater surplus from a strictly smaller choice set. In Section 5, I consider the implications of contextual inference for default effects and provide empirical evidence that supports the inference interpretation. Section 6 concludes.

2 A Model of Contextual Inference

Suppose there is a continuum of consumers and a single firm. Let X be a finite set of technologically feasible varieties. Each variety $x \in X$ is characterized by the utility it yields to the consumers, its marginal cost of production $c(x)$, and its (possibly stochastic) fixed cost $K(x)$. The randomness in the fixed costs will provide exogenous variation in the product line. The utility function is quasi-linear: consumer i obtains utility $u(\theta_i, s, x) - p$ from purchasing variety x at price p. The utility depends on the consumer's individual type, $\theta_i \in \Theta$, and the global preference parameter, $s \in S$.

Each consumer has unit demand and an outside option $\underline{u}_i \sim F$ that she obtains if she does not purchase any variety. For notational convenience, I equate the outside option with consumption of variety x_0 at a zero price. The support of F, $Supp(F)$, is bounded below. Let Λ denote the probability distribution over the types. Each consumer i knows her own type θ_i and the type distribution Λ, but a fraction $\alpha \in [0, 1)$ of the consumers do not know the global preference parameter s. The fraction of the uninformed is independent of the type. The uninformed share a common prior π over S.

The monopolist has some information about s and chooses a product line $M \subset X$ and a pricing strategy $p_x \ \forall x \in M$ given the costs.[8] The firm also knows the uninformed consumers' prior π. A competitive retail industry bridges the monopolist and the consumers. The retail costs, $m_x \sim G$, are independently distributed across the varieties but are common across retail stores. Since the industry is competitive, the price consumers face for variety x is $\tilde{p}_x = p_x + m_x$. I denote the vector of retail prices by $\tilde{p}$. The retail costs are not observable to the consumers and thus reduce the signal value of prices.

The global preference parameter s is the key component of the model. The precise interpretation of s depends on the particular application; in general, s may capture features of the external world (e.g., the meaning of technical units of quality) or features of internal tastes (e.g., the mapping from flavors to preferences). One way to think about s is as a taste shifter unobserved by a fraction of the population it affects.

The firm's strategy may depend on s, so the uninformed consumers rationally update their

[8] All the results obtain if the monopolist exactly knows s. For some applications, however, this will not be a reasonable assumption. Therefore, in those settings, I will only assume that the monopolist has better information about s than the uninformed consumers.

beliefs about s based on the firm's behavior.[9] I assume the uninformed cannot observe the behavior of other consumers.[10] In general, both the prices and the product line will contain information about s. However, since price signalling has already been widely explored (e.g., Milgrom and Roberts 1986) and since prices would reveal too much information to the uninformed, I introduce retail cost shocks to reduce the ease of inferring s from the firm's pricing strategy. In particular, I assume that the prices are sufficiently uninformative that their impact on beliefs is minimal.

Assumption P. *Distribution of retail costs, G, is such that* $\arg\max_{x \in M \cup \{x_0\}} E_{\pi(\cdot|\tilde{p},M)} [u(\theta, s, x) - p_x] = \arg\max_{x \in M \cup \{x_0\}} E_{\pi(\cdot|M)} [u(\theta, s, x) - p_x]$ $\forall \theta \in \Theta$ *for any realization of* $\tilde{p}$.

Assumption P requires that the likelihood function be "gentle" relative to the prior.[11] For a specific example consider the case where $m_x \sim N\left(\mu, \sigma^2\right)$. In this case, as $\sigma \to \infty$ the posterior given the retail prices weakly converges to the prior for any realization of $\tilde{p}$. Hence, when σ^2 is large enough the behavior of the uninformed will not be changed by the informational content of prices. Note that in this example the support of the retail prices is independent of s, so Assumption P does not place any restrictions on off-equilibrium beliefs.

The solution concept is Perfect Bayesian Equilibrium with the $D1$ criterion (Banks and Sobel 1987; Cho and Kreps 1987). The $D1$ criterion is an equilibrium refinement widely used in signalling games. It strengthens the "Intuitive Criterion" of Cho and Kreps (1987): it requires that if the set

[9] Matthew Rabin and his colleagues have developed several tractable formalizations of mistaken inference (Eyster and Rabin 2005; Rabin 2002; Rabin and Schrag 1999). The cursed equilibrium model (Eyster and Rabin 2005), in particular, could be relevant to this setting. However, I utilize a standard equilibrium notion to demonstrate that my results do not require any unconventional assumptions.

[10] Previous research has explored learning from others (e.g., McFadden and Train 1996; Bergemann and Valimaki 1999; Bolton and Harris 1999).

[11] I use this term in deference to the idea of a *gentle* or a *weak* prior, i.e, a prior that is, loosely speaking, very sensitive to the data.

of uninformed consumers' responses that make the firm willing to deviate to some action a when $s = s'$ is strictly smaller than set of such responses when $s = s''$, then the uninformed consumers should believe that the firm is infinitely more likely to deviate to a when $s = s''$ than when $s = s'$. Without such a restriction, seemingly implausible equilibria built on "threat beliefs" arise.

I can now introduce some of the ideas from Section 1 in formal terms. A consumer engages in *contextual inference* if $\pi(s|M) \neq \pi(s)$. *Context effects* will arise if the posterior under an expanded menu affects the relative valuations of two goods, i.e., $\exists x, x' \in M \subsetneq M'$ s.t. $E_{\pi(\cdot|M)}[u(\theta, s, x)] > E_{\pi(\cdot|M)}[u(\theta, s, x')]$ but $E_{\pi(\cdot|M')}[u(\theta, s, x)] < E_{\pi(\cdot|M')}[u(\theta, s, x')]$. The compromise effect is a specific example of a context effect. Let $\succ$ denote a partial ordering on $\mathbb{R}^2$ defined by $(a_1, a_2) \succ (a_1', a_2')$ if and only if $a_1 > a_1'$ and $a_2 < a_2'$. The *compromise effect* will obtain in equilibrium if $\exists x_1, x_2, x_3 \in \mathbb{R}^2$ s.t. $x_1 \succ x_2 \succ x_3$ and $x_2 = \underset{\{x_1,x_2,x_3\}}{\arg\max} E_{\pi(\cdot|\{x_1,x_2,x_3\})}[u(\theta, s, x)]$, but $E_{\pi(\cdot|\{x_1,x_2\})}[u(\theta, s, x_1)] > E_{\pi(\cdot|\{x_1,x_2\})}[u(\theta, s, x_2)]$ or $E_{\pi(\cdot|\{x_2,x_3\})}[u(\theta, s, x_3)] > E_{\pi(\cdot|\{x_2,x_3\})}[u(\theta, s, x_2)]$. Finally, consumers will engage in rational *choice overload* if there exist $M \subsetneq M'$ s.t. $\max_{x \in M} E_{\pi(\cdot|M)}[u(\theta, s, x)] > \max_{x \in M'} E_{\pi(\cdot|M')}[u(\theta, s, x)]$. Subsequent sections provide concrete theoretical and empirical examples of these phenomena.

3 Goldilocks and the Three Goods: The Compromise Effect as a Market Equilibrium

Interpreting technical units of quality can be difficult. How much more, for example, would you be willing to pay for a flashlight that delivers 40 rather than 35 lumens of light?[12] Similarly, in order

[12] Knowing that a lumen is "a unit of luminous flux, equal to the flux emitted by a point source of intensity one candela into a solid angle of one steradian" (*Oxford English Dictionary*, 2nd edition), is hardly helpful for

to optimally choose a personal computer, a consumer may need to know her willingness to pay for megahertz, gigabytes, and numerous other technical measures of quality. How do consumers make choices in the demanding environments of numerical information? In this section, I identify the ways in which informational externalities can ease the task of selecting the optimal variety when there is uncertainty about the hedonic interpretation of quality. In a market setting, a consumer's knowledge of her relative position in the distribution of tastes is often sufficient for identifying the optimal good. Goldilocks may not know how many dollars she is willing to pay for an additional megahertz, but, as long as she knows she is in the middle of the distribution of taste for speed, she will do well purchasing the computer that is neither too slow nor too fast.[13]

Extracting information from the set of available options, however, may lead consumers to violate the naïve formulation of the Weak Axiom of Revealed Preference. Recall that the compromise effect refers to the finding that, when three alternatives are available, the middle alternative is chosen more often than when it is paired with only one other option. A simple version of the compromise effect obtains when the alternatives are defined by their quality and price. Specifically, suppose that there are three possible alternatives, $x_1 = (q_1, p_1)$, $x_2 = (q_2, p_2)$, and $x_3 = (q_3, p_3)$, with $q_j < q_k$ and $p_j < p_k$ whenever $j < k$. Using the standard choice theoretic notation, I denote all the alternatives that an agent of type θ may select from choice set M by $C_\theta(M)$. Then, a

understanding the utility equivalent of the additional 5 lumens.

[13] Shapiro and Varian (1999) also refer to firm behavior that exploits the compromise effect as "Goldilocks pricing."

consumer of type θ exhibits the compromise effect if[14]

$$\begin{aligned} C_\theta(\{x_1, x_2\}) &= \{x_1\} \\ C_\theta(\{x_1, x_2, x_3\}) &= \{x_2\}. \end{aligned}$$

In this section I will illustrate how such behavior can arise because the presence of x_3 tells the consumer something about the relative hedonic value of q_1 and q_2.

3.1 Consumers' Inference when the Firm Does Not Manipulate Beliefs

For now, suppose that the uninformed consumers are zero measure. Consequently, the firm will not respond to their presence and the equilibrium product line will be the same as in a standard model of discrete choice. The next subsection introduces more uninformed consumers and analyzes the firm's response.

I begin by imposing some structure on the model from Section 2. Suppose that each variety x is defined by its quality $q(x)$, its marginal cost $c(x)$, and its stochastic fixed cost $K(x) \sim H_x$. As the term 'quality' implies, the varieties are vertically differentiated – all consumers would agree on the ranking of the varieties if they were to have identical prices. There are three types of consumers who differ in the intensity of their taste for quality. In particular, a consumer of type θ obtains utility $u(\theta, s, q(x)) - p_x$ from purchasing a product of quality $q(x)$ for price p_x, where $\theta \in \{\theta_l, \theta_m, \theta_h\} = \Theta$. I suppose all the first-partial and cross derivatives of u are positive, i.e., $u_v, u_{vw}, u_{vwz} > 0 \ \forall v \neq w \neq z \neq v$. Each consumer i has unit demand and an outside option

[14] As clarified in the formal definition in Section 2, this is not an 'only if.' The consumer also exhibits the compromise effect if $C(\{x_2, x_3\}) = \{x_3\}$ and $C(\{x_1, x_2, x_3\}) = \{x_2\}$.

$\underline{u}_i \sim F$. We have $0 < \theta_l < \theta_m < \theta_h$ and let λ_t denote the measure of consumers of type θ_t. Note that the type is the consumer's relative position in the distribution of tastes for quality,[15] and each consumer knows both her own type and the overall distribution of tastes. We have $s \in S$, where S is a non-empty compact subset of $\mathbb{R}_+$.

The global preference parameter s captures the hedonic value of quality. For example, suppose that u is linear, i.e., $u(\theta, s, q(x)) = \theta s q(x)$, that the firm is producing flashlights, and that quality, q, is measured in lumens. A consumer of type θ then, would be willing to pay additional $\$5\theta s$ for a flashlight that delivers 40 instead of 35 lumens of light. The effective hedonic value of a flashlight of quality q is $\theta s q$. With this formulation, we represent uncertainty about the utility interpretation of quality as uncertainty about the value of s. In the style of high school physics exercises, we can rewrite $u = \theta s q(x)$ with the emphasis on the units: $u\ \$ = \theta\ \frac{\$}{\text{brightness}} * s\ \frac{\text{brightness}}{\text{lumens}} * q\ \text{lumens} - p\ \$$ in the case of flashlights, or $u\ \$ = \theta\ \frac{\$}{\text{speed}} * s\ \frac{\text{speed}}{\text{Mhz}} * q\ \text{Mhz} - p\ \$$ in the case of computer processors. The global preference parameter s thus translates *technical units* like lumens and Mhz into *hedonic units* like brightness and speed.

There are only four technologically feasible varieties, $\{x_1, x_2, x_3, x_4\}$, defined by their quality q_j, marginal cost c_j, and fixed cost $K_j \sim H_j$, with $q_j < q_k$ and $c_j < c_k$ whenever $j < k$.[16] The firm knows s and solves

$$\max_M \max_{\overrightarrow{p}} E\left[\sum_{j:x_j \in M} D_j(\overrightarrow{p}, s)(p_j(s) - c_j) - K_j\right]$$

[15] We can also think of a particular person exhibiting a different θ on different days. For example, the intensity of taste for wine quality may depend on the occasion.

[16] If the firm were to choose quality locations from a richer set, its choices would reveal too much information to the uninformed. Additionally, the considerations of price discrimination with endogenous qualities would substantially complicate the model (Mussa and Rosen 1978; Tirole 1988, Chapter 3; Anderson and Dana 2005)

where M is the set of varieties the firm offers, $D_j(\overrightarrow{p}, s)$ is the demand for variety x_j given all the prices and the preference parameter s, and the expectation is taken over the joint distribution of fixed costs and retail costs. Let $p^*_{j,M}(s)$ denote the firm-set price of variety j when M is the product line.[17]

In order to study the compromise effect, we need the consumers to occasionally face three varieties. I therefore assume that, conditional on s, each variety is optimal for a distinct type, i.e., the three cheaper varieties, $\{x_1, x_2, x_3\}$, are optimal when s is low ($s \in \underline{S}$), and the three better varieties, $\{x_2, x_3, x_4\}$, are optimal when s is high $\left(s \in \overline{S}\right)$.[18]

We now examine the possible choices that an uninformed consumer may face. First, note that θ_l and θ_h types will never choose a variety that is inferior, given their taste, to another available variety. The information in the product line always reveals which of the available goods is best for them, so they never exhibit the compromise effect. For the compromise effect to arise, a consumer must purchase a variety that is inferior to another available option, since the underlying utility does not depend on the choice set. The θ_h and θ_l types always purchase the highest and lowest quality available, respectively, as long as their expected utility exceeds their outside option.[19]

[17] The fact S is compact and $Supp(F)$ is bounded below ensures the existence of a solution to the firm's problem. Generically, the solution is unique.

[18] Formally, there exists a partition of S, $\left\{\underline{S}, \overline{S}\right\}$, s.t. $\forall s \in \underline{S}$

$$\begin{array}{ll} u(\theta_l, s, q_2) - c_1 > u(\theta_l, s, q_j) - c_j & \forall j \neq 1 \\ u(\theta_m, s, q_3) - c_2 > u(\theta_m, s, q_j) - c_j & \forall j \neq 2 \\ u(\theta_h, s, q_4) - c_3 > u(\theta_h, s, q_j) - c_j & \forall j \neq 3, \end{array} \qquad (\underline{IC})$$

while $\forall s \in \overline{S}$

$$\begin{array}{ll} u(\theta_l, s, q_2) - c_2 > u(\theta_l, s, q_j) - c_j & \forall j \neq 2 \\ u(\theta_m, s, q_3) - c_3 > u(\theta_m, s, q_j) - c_j & \forall j \neq 3 \\ u(\theta_h, s, q_4) - c_4 > u(\theta_h, s, q_j) - c_j & \forall j \neq 4. \end{array} \qquad (\overline{IC})$$

As the proof of Proposition 1 makes clear, we will focus on the case where these inequalities hold with retail prices in place of costs.

[19] Depending on the parameter values, however, they might occasionally purchase a good that is inferior to their

In contrast, the middle types will not always be able to choose the best available variety. When x_2 and x_3 are the only varieties offered, the uninformed θ_m will not know which one is better for them. If $s \in \underline{S}$, x_2 is optimal, but if $s \in \overline{S}$, x_2 is inferior to x_3. They will thus buy the variety with a greater expected utility and occasionally make a mistake. Whenever they are offered three varieties, however, they will know that the middle one is optimal.

Specifically, suppose x_2 is better in expectation than x_3. Then if $s \in \overline{S}$, the θ_m types exhibit the compromise effect:[20]

$$\begin{aligned} C_{\theta_m}(\{x_2, x_3\}) &= \{x_2\} \\ C_{\theta_m}(\{x_2, x_3, x_4\}) &= \{x_3\}. \end{aligned}$$

Similarly, if x_3 were preferable in expectation, the compromise effect would arise when $s \in \underline{S}$.

Note that for this result to obtain, I need to ensure that (i) the consumers will occasionally face a menu that contains three varieties, (ii) the fixed costs sometimes exclude a variety from the choice set, (iii) at least some uninformed θ_m consumers will participate in the market when $M = \{x_2, x_3\}$ even if no information about s is available, and (iv) the uninformed θ_m consumers are not indifferent between x_2 and x_3 under the prior. To guarantee these four conditions, I introduce the following technical assumption:

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outside option. Similarly, if expected surplus from a single variety is negative, they could exhibit a "context effect" in a sense of choosing the outside option when a single variety is available, but selecting that variety out of a richer choice set.

[20] I abuse the notation here and treat x_i's as defined from the consumer's perspective, i.e., by their quality and price.

Assumption A1. *The parameters* $\{(q_j, c_j, H_j)\}_{j=1}^4$, $\{(\theta_t, \lambda_t)\}_{t\in\{l,m,h\}}$, π, F, *and* G *are such that (i) for each value of* s, *the firm introduces all three optimal varieties when the fixed costs are sufficiently low, (ii)* $\min_j \max Supp(H_j)$ *is sufficiently high that each variety will be excluded with a positive probability, (iii)* $\max_{j\in\{2,3\}} \int_S u(\theta_m, s, q_j) - E_G\left[\tilde{p}_{j,\{x_2,x_3\}}(s)\right] d\pi(s) > \min Supp(F)$, *and (iv)* $\int_S u(\theta_m, s, q_2) - E_G\left[\tilde{p}_{2j,\{x_2,x_3\}}(s)\right] d\pi(s) \neq \int_S u(\theta_m, s, q_3) - E_G\left[\tilde{p}_{3,\{x_2,x_3\}}(s)\right] d\pi(s)$.

Unfortunately, Assumption $A1$ is not stated in terms of primitives. I present it this way in order to make transparent what role the assumption plays in establishing the proposition. One can easily see, however, that Assumption $A1$ can follow from restrictions on exogenous parameters. For example, suppose that F is degenerate at zero and G and H_j are distributed uniformly on $[0, \tau_G]$ and $[0, \tau_H]$, respectively. In this case, slack IC constraints ensure (i), a large τ_H ensures (ii), and a large τ_G yields (iii). Condition (iv) is generically satisfied regardless of the distributions. With specific distributions it is also easy to show that the subset of the parameter space where this assumption is satisfied is full dimensional.

Proposition 1. *Suppose Assumptions* P *and* $A1$ *hold. Uninformed consumers of type* θ_m *exhibit the compromise effect with a positive probability in equilibrium.*

All proofs are relegated to the Appendix. The analysis behind Proposition 1 reveals several new results. Most importantly, it establishes that information contained in the product line may lead to the compromise effect in a market equilibrium. A similar line of reasoning can be used to explain the attraction effect (Huber, Payne, and Puto 1982).[21] Also, the analysis yields a normative

[21] The attraction effect refers to the finding that, given two multi-attribute alternatives (say A and B), the addition of a third option (C) that is dominated on all attributes by one existing alternative (B) but not the other (A) increases the appeal of the now dominating alternative (B).

ranking of inconsistent choices in the case of the compromise effect: those choices made within a larger context are the better ones.[22] The prediction here is exactly opposite of that made by Hsee (2000). He argues that consumption always takes place in a separate evaluation mode and that, consequently, choices made without comparison are superior *ex post*. Further, the proposition reveals that consumers who are not at the extremes of the taste distribution are the ones who engage in the compromise effect. Finally, more noise in the retail prices makes inference of s more difficult and thus the compromise effect more likely.

All these predictions are testable. For example, determining or inducing relative taste for quality would enable us to test whether agents with moderate tastes drive the effect. Also, measuring subsequent satisfaction with the goods purchased during the experiment (say, by allowing returns or observing use) would reveal whether choices made in richer contexts are in fact more likely to be *ex post* optimal.

3.1.1 Interpreting Uncertainty About s

Uncertainty about s plays a crucial role in establishing Proposition 1. As noted above, this uncertainty can be understood in terms of the distinction between technical and hedonic units of quality. This distinction additionally illuminates other behavioral anomalies. Consider the research on joint-separate evaluation preference reversals (e.g., Bazerman, Loewenstein and White 1992; Bazerman *et al.* 1994; Lowenthal 1993). A joint-separate evaluation preference reversal obtains when an option (A) is generally preferred to its alternative (B) if each is presented separately

[22] This holds in the particular model I have used to generate the compromise effect. More generally, the informational content of a complete product line will be superior to that of a partial one, but it is possible to construct an example where quality of information is not monotone in the breadth of the product line.

to two groups of subjects, but B is generally preferred to A if a group of subjects is presented with both options. In a representative experiment, Hsee (2000) asked subjects how much they would be willing to pay for a CD changer. One of the CD changers (A) had THD of .01% and capacity of 20 CDs, while the other (B) had THD of .003% and could hold 5 CDs. All subjects were told that THD stands for total harmonic distortion and that small values of THD imply better sound quality. Some of the subjects were also told that "For most CD changers on the market, THD ratings range from .002% (best) to .012% (worst)." The subjects were assigned to 6 conditions, with 3 evaluation modes (joint evaluation, separate evaluation of A, or separate evaluation of B) by 2 information modes (information about the range of THD values or not). Unsurprisingly, in low information separate evaluation conditions, subjects could not interpret THD values and exhibited a higher willingness to pay for option A, the option that holds more CDs. When context was provided, however, whether through the presence of both A and B or in the form of information about the market distribution of THD values, subjects were able to price sound quality and CD changer B obtained higher prices.[23] If we think of q as the THD value, uncertainty about s neatly captures the intuition behind this experiment.[24,25]

[23] Specifically, in low information separate evaluation conditions, mean WTP values for A and B were \$256 and \$212, respectively ($p < 0.1$), while in low information joint evaluation mode, WTP for A and B were \$204 and \$228, respectively ($p < 0.01$). In high information modes, prices were \$186 and \$222 ($p < 0.01$) in joint evaluation mode and \$177 and \$222 ($p < 0.01$) in separate evaluation mode.

[24] In the model the goods have a single-dimensional quality and price, while the experiment utilizes goods with two-dimensional quality. The more easily interpretable quality dimension, i.e., the CD capacity, plays the role of the price.

[25] Uncertainty about s can also be used to interpret results on scope neglect (e.g., Kahneman 1986; Desvousges *et al.* 1992; McFadden and Leonard 1993; Frederick and Fischhoff 1998), and the experiments on "travelling indifference curves" (Drolet, Simonson, and Tversky 2000).

3.2 Premium Loss Leaders: Firm's Manipulation of Consumers' Beliefs

I now examine a setting with a positive measure of uninformed consumers, i.e., $\alpha \in (0,1)$. If these consumers rely on context to decide what to purchase, the firm may have an incentive to distort its product line in order to increase the demand for its most profitable varieties.[26] Consider the anecdote, reported in Simonson and Tversky (1992), about Williams-Sonoma, a retail and mail-order company that sells high-end cookware. The company used to offer a single bread-baking appliance for $275, but then it introduced another, higher quality machine, for $429. The new item did not sell well, but the demand for the $275 variety almost doubled! Simonson and Tversky suggest that the company did not anticipate this effect,[27] but the anecdote raises the possibility of the existence of premium loss leaders – goods of exceptionally high quality whose purpose is simply to boost the sales of more moderate varieties.[28]

While the compromise effect necessarily involves at least three goods, supply distortions can be demonstrated with only two goods. To simplify the exposition, I assume there are only two types, $\{\theta_l, \theta_h\} = \Theta$, and two varieties, $\{x_1, x_2\}$, defined by their quality q_j, marginal cost c_j, and fixed cost K_j, with $q_1 < q_2$ and $c_1 < c_2$. Recall that λ_t denotes the fraction of consumers of type θ_t. As in the previous subsection, $u(\theta, s, x) = u(\theta, s, q(x)) - p_x$ with positive first-partial and cross derivatives. Let $\underline{u}_i \sim F$ with $Supp(F) = [0, \underline{u}_{\max}]$. Suppose that when s is low ($s \in \underline{S}$), x_1 is optimal for the high types while all the low types prefer the outside option to both varieties.

[26] Glaeser (2004) argues that knowing that people are sensitive to frames and contexts begs the question of how frames and contexts arise in the real world. In other words, if consumers are context sensitive, we should study the market supply of context.

[27] At the time of this paper's writing, Williams-Sonoma offers a single bread-baking appliance for $150.

[28] Smith and Nagle (1995) advise managers to introduce premium products even if they do not sell well, in order to "enhance buyers' perceptions of lower-priced products in the product line."

When s is high $\left(s \in \overline{S}\right)$, x_1 is optimal for the low types while x_2 is optimal for the high types.[29,30]

Note that, unlike in the previous subsection, I cannot analyze the monopolist's problem by first determining the optimal the pricing policy given s and a set of varieties and then solving for the optimal product line. I must account for the fact that the equilibrium beliefs by the uninformed, and consequently the equilibrium demand, depends on the firm's product line strategy. Thus, I consider each potential product line strategy in turn and examine whether there are consumer beliefs and a pricing policy that justify it in equilibrium. In particular, I wish to examine the feasibility of a pooling strategy that introduces $\{x_1, x_2\}$ whether $s \in \underline{S}$ or $s \in \overline{S}$. Such a strategy may involve a premium loss leader, since x_2 may lose money in $\underline{S}$.

I need to assume that the expected surplus from participation exceeds the outside option for at least some uninformed consumers of low type:

Assumption A2. *The parameters* $\{(q_j, c_j, K_j)\}_{j=1}^{2}$, $\{(\theta_t, \lambda_t)\}_{t\in\{l,h\}}$, α, π, *and* F *are such that* $\int_S u(\theta_l, s, q_1) - p^*_{1,\{x_1,x_2\}}(s) d\pi(s) > 0$.

Once again, the restrictions imposed by this assumption are much easier to see for a particular distribution. For example, if F is distributed uniformly on $[0, \underline{u}_{\max}]$, sufficiently large $\pi\left(\overline{S}\right)$ and

[29] Formally, there exists a partition of S, $\left\{\underline{S}, \overline{S}\right\}$, with $\pi\left(\underline{S}\right), \pi\left(\overline{S}\right) > 0$ s.t. $\forall s \in \underline{S}$

$$u(\theta_l, s, q_2) - c_2 < u(\theta_l, s, q_1) - c_1 < 0$$
$$u(\theta_h, s, q_1) - c_1 > 0 > u(\theta_h, s, q_2) - c_2,$$

while $\forall s \in \overline{S}$

$$u(\theta_l, s, q_1) - c_1 > 0 > u(\theta_l, s, q_2) - c_2$$
$$u(\theta_h, s, q_2) - c_2 > u(\theta_h, s, q_1) - c_1 > 0.$$

As in the previous subsection, we will consider the case where these inequalities hold with retail prices in place of costs.

[30] This model easily fits the Williams-Sonoma anecdote. We can think of x_1 as the \$275 variety and of x_2 as the \$429 variety. Suppose that most consumers are low type. When only the \$275 variety was available, the customers presumed that $s \in \underline{S}$, and only the high types entered the market. The introduction of the \$429 bread maker, however, led the uninformed to believe that $s \in \overline{S}$ and thus pulled the low types into the market for the \$275 variety.

$\underline{u}_{\max}$ guarantee Assumption $A2$.

Proposition 2. *Suppose Assumptions P and $A2$ hold. There exist $\hat{\lambda}_l < 1$, $\hat{K}_1, \hat{K}_2 > 0$ s.t. if $\lambda_l > \hat{\lambda}_l$, $K_1 < \hat{K}_1$, and $K_2 < \hat{K}_2$, there is a unique equilibrium product line strategy: the firm introduces $\{x_1, x_2\}$ whether $s \in \underline{S}$ or $s \in \overline{S}$.*

Note that such a product line strategy allows for a premium loss leader, since $\hat{K}_2 > 0$ and the profits from x_2 are arbitrarily small (as the fraction of low types, λ_l, is arbitrarily close to 1). Importantly, Proposition 2 demonstrates that, if enough consumers are of low type, the pooling strategy *uniquely* constitutes an equilibrium: even though introducing x_2 in $\underline{S}$ entails a social cost, withholding it is not an equilibrium. Moreover, the Proposition holds even with arbitrarily few uninformed consumers. This feature depends on the fact that, in the model, the supply distortion does not reduce the informed consumers' surplus. In an alternative model where indicating a high s requires removing a good that some informed consumers would like to consume, supply distortions will arise only if there are sufficiently many uninformed consumers.

The presence of the premium loss leader reduces the social surplus without improving the firm's ability to price discriminate, so the firm would wish to commit to introduce x_2 only in $\overline{S}$. Such a commitment, however, would not be credible: if $s \in \underline{S}$ and most of the consumers are low type, the firm will profit if it brings those low types into the market by introducing x_2 and thus suggesting that s is in $\overline{S}$.

Anecdotal evidence supports the existence of premium loss leaders. The Williams-Sonoma episode is one example. Xerox has also been reported to increase the sales of its high-volume

copier by introducing an additional, higher quality, version.[31] Rigorously demonstrating these phenomena is a worthwhile challenge for future empirical research.

Contextual inference has substantial implications for the analysis of product differentiation. A large literature in industrial organization examines the determination of the product line in models of discrete choice (see Anderson, de Palma, and Thisse 1992 for a textbook treatment). The results in this section suggest that we could enrich this literature by considering the informational content of product lines. Note that contextual inference may change firms' equilibrium behavior no matter the nature of the competition (e.g., monopoly, duopoly, *etc.*) and no matter the structure of preferences (e.g., vertical or horizontal differentiation). This paper scratches the surface of a series of industrial organization questions that arise once we allow for the possibility of contextual inference.

4 Choice Overload: Preference for Smaller Choice Sets

One of the simplest choice theoretic principles is that, in non-strategic situations, one cannot be worse off having more options.[32] A burgeoning literature in marketing, however, demonstrates violations of this principle.[33] Iyengar and Lepper (2000) set up a jam tasting booth in an upscale grocery store and varied whether the booth displayed 6 (limited-selection) or 24 (extensive-selection) distinct flavors of jam. They strikingly found that almost 12% of the potential customers in the limited-selection condition purchased a jam, while only 1.65% of those in the extensive-selection

[31] "The Compromise Effect," *Washington Post*, January 27, 2002.

[32] A notable exception arises if agents have self-control problems (e.g., Strotz 1955; Laibson 1997; Gul and Pesendorfer 2001). I abstract from these issues.

[33] The idea that excessive choice is potentially undesirable has been emphasized in the popular press as well. For a recent example, see "One Nation, With Niches for All," *New York Times*, June 11, 2005.

condition did so ($p < 0.001$). Boatwright and Nunes (2001) report an experiment run by an online grocery store. The store reduced its product selection by roughly a half[34] for a fraction of its customers (the experimental group)[35] and tracked both their purchases and the purchases of the remaining customers (the control group) for six months prior and five months subsequent to the intervention. Sales in the experimental group were 11% ($p < 0.0001$) higher. Demonstrations of choice overload are not limited to the retail industry. A field experiment by Bertrand *et al.* (2005) reveals that offering a single loan instead of numerous options increases take-up substantially. Iyengar, Huberman, and Jiang (2004) show that, on average, 75% of employees participate in a company 401(k) plan when there are only 2 funds available, but participation rate falls to roughly 60% when employees must choose between 59 funds. Other demonstrations of preference for smaller choice sets include Tversky and Shafir (1992), Redelmeier and Shafir (1995), Dhar (1997), and Chernev (2003).[36]

Iyengar and Lepper interpret their result as evidence for the "choice overload hypothesis," which states that extensive choice may be demotivating. Alternatively, however, we can use the idea of contextual inference to interpret the observed effects in a manner that is consistent with standard theories of choice.[37] The basic insight is that smaller choice sets can provide better information: the uninformed know more about which varieties are popular (and are likely to suit them) when

[34] Depending on the product category the assortment decreased by between 22% and 82%. The average decrease was close to 50%.

[35] In the article, Boatwright and Nunes (2001) do not specify whether the selection of the experimental group was randomized. In my correspondence with the authors I have learned that they were not involved in the design of the experiment and thus do not know whether the treatments were randomized. I have been unable to obtain contact information for any person at the store who was involved with the experiment.

[36] Schwartz (2004) goes so far as to suggest that the expansion of product lines over the last 30 years has played an important role in increasing the prevalence of depression in the United States.

[37] A related point is made by Kuksov and Villas-Boas (2005) in a setting with evaluation costs and exogenous prices.

they face a smaller product line.

4.1 Contextual Inference Interpretation of Choice Overload

Suppose that there are N possible flavors of jam, $X = \{1, 2, ...N\}$, each of which costs c to produce. A consumer of type θ obtains utility $v_x + \varepsilon_{x,\theta}$ from variety x. The $\varepsilon_{x,\theta}$'s are random variables with a continuous c.d.f. They are independently and identically distributed across varieties, but are potentially different across consumer types. Without loss of generality, I set $E[\varepsilon_{x,\theta}] = 0$, so that v_x is the average utility obtained from consuming variety x. I will refer to v_x as the *popularity* of flavor x. Let $\rho : X \to \mathbb{R}$ denote the mapping from the flavors to their popularity. Each consumer has unit demand and an outside option $\underline{u}_i \sim F$.

An informed consumer of type θ knows both ρ and the realizations of $\varepsilon_{x,\theta}$ for all x. The firm knows ρ, but does not know the realizations of $\varepsilon_{x,\theta}$'s. The uninformed consumers know neither ρ nor the realizations of of $\varepsilon_{x,\theta}$'s. In other words, an informed consumer knows exactly how much she likes each flavor, the firm knows how popular each flavor is, and an uninformed consumer knows neither which flavors she likes nor which flavors are popular.

Note that, if we let $s = (\rho, \{\varepsilon_{x,\theta}\})$, the model in this section is a specific case of the model in Section 2.[38] Fraction $\alpha \in [0, 1)$ of the consumers are uninformed. For simplicity I suppose that the total average utility from jams, $\sum_{x \in X} v_x$, is independent of s and that under the prior π each flavor is equally popular. As before, the firm chooses the product line $M \subset \{1, 2, ..., N\}$ and the prices $p_x \ \forall x \in M$. The consumers purchase the jam from a competitive retail industry with costs

[38] Strictly speaking, since in Section 2 the informed are assumed to exactly know s, this would imply that they know the realizations of $\varepsilon_{x,\theta}$'s for all types, not just their own.

$m_x \sim G$. Finally, I introduce the following assumption:

Assumption A3. *No two flavors are equally popular, i.e.,* $x \neq x' \Longrightarrow v_x \neq v_{x'}$.

Assumption $A3$ is generically satisfied. Moreover, even without it the subsequent results still hold, albeit with weak inequalities. I first establish that the firm will introduce the most popular flavors:

Lemma 1. *Suppose Assumptions P and A3 hold. The firm introduces the most popular flavors, i.e., if* M *is an equilibrium product line,* $x \in M$ *and* $x' \notin M \Longrightarrow v_x > v_{x'}$.

This Lemma requires the independence of the $\varepsilon_{x,\theta}$'s. If the tastes for varieties were correlated, or if some varieties were 'closer together' than others in some other way, the result might not hold. More subtly, the Lemma relies on the homogeneity of costs. If less popular flavors were cheaper to produce and uninformed were many, the firm may strategically introduce a generally undesirable but cheap flavor. The analysis of such a situation is closely related to the analysis of premium loss leaders in the previous section.

The most important implication of Lemma 1 is that the average popularity of the available flavors is decreasing in the breadth of the product line. Consequently, if the uninformed must choose blindly, they prefer smaller choice sets. Let $D^{\text{unf}}(M, \tilde{p})$ be the total number of jams purchased by the uninformed consumers in an equilibrium where the firm offers the product line M and the retail prices are $\tilde{p}$.

Proposition 3. *Suppose Assumptions P and A3 hold. In any equilibrium, the demand by the uninformed is strictly decreasing in product line breadth. Formally,* $\forall (M, \tilde{p}), (M', \tilde{p}')$ *s.t.* $|M| < |M'|$ *and* $\min_{x \in M} \tilde{p}_x \leq \min_{x \in M'} \tilde{p}'_x$, $D^{unf}(M, \tilde{p}) > D^{unf}(M', \tilde{p}')$.

Note that $(M, \tilde{p})$ and $(M', \tilde{p}')$ are not necessarily equilibrium outcomes: Proposition 3 relates the uninformed demand to product line breadth *within* any equilibrium. Hence, the proposition rests heavily on the restrictions on off-equilibrium beliefs. However, I also establish a comparative static that compares the demand by the uninformed across any two equilibria:

Proposition 4. *Suppose Assumptions P and A3 hold. Let* $(M, \tilde{p})$ *and* $(M', \tilde{p}')$ *be any two equilibrium product lines and prices. The demand by the uninformed is strictly greater with the smaller product line. Formally, if* $|M| < |M'|$ *and* $\min_{x \in M} \tilde{p}_x \leq \min_{x \in M'} \tilde{p}'_x$*, then* $D^{unf}(M, \tilde{p}) > D^{unf}(M', \tilde{p}')$.

While unobserved retail costs provide the results in a manner that is consistent with the previous section, requiring homogeneous prices might be a more realistic way to deliver Propositions 3 and 4. In imperfectly competitive industries, optimal prices of different varieties are generally distinct due to differences in demand, yet firms often provide many differentiated products at identical prices (McMillan 2005). For example, branded T-shirts of different colors, while they differ greatly in popularity, typically sell at same price. Homogeneous prices are common in a variety of industries, from yogurts to movie theatres (Orbach and Einav 2001). However, since jams used in Iyengar and Lepper's experiment *do* vary somewhat in price and the pricing uniformity in other imperfectly competitive industries lacks a compelling theoretical explanation, I rely on the retail cost shocks to eliminate information in prices.

Note that the firm can increase both its profits and social welfare by simply labeling the popularity of the varieties it introduces. At first glance this may seem like an important problem with the model. Choice overload, however, also arises if each variety is produced by a different

firm. In this case, "popularity labels" would convey no information in equilibrium since every firm would have an incentive to claim its product is the most popular. Moreover, even when a single firm produces all varieties, heterogenous costs may lead the firm to falsely label a cheap product as popular.

Propositions 3 and 4 provide a rational explanation for choice overload. Moreover, the suggested mechanism behind the phenomenon yields a testable implication. If the uninformed know their relative position in the distribution of tastes for an ordered, observable attribute (as in Section 3), rational choice overload should not obtain. Hence, contextual inference predicts that choice overload is less likely when the available varieties differ along a single, ordered dimension. An experiment by Gourville and Soman (forthcoming) confirms this prediction. Gourville and Soman presented subjects with hypothetical choices of microwaves. Each choice set included n Sharp microwaves and a single Panasonic option. The experimenters varied n from one to five. Moreover, in some conditions the Sharp microwaves differed only on capacity and price, while in others they varied on a number of attributes. As the inference interpretation predicts, choice overload obtained in the latter but not in the former conditions.

Salgado (2005) provides a more direct confirmation of the contextual inference mechanism. In her experiments, subjects first made a selection between a large set of lotteries (with 25 or 50 options) and a smaller subset (with 5 options) and then chose one of the lotteries from the selected menu. The subjects were told that the subset was (i) chosen randomly, (ii) chosen by graduate students in economics, or (iii) chosen to include only the 5 undominated lotteries from the larger set. As we would expect under the contextual inference interpretation of choice overload, the

fraction of subjects selecting the smaller set was much larger in the latter two conditions.[39]

An alternative way to generate rational choice overload would be to assume that uninformed consumers obtain social capital, and thus a higher utility, from whatever goods the informed are consuming, as in Becker and Murphy (2000). In this interpretation, the uninformed do not know from which good they would most benefit precisely because they do not know which good is the most popular. This social interactions story, however, does not predict the Gourville and Soman (forthcoming) finding. Nonetheless, a social interactions model of choice overload might be suitable for certain types of goods (e.g., books or music).

The most common alternative hypothesis that attempts to explain choice overload argues that cognitive costs reduce the desirability of excessive choice sets (Huffman and Kahn 1998; Cristol and Sealey 2000; Gourville and Soman forthcoming). Most treatments of this hypothesis, however, seem not to recognize that the consumer can always randomly select a "small choice set" out of the large one. Since such a procedure need not entail any thinking, the consumer cannot be worse off with more options simply because of the decision-making costs (unless we allow for a disutility of regret).[40] In order for choice overload to take place, the elements of the smaller choice set must be different in some way from a random selection from the larger set.[41] Contextual inference provides a concrete microfounded difference, namely popularity.

[39] Some subjects chose the smaller choice set even when it was selected randomly. This does not pose a challenge to the theory, however, since the elicited preferences were not strict. Moreover, in the rounds when feedback was provided, the fraction of subjects behaving this way was relatively small (13% in the 25-option group and 22% in the 50-option group).

[40] See Irons and Hepburn (2003) and Sarver (2005) for treatments of choice overload under regret.

[41] In the Kuksov and Villas-Boas (2005) model, the expected 'fit' is decreasing in the number of alternatives.

4.2 Firm's Response to Choice Overload

In contrast to the uninformed, the informed consumers know which flavors they like. Therefore, they prefer longer product lines since those are more likely to include their preferred flavors: the demand by the informed is increasing in product line breadth.

Since the uninformed prefer smaller and the informed larger menus, the equilibrium product line is decreasing in the measure of uninformed consumers. To state this result formally, let $\Pi(M, \alpha)$ denote the firm's maximum attainable profit when the product line is M and fraction α of consumers are uninformed.

Proposition 5. *Suppose Assumptions P and A3 hold. The firm's profit from a smaller product line is strictly increasing in the number of uninformed consumers. Formally, if* $|M| < |M'|$ *and for some* a_0, $\Pi(M, \alpha_0) \geq \Pi(M', \alpha_0)$, *then* $\forall \alpha > \alpha_0 \ \Pi(M, \alpha) > \Pi(M', \alpha)$.

Proposition 5 implies the following comparative static:

Corollary 6. *Suppose Assumptions P and A3 hold. The breadth of the product line is weakly decreasing in the number of uninformed consumers.*

The comparative static is weak only because product line breadth is a discrete variable: as Proposition 5 reveals, the firm's profit from a smaller product line is strictly increasing in the size of the uninformed population. A direct consequence of Corollary 6 is that the uninformed consumers' utility, which is decreasing in $|M|$, is increasing in α. In other words, the uninformed are better off when there are more uninformed in the market. The informed, however, prefer a wider choice set, so they suffer from the presence of the uninformed. These externalities are quite

similar to the preference externalities that arise when the prevalence of a particular taste induces a product line that provides less surplus for consumers with less common tastes (Waldfogel 2003; George and Waldfogel 2003). Because of these externalities, the consumers would wish to sort into separate stores for the informed and the uninformed. This desire for sorting may be an important factor in the industrial organization of the retail industry.

Choice overload is often invoked as an important consideration in the debate on Social Security reform. Iyengar, Huberman, and Jiang's (2004) study of choice overload was published in a book entitled *Pension Design and Structure*. Cronqvist and Thaler (2004) discuss the Swedish experience with Social Security privatization, emphasizing the seemingly negative effects of numerous fund options. Finally, the idea that politicians who push for Social Security reform are mistaken because they do not understand choice overload has been put forth in the popular press as well.[42] As the analysis in this section reveals, however, if choice overload stems from contextual inference, the welfare impact of expanding retirement options would crucially depend on whether these options are accompanied by suitable information.

5 Default Effects

Contextual inference may also play an important role in default effects. Default effects, i.e., the tendency to select the alternative that you receive if you do not specify otherwise, have been convincingly shown to affect decisions ranging from e-mail list participation (Johnson, Bellman, and Lohse 2002) to cadaveric organ donation (Abadie and Gay 2004). I will focus on default

[42] "Choice Overload Burdens Daily Life," *USA Today*, January 5, 2004.

effects in savings behavior. Madrian and Shea (2001) demonstrate that employee participation in a 401(k) plan is much higher under automatic enrollment even though all employees can easily opt out of the default.[43] Moreover, most employees keep the default rate and the default asset allocation in their plan. Choi *et al.* (2003) explain this phenomenon by suggesting that employees have self-control problems that prevent them from paying the small immediate cost of opting out of the default, despite the much larger future benefits of a superior savings rate and asset allocation.

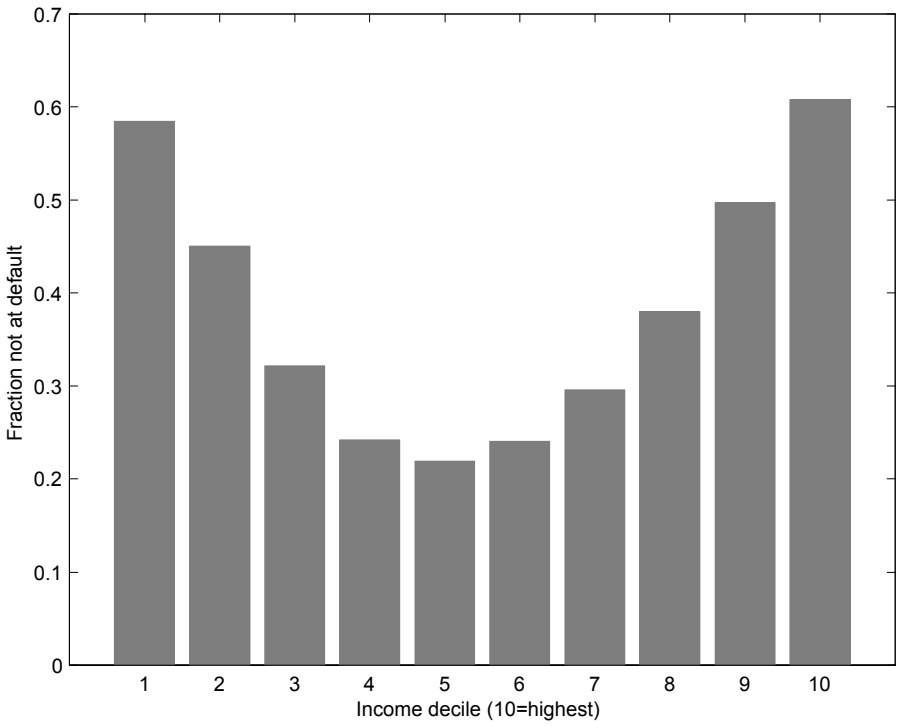

Figure 2: Fraction of employees not at default asset allocation.
Courtesy of James Choi, David Laibson, Brigitte C. Madrian, and Andrew Metrick.

[43] Also see Samuelson and Zeckhauser (1988) and Choi *et al.* (2004)

This explanation, however, de-emphasizes the potential role of inference: uninformed employees might conclude that the firm-set default is optimal for the typical employee.[44] The inference story thus suggests that the uninformed employees who are closer to the middle of the distribution may be more likely to remain at the default.

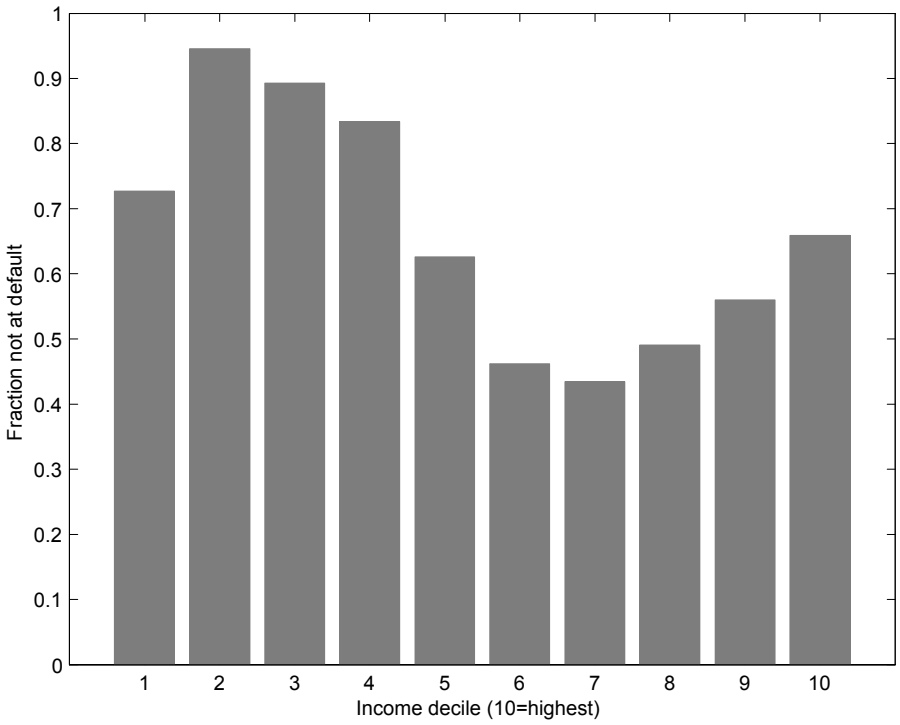

Figure 3: Fraction of employees not at default saving rate.
Courtesy of James Choi, David Laibson, Brigitte C. Madrian, and Andrew Metrick.

The problem of optimally allocating one's savings across asset classes may be much harder than

[44] Madrian and Shea (2001) also acknowledge the possible role of default as advice. They note that the employees who were hired before automatic enrollment but join the 401(k) plan after its introduction are more likely to invest in the default fund than those who join the plan beforehand.

the problem of determining the optimal saving rate. In fact, people appear to be deeply confused about asset allocations (Benartzi and Thaler 2002), but may have a strong sense of the rate at which they should be saving (Benartzi and Thaler 2004).[45] Given these two facts, contextual inference predicts that we should observe a negative relationship between an employee's propensity to remain at the default asset allocation and her distance to the median, but no such relationship for the default savings rate.

Figures 2 and 3, generously generated by James Choi, David Laibson, Brigitte C. Madrian, and Andrew Metrick at my request,[46] examine these predictions using the data from a U.S.-based office equipment company with approximately 32,000 employees. Figure 2 depicts the fraction of employees who move away from the default asset allocation (stable value fund and company stock) as a function of their income decile. Figure 3 does the same for the default savings rate (2%). Specifically, the data show the percentage of all employees hired between July 1, 1997 and December 31, 1997 who are no longer at the default as of December 31, 1998.[47] Figure 2 demonstrates quite clearly that the probability of opting out of the default asset allocation rate increases with the distance from the median in both directions. As expected, this relationship does not hold as well for the default contribution rate.

These results provide suggestive evidence that contextual inference plays an important role in a wide variety of decisions, including those as important as savings behavior.

[45] Due to self-control problems, however, attaining the desired level is not easy for most people.
[46] The data they use is proprietary, so I did not have any access to it.
[47] There are 3,446 observations in Figure 2 and 7,287 observations in Figure 3.

6 Conclusion

Characteristics of market equilibria often contain information that allows market participants to make better decisions. The most widely studied aspect of this feature of the market is the fact that prices can aggregate information and thus lead to a more efficient allocation of scarce resources. This paper, in contrast, focuses on the informational content of equilibrium product lines. A firm's decision to offer a particular set of goods may reveal information that helps uninformed consumers make better choices. But, the information revelation is far from perfect, and contextual inference sometimes leads consumers to engage in apparently anomalous behaviors.

In response to consumer inference, firms may attempt to manipulate the informational content of their product lines and induce supply distortions. Proposition 2 demonstrates that a monopolist may introduce a premium loss leader while Corollary 6 shows that the presence of uninformed consumers can reduce the number of varieties offered. The product line, however, may in turn influence what proportion of the consumer population is uninformed. Consumers' information may depend on their consumption in the previous period. Since that consumption depends on the available choice set, the product line in one time period has an impact on the proportion of the uninformed in the next. Future theoretical research might consider a dynamic model that allows for such feedback.

Contextual inference also suggests a number of directions for empirical research. When a new good is introduced, is its impact on the demand for existing varieties consistent with the compromise effect? Can one rigorously demonstrate the existence of goods whose purpose is to influence consumers' beliefs? If consumers are aware that the product line is small for reasons

unrelated to popularity, does choice overload still obtain? Are there other determinants of the decision to accept a default savings rate or asset allocation? These are but some of the questions whose answers may help us better understand the role and the scope of contextual inference in markets.

A Appendix

A.1 Proof of Proposition 1

Proof. Consider an uninformed consumer of type θ_m. Let A_2 and A_3 respectively denote her expected utility of x_2 and x_3 under $\pi(\cdot|\{x_2, x_3\})$ given the wholesale prices, i.e., for $j = 2, 3$, let $A_j = \int_S \left(u(\theta_m, s, q_j) - p^*_{j,\{x_2,x_3\}}(s)\right) d\pi(\cdot|\{x_2, x_3\})$. Fix some realizations of retail shocks such that ($\underline{IC}$) and ($\overline{IC}$) hold with retail prices and $|m_2 - m_3| < |A_2 - A_3|$. By Assumption $A1$ (iv), $A_2 \neq A_3$, so such realizations occur with a positive probability. I first consider the case where $A_2 > A_3$. Fix any $\hat{s} \in \overline{S}$. By Assumption $A1$ (i), we know that the firm offers $\{x_2, x_3, x_4\}$ if the fixed costs are sufficiently low. Moreover, we know $C_{\theta_m}(\{x_2, x_3, x_4\}) = \{x_3\}$. Recall that this notation does not exclude the possibility that some, but not all, consumers select the outside option. Now, by Assumption $A1$ (ii), we know that the distribution of the fixed costs is such that the firm sometimes offers $\{x_2, x_3\}$. In this case, since $A_2 > A_3$, Assumptions P and $A1$ (iii) yield $C_{\theta_m}(\{x_2, x_3\}) = \{x_2\}$.

The other case is $A_2 < A_3$. Fix any $\widehat{s} \in \underline{S}$. By Assumption $A1$ (i), we know that the firm offers $\{x_1, x_2, x_3\}$ if the fixed costs are sufficiently low. Moreover, $C_{\theta_m}(\{x_1, x_2, x_3\}) = \{x_2\}$. Now, by Assumption $A1$ (ii), we know that the distribution of the fixed costs is such that the firm sometimes offers $\{x_2, x_3\}$. In this case, since $A_2 < A_3$, Assumptions P and $A1$ (iii) yield $C_{\theta_m}(\{x_2, x_3\}) = \{x_3\}$. ■

A.2 Proof of Proposition 2

Proof. I denote the firm's product line strategy by $\mathcal{M}$ and its pricing strategy by p. First I show that $\mathcal{M}(s) = \{x_1, x_2\}\ \forall s \in S$ is the unique pure strategy equilibrium. Then, I will show there are no equilibria in nondegenerate mixed strategies.

Suppose $\mathcal{M}$ is a pure product line strategy. Let $\lambda_l > 0.5$. I first establish that $\mathcal{M}$ must be monotone, i.e. $\forall s, \hat{s}$ s.t. $s > \hat{s} \in S$, $\mathcal{M}(\hat{s}) \subset \mathcal{M}(s)$. Suppose to the contrary that $\exists s_1 < s_2 \in S$ s.t. $\exists x_i$ s.t. $x_i \in \mathcal{M}(s_1)$ and $x_i \notin \mathcal{M}(s_2)$. Note that the menu is everywhere-non-empty, i.e., $\nexists s \in S$ s.t. $\mathcal{M}(s) = \phi$, since for any s, regardless of the uninformed beliefs, the firm can make strictly positive profits by introducing x_1. Hence, $\exists x_i$ s.t. $x_i \notin \mathcal{M}(s_2)$ and $\mathcal{M}(s_1) = \mathcal{M}(s_2) \cup \{x_i\}$. With $\lambda_l > 0.5$, the demand by the informed consumers for each x_i is weakly increasing in s. Thus, for a non-monotonic strategy to be a best response, it must be the case that the presence of x_i implies a lower expected state than its absence. For removal of x_i not to be a profitable deviation in s_1, it must be the case that the loss in the informed demand for x_i in s_1 outweighs the increased uninformed demand for $M \setminus \{x_i\}$. But, since the informed demand for x_i is non-decreasing in s, this implies that the loss in the informed demand for x_i in s_2 also outweighs the increased uninformed demand for $M \setminus \{x_i\}$. Therefore, $\mathcal{M}$ must be monotone.

Next, I show that $\mathcal{M}$ must be constant, i.e., $\exists M$ s.t. $\mathcal{M}(s) = M\ \forall s \in S$. Suppose that $\mathcal{M}$ is not constant. Since it is monotone and everywhere-non-empty, $\exists\ \hat{s}$ s.t. $\mathcal{M}(s) = \{x_i\}\ \forall s < \hat{s}$ and $\mathcal{M}(s) = \{x_i, x_j\}\ \forall s > \hat{s}$ with $i \neq j$. I will show that this cannot be an equilibrium since the firm can deviate by introducing x_j at $s < \hat{s}$. To establish that this is a profitable deviation, I first note that the gross profit from the informed consumers could not decrease with this deviation.

Moreover, on the equilibrium path $\{x_i, x_j\}$ implies a strictly higher state than $\{x_i\}$. Hence, the introduction of x_j would strictly increase the demand by the uninformed consumers. Therefore, if K_j is sufficiently small, the deviation is profitable. Thus, $\mathcal{M}$ must be constant.

Now we know there are at most three possible product line strategies: (i) $\mathcal{M}(s) = \{x_1\}\ \forall s$, (ii) $\mathcal{M}(s) = \{x_2\}\ \forall s$, and (iii) $\mathcal{M}(s) = \{x_1, x_2\}\ \forall s$. I first show that (i) cannot be an equilibrium. I consider a deviation where for some $s_2 \in \overline{S}$, the firm introduces x_2 at the price p_2^* that maximizes the profit from the informed consumers. For this deviation not to be profitable, it must be the case that there are sufficiently many uninformed consumers and that their off-equilibrium beliefs are such that the expected value of s is higher when $M = \{x_1\}$ than when $M = \{x_1, x_2\}$. I will demonstrate that such off-equilibrium beliefs do not satisfy the $D1$ criterion. Let $\Pi^{EQ}(s)$ denote the firm's equilibrium profits in s. Suppose $s_1 < s_2$ and let $A(s, (M, p))$ denote the set of uninformed consumers' mixed actions that make the firm's profit in s if it introduces M and charges p strictly greater than $\Pi^{EQ}(s)$. Let $A^0(s, (M, p))$ denote the set of uninformed consumers' mixed actions that make the firm's profit in s if it introduces M and charges p exactly equal to $\Pi(s)$. I need to show that $A(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) \cup A^0(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) \subsetneq A(s_2, (\{x_1, x_2\}, (p_1, p_2^*)))\ \forall p_1$. Fix some p_1. Let Π^δ denote the firm's profit from the uninformed consumers when the firm plays the deviation under consideration and the uninformed consumers play the mixed action δ. Let $\Pi^{iDEV}(s)$ denote the firm's profit from the informed if the firm plays the deviation under consideration. Then, $A(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) \cup\ A^0(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) = \left\{\delta : \Pi^\delta \geq \Pi^{EQ}(s_1) - \Pi^{iDEV}(s_1)\right\}$ and $A(s_2, (\{x_1, x_2\}, (p_1, p_2^*))) = \{\delta : \Pi^\delta > \Pi^{EQ}(s_2) - \Pi^{iDEV}(s_2)\}$. Since the deviation maximizes the profit from the informed in s_2, we have $\Pi^{iDEV}(s_2) - \Pi^{EQ}(s_2) > \Pi^{iDEV}(s_1) - \Pi^{EQ}(s_1)$. Hence, $A(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) \cup A^0(s_1, (\{x_1, x_2\}, (p_1, p_2^*))) \subsetneq A(s_2, (\{x_1, x_2\}, (p_1, p_2^*)))$.

I now show that (ii) cannot be an equilibrium. I consider a deviation where for some $s \in \overline{S}$, the firm introduces x_1 at the price p_1^* that maximizes the profit from the informed consumers. The off-equilibrium beliefs that provide strongest support for (ii) assign probability one to $s = \inf S$ when the firm introduces x_1. Yet, even with these beliefs, for any fixed α, if λ_l is sufficiently close to one, when the firm introduces x_1 the increase in the profit from the informed low types exceeds the loss in the profits from the uninformed high types.

Hence, the only possible pure product line strategy is $\mathcal{M}(s) = \{x_1, x_2\}\ \forall s$. The off-equilibrium beliefs that support this strategy satisfy the $D1$ criterion since, holding the K_i's fixed, the set of the actions by the uninformed that justify a deviation that removes a variety is greater for lower s.

Finally, I show that there are no equilibria with a nondegenerate mixed product line strategy. Let $\Pi^{\inf}(M, s)$ and $\Pi^{\text{unf}}(M, s)$ denote the firm's equilibrium profit from the informed and uninformed consumers, respectively, if it introduces product line M at s. Suppose there is a nondegenerate mixed product line strategy. Then, $\exists M, M'$ and $\hat{s}$ s.t. $M \neq M'$ and $\alpha\Pi^{\text{unf}}(M, \hat{s}) + (1-\alpha)\Pi^{\inf}(M, \hat{s}) = \alpha\Pi^{\text{unf}}(M', \hat{s}) + (1-\alpha)\Pi^{\inf}(M', \hat{s})$. For each $s \in S$ there is a unique product line that maximizes the profit from the informed consumers. Without loss of generality, consider the case where $\Pi^{\inf}(M, \hat{s}) > \Pi^{\inf}(M', \hat{s})$. Since $\alpha \in (0, 1)$, this implies $\Pi^{\text{unf}}(M', \hat{s}) > \Pi^{\text{unf}}(M, \hat{s})$. This can only be the case if on the equilibrium path M' implies a higher s on average than M does. But in that case, by the same argument that established that a pure product line strategy must be constant, we know that if K_i's are sufficiently small, the firm can profitably deviate at some s by introducing M' instead of M. ■

A.3 Proof of Lemma 1

Proof. Suppose to the contrary that the firm offers the product line M s.t. $\exists x, x'$ s.t. $x \in M$ and $x' \notin M$ at some s_0 where $v_x \leq v_{x'}$ with prices p. Let $m = |M|$. I consider a deviation where the firm instead introduces the menu M' that consists of the m most popular flavors at s_0 with prices p^* that maximize the profit with the product line $M^{'}$. By Assumption $A3$, $\sum_{\hat{x} \in M'} v_{\hat{x}} > \sum_{\hat{x} \in M} v_{\hat{x}}$. Since $\varepsilon_{x,\theta}$, are independently and identically distributed across varieties, this deviation would increase the profit from the informed consumers. Hence, it must be the case that under the off-equilibrium beliefs $E_{\pi(\cdot|M)} \frac{1}{m} \sum_{\hat{x} \in M'} v_{\hat{x}} < E_{\pi(\cdot|M)} \frac{1}{m} \sum_{\hat{x} \in M} v_{\hat{x}}$. Such off-equilibrium beliefs, however, do not satisfy the $D1$ criterion. To see this, let Π^{δ} denote the firm's profit from the uninformed consumers when the firm plays the deviation under consideration and the uninformed consumers play the mixed action δ. Let $\Pi^{EQ}(s)$ denote the firm's equilibrium profit in s. Let $\Pi^{iDEV}(s)$ denote the firm's profit in s from the informed if the firm plays the deviation under consideration. Finally, let $T = \left\{ s \in S : \frac{1}{m} \sum_{\hat{x} \in M'} v_{\hat{x}} < E_{\pi(\cdot|M,p)} \frac{1}{m} \sum_{\hat{x} \in M} v_{\hat{x}} \right\}$. Fix some $t_0 \in T$. Now, $A(t_0, (M', p^*)) \cup A^0(t_0, (M', p^*)) = \left\{ \delta : \Pi^{\delta} \geq \Pi^{EQ}(t_0) - \Pi^{iDEV}(t_0) \right\}$ and $A(s_0, (M', p^*)) = \left\{ \delta : \Pi^{\delta} > \Pi^{EQ}(s_0) - \Pi^{iDEV}(s_0) \right\}$. Since the deviation maximizes the profit from the informed consumers in s_0, we have $\Pi^{iDEV}(s_0) - \Pi^{EQ}(s_0) > \Pi^{iDEV}(t_0) - \Pi^{EQ}(t_0)$. Therefore $A(t_0, (M', p^*)) \cup A^0(t_0, (M', p^*)) \subsetneq A(s_0, (M', p^*))$ and the off-equilibrium beliefs needed to support M which does not contain the most popular flavors do not satisfy the $D1$ criterion. ■

A.4 Proof of Proposition 3

Proof. Fix some equilibrium. Suppose M and M' are two product lines with $|M| < |M'|$, while $\tilde{p}$ and $\tilde{p}'$ are the realized retail prices for these two product lines with $\min_{x \in M} \tilde{p}_x \leq \min_{x \in M'} \tilde{p}'_x$. By Assumption P, for any $\varepsilon > 0$, an uninformed consumer's expected utilities from any two flavors in a given product line are within $\frac{\varepsilon}{|M'|}$ of each other. Hence, $\forall x \in M$,

$$\left| E_{\pi(\cdot|M)} u(x; \theta, s) - E_{\pi(\cdot|M)} \frac{1}{|M|} \sum_{\hat{x} \in M} v_{\hat{x}} \right| < \varepsilon.$$

Similarly, $\forall x' \in M'$,

$$\left| E_{\pi(\cdot|M)} u(x'; \theta, s) - E_{\pi(\cdot|M')} \frac{1}{|M'|} \sum_{\hat{x} \in M'} v_{\hat{x}} \right| < \varepsilon.$$

From the proof of Lemma 1, we know that the $D1$ criterion ensures that the uninformed believe both M and M' contain the most popular flavors. Hence, the expected average popularity is decreasing in the size of the menu:

$$E_{\pi(\cdot|M)} \frac{1}{|M|} \sum_{x \in M} v_x > E_{\pi(\cdot|M')} \frac{1}{|M'|} \sum_{x \in M'} v_x.$$

Let $x_{\min} \equiv \arg\min_{x \in M} \tilde{p}_x$ and $x'_{\min} \equiv \arg\min_{x \in M'} \tilde{p}'_x$, and let d and d' denote the minimum positive difference between the lowest and second lowest retail price in M and M', respectively:

$$\begin{aligned} d &\equiv \min_{x \in M} \{\tilde{p}_x - \tilde{p}_{x_{\min}} : \tilde{p}_x \neq \tilde{p}_{x_{\min}}\} \\ d' &\equiv \min_{x \in M'} \left\{\tilde{p}'_x - \tilde{p}'_{x'_{\min}} : \tilde{p}'_x \neq \tilde{p}'_{x'_{\min}}\right\}. \end{aligned}$$

Now, set

$$\varepsilon < \min\left\{\frac{1}{2}\left(E_{\pi(\cdot|M)}\frac{1}{|M|}\sum_{x\in M} v_x - E_{\pi(\cdot|M')}\frac{1}{|M'|}\sum_{x\in M'} v_x\right), d, d'\right\}.$$

Since $\varepsilon < d, d'$, we know that, whether the product line is M or M', the consumer will buy the least expensive flavor. Since $\varepsilon < \frac{1}{2}\left(E_{\pi(\cdot|M)}\frac{1}{|M|}\sum_{x\in M} v_x - E_{\pi(\cdot|M')}\frac{1}{|M'|}\sum_{x\in M'} v_x\right)$, we know that the expected utility from the least expensive flavor in M is strictly greater than the expected surplus from the least expensive flavor in M'. Hence, $\min_{x\in M}\tilde{p}_x \leq \min_{x\in M'}\tilde{p}'_x$ yields $D^{\text{unf}}(M,\tilde{p}) > D^{\text{unf}}(M',\tilde{p}')$. ■

A.5 Proof of Proposition 4

Proof. Let $(M,\tilde{p})$ and $(M',\tilde{p}')$ be any two equilibrium product lines and prices s.t. $|M| < |M'|$ and $\min_{x\in M}\tilde{p}_x \leq \min_{x\in M'}\tilde{p}'_x$. By Assumption P, for any $\varepsilon > 0$ an uninformed consumer's expected utilities from any two flavors in a given product line are within $\frac{\varepsilon}{|M'|}$ of each other. Hence, $\forall x \in M$,

$$\left|E_{\pi(\cdot|M)}u(x;\theta,s) - E_{\pi(\cdot|M)}\frac{1}{|M|}\sum_{\hat{x}\in M} v_{\hat{x}}\right| < \varepsilon.$$

Similarly, $\forall x' \in M'$,

$$\left|E_{\pi(\cdot|M)}u(x';\theta,s) - E_{\pi(\cdot|M')}\frac{1}{|M'|}\sum_{\hat{x}\in M'} v_{\hat{x}}\right| < \varepsilon.$$

Since M and M' are equilibrium product lines, Lemma 1 guarantees they contain the most popular flavors. Hence, the expected average popularity is decreasing in the size of the menu:

$$E_{\pi(\cdot|M)}\frac{1}{|M|}\sum_{x\in M} v_x > E_{\pi(\cdot|M')}\frac{1}{|M'|}\sum_{x\in M'} v_x.$$

Let $x_{\min} \equiv \arg\min_{x \in M} \tilde{p}_x$ and $x'_{\min} \equiv \arg\min_{x \in M'} \tilde{p}'_x$, and let

$$\begin{aligned} d &\equiv \min_{x \in M} \{\tilde{p}_x - \tilde{p}_{x_{\min}} : \tilde{p}_x \neq \tilde{p}_{x_{\min}}\} \\ d' &\equiv \min_{x \in M'} \left\{\tilde{p}'_x - \tilde{p}_{x'_{\min}} : \tilde{p}'_x \neq \tilde{p}_{x'_{\min}}\right\}. \end{aligned}$$

Now, set

$$\varepsilon < \min \left\{ \frac{1}{2} \left(E_{\pi(\cdot|M)} \frac{1}{|M|} \sum_{x \in M} v_x - E_{\pi(\cdot|M')} \frac{1}{|M'|} \sum_{x \in M'} v_x \right), d, d' \right\}.$$

Since $\varepsilon < d, d'$, we know that in each equilibrium the uninformed buy the least expensive flavor. Since $\varepsilon < \frac{1}{2} \left(E_{\pi(\cdot|M)} \frac{1}{|M|} \sum_{x \in M} v_x - E_{\pi(\cdot|M')} \frac{1}{|M'|} \sum_{x \in M'} v_x \right)$, we know that the expected utility from the least expensive flavor in M is strictly greater than the expected surplus from the least expensive flavor in M'. Hence, $\min_{x \in M} \tilde{p}_x \leq \min_{x \in M'} \tilde{p}'_x$ yields $D^{\text{unf}}(M, \tilde{p}) > D^{\text{unf}}(M', \tilde{p}')$. ■

A.6 Proof of Proposition 5

Proof. Suppose M and M' are two product lines with $|M| < |M'|$. Let $\Pi^{diff}(\alpha)$ be the difference in the profit from the smaller and the larger product line when fraction α of consumers are uninformed: $\Pi^{diff}(\alpha) \equiv \Pi(M, \alpha) - \Pi(M', \alpha)$. I first note that Proposition 3 guarantees that $\Pi^{diff}(1) > 0$. Furthermore, $\Pi^{diff}(0) < 0$. Since Π^{diff} is continuous, the intermediate value theorem implies $\exists \widehat{\alpha} \in (0,1)$ s.t. $\Pi^{diff}(\widehat{\alpha}) = 0$, i.e., there exists a fraction of uninformed consumers such that the firm is indifferent between introducing M and M'. It is easy to see that Π^{diff} is differentiable at $\hat{\alpha}$, so it will suffice to show $\left.\frac{d\Pi^{diff}(\alpha)}{d\alpha}\right|_{\alpha=\hat{\alpha}} > 0$. Let $\Pi^{\text{inf}}(M, p, \alpha)$ and $\Pi^{\text{unf}}(M, p, \alpha)$ respectively denote the profit from the informed and the uninformed consumers when the product line is M, prices are p, and there is a fraction α of the uninformed. Let $p^*(M, \alpha)$ denote the equilibrium

price vector if the product line is M and fraction α of consumers are uninformed. By the envelope theorem,

$$\left.\frac{d\Pi^{diff}(\alpha)}{d\alpha}\right|_{\alpha=\hat{\alpha}} = \begin{array}{c}\left\{\Pi^{\text{unf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{unf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)\right\}+\\ \left\{\Pi^{\text{inf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{inf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)\right\}.\end{array}$$

By definition of $\hat{\alpha}$,

$$\begin{array}{c}\hat{\alpha}\left\{\Pi^{\text{unf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{unf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)\right\}=\\ \left(1-\hat{\alpha}\right)\left\{\Pi^{\text{inf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{inf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)\right\}.\end{array} \tag{1}$$

Now if $\Pi^{\text{inf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)\leq\Pi^{\text{inf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)$, since the relative consumer surplus from the smaller choice set is higher from the uninformed we also have $\Pi^{\text{unf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)<\Pi^{\text{unf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)$. But, then Equation (1) cannot be satisfied. Hence, both

$$\Pi^{\text{unf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{unf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)$$

and

$$\Pi^{\text{inf}}\left(M',p^{*}\left(M',\hat{\alpha}\right),\hat{\alpha}\right)-\Pi^{\text{inf}}\left(M,p^{*}\left(M,\hat{\alpha}\right),\hat{\alpha}\right)$$

must be strictly positive. Therefore, $\left.\frac{d\Pi^{diff}(\alpha)}{d\alpha}\right|_{\alpha=\hat{\alpha}}>0$. ■

References

Abadie, A., and S. Gay (2004): "The Impact of Presumed Consent Legislation on Cadaveric Organ Donation: A Cross Country Study," NBER Working Paper 10604.

Akerlof, G. A. (1970): "The Market for "Lemons": Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84(3), 488–500.

Anderson, E. T., and J. Dana (2005): "When Is Price Discrimination Profitable?," Working Paper.

Anderson, S. P., A. de Palma, and T. Jacques-Francois (1992): *Discrete Choice Theory of Product Differentiation*. The MIT Press, Cambridge, MA.

Ariely, D., G. Loewenstein, and D. Prelec (2003): ""Coherent Arbitrariness": Stable Demand Curves Without Stable Preferences," *Quarterly Journal of Economics*, 118(1), 73–106.

Banks, J., and J. Sobel (1987): "Equilibrium Selection in Signaling Games," *Econometrica*, 55(3), 647–662.

Bazerman, M. H., G. F. Loewenstein, and S. B. White (1992): "Reversals of Preference in Allocation Decisions: Judging an Alternative Versus Choosing Among Alternatives," *Administrative Science Quarterly*, 37(2), 220–240.

Bazerman, M. H., H. A. Schroth, P. P. Shah, K. A. Diekmann, and A. E. Tenbrunsel (1994): "The Inconsistent Role of Comparison Others and Procedural Justice in Reactions to Hypothetical Job Offers: Implications for Job Acceptance Decisions," *Organizational Behavior and Human Decision Processes*, 60(3), 326–352.

Becker, G. S., and K. M. Murphy (2000): *Social Economics: Market Behavior in a Social Environment*. The Belknap Press of Harvard University Press, Cambridge, MA.

Benartzi, S., and R. H. Thaler (2002): "How Much Is Investor Autonomy Worth?," *Journal of Finance*, 57(4), 1593–1616.

——— (2004): "Save More Tomorrow: Using Behavioral Economics to Increase Employee Saving," *Journal of Political Economy*, 112(1), 164–187.

Bergemann, D., and J. Valimaki (1999): "Experimentation in Markets," Working Paper.

Bertrand, M., D. S. Karlan, S. Mullainathan, E. Shafir, and J. Zinman (2005): "What's Psychology Worth: A Field Experiment in the Consumer Credit Market," Working Paper.

Boatwright, P., and J. C. Nunes (2001): "Reducing Assortment: An Attribute-Based Approach," *Journal of Marketing*, 65(3), 50–63.

Bolton, P., and C. Harris (1999): "Strategic Experimentation," *Econometrica*, 67(2), 349–374.

Chamberlin, E. H. (1951): "Monopolistic Competition Revisited," *Economica*, 18(4), 343–362.

Chan, Y.-S., and H. Leland (1982): "Prices and Qualities in Markets With Imperfect Information: A Search Model," *Review of Economic Studies*, 49(4), 499–516.

Chernev, A. (2003): "When More Is Less and Less Is More: The Role of Ideal Point Availability and Assortment in Consumer Choice," *Journal of Consumer Research*, 30(2), 170–183.

Cho, I.-K., and D. Kreps (1987): "Signaling Games and Stable Equilibria," *Quarterly Journal of Economics*, 102(2), 179–221.

Choi, J., D. Laibson, B. C. Madrian, and A. Metrick (2003): "Optimal Defaults," *American Economic Review Papers and Proceedings*, 93(2), 180–185.

——— (2004): "For Better or For Worse: Default Effects and 401(k) Savings Behavior," in *Perspectives in the Economics of Aging*, ed. by D. Wise, pp. 81–121. University of Chicago Press, Chicago.

Cooper, R., and T. W. Ross (1985): "Monopoly Provision of Product Quality with Uninformed Buyers," *International Journal of Industrial Organization*, 3(4), 439–449.

Cristol, S., and P. Sealey (2000): *Simplicity Marketing*. The Free Press, New York.

Cronqvist, H., and R. H. Thaler (2004): "Design Choices in Privatized Social-Security Systems: Learning from the Swedish Experience," *American Economic Review*, 94(2), 424–428.

DellaVigna, S., and U. Malmendier (2004): "Contract Design and Self-Control: Theory and Evidence," *Quarterly Journal of Economics*, 119(2), 353–402.

Desvousges, W. H., F. R. Johnson, R. Dunford, K. J. Boyle, S. P. Huson, and K. N. Wilson (1992): "Measuring Non-Use Damages Using Contingent Valuation: An Experimental Evaluation of Accuracy," Research Triangle Institute Monograph 92-1.

Dhar, R. (1997): "Consumer Preference for a No-Choice Option," *Journal of Consumer Research*, 24(2), 215–231.

Doyle, J. R., D. J. O'Connor, G. M. Reynolds, and P. A. Bottomley (1999): "The Robustness of the Asymmetrically Dominated Effect: Buying Frames, Phantom Alternatives, and In-Store Purchases," *Psychology and Marketing*, 16(3), 225–243.

Drolet, A., I. Simonson, and A. Tversky (2000): "Indifference Curves That Travel With the Choice Set," *Marketing Letters*, 11(3), 199–209.

Ellison, G. (2005): "Bounded Rationality in Industrial Organization," Working Paper.

Eyster, E., and M. Rabin (2005): "Cursed Equilibrium," *Econometrica*, 73(5), 1623–1672.

Frederick, S., and B. Fischhoff (1998): "Scope (In)sensitivity in Elicited Valuations," *Journal of Risk Decision and Policy*, 3(2), 109–123.

Gabaix, X., and D. Laibson (2005): "Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets," Working Paper.

George, L., and J. Waldfogel (2003): "Who Affects Whom in Daily Newspaper Markets?," *Journal of Political Economy*, 111(4), 765–84.

Glaeser, E. L. (2004): "Psychology and the Market," *American Economic Review*, 94(2), 408–13.

Gourville, J. T., and D. Soman (forthcoming): "Overchoice and Assortment Type: When and Why Variety Backfires," *Marketing Science*.

Gul, F., and W. Pesendorfer (2001): "Temptation and Self-Control," *Econometrica*, 69(6), 1403–1435.

Harrison, G. W., R. M. Harstad, and E. E. Rutstrom (2004): "Experimental Methods and Elicitation of Values," *Experimental Economics*, 7(2), 123–140.

Heidhues, P., and B. Koszegi (2005a): "The Impact of Consumer Loss Aversion on Pricing," Working Paper.

——— (2005b): "Competition and Price Variation when Consumers are Loss Averse," Working Paper.

Herne, K. (1997): "Decoy Alternatives in Policy Choices: Asymmetric Domination and Compromise Effects," *European Journal of Political Economy*, 13(3), 575–89.

Hotelling, H. (1929): "Stability in Competition," *Economic Journal*, 39(1), 41–57.

Hsee, C. K. (2000): "Attribute Evaluability: Its Implications for Joint-Separate Evaluation Reversals and Beyond," in *Choices, Values, and Frames*, ed. by D. Kahneman, and A. Tversky, pp. 543–563. Russel Sage Foundation, New York.

Huber, J., J. W. Payne, and C. Puto (1982): "Adding Asymmetrically Dominated Alternatives: Violations of Regularity and the Similarity Hypotheses," *Journal of Consumer Research*, 9(1), 90–98.

Huffman, C., and B. E. Kahn (1998): "Variety for Sale: Mass Customization or Mass Confusion," *Journal of Retailing*, 74(4), 491–513.

Irons, B., and C. Hepburn (2003): "Regret Theory and the Tyranny of Choice," Working Paper.

Iyengar, S. S., G. Huberman, and W. Jiang (2004): "How Much Choice Is Too Much? Contributions to 401(k) Retirement Plans," in *Pension Design and Structure: New Lessons from Behavioral Finance*, ed. by O. S. Mitchell, and S. P. Utkus, chap. 5. Oxford University Press.

Iyengar, S. S., and M. Lepper (2000): "When Choice Is Demotivating: Can One Desire Too Much of a Good Thing?," *Journal of Personality and Social Psychology*, 79(6), 995–1006.

Johnson, E. J., S. Bellman, and L. G. L. (2002): "Defaults, Framing, and Privacy: Why Opting In Doesn't Equal Opting Out," *Marketing Letters*, 13(1), 5–15.

Kahneman, D. (1986): "Comments on the Contingent Valuation Method," in *Valuing Environmental Goods: An Assessment of the Contingent Valuation Vethod*, ed. by R. Cummings, D. Brookshire, and W. Schulze, pp. 185–194. Rowman and Allanheld, Totowa, NJ.

Kalai, G., A. Rubinstein, and R. Spiegler (2002): "Rationalizing Choice Functions by Multiple Rationales," *Econometrica*, 70(6), 2481–2488.

Kuksov, D., and J. M. Villas-Boas (2005): "When More Alternatives Lead to Less Choice," Working Paper.

Laibson, D. (1997): "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics*, 112(2), 443–77.

Lowenthal, D. J. (1993): "Preference Reversals in Candidate Evaluation," Carnegie Mellon University Working Paper.

Luce, D. R., and H. Raiffa (1957): *Games and Decisions: Introduction and Critical Survey*. Wiley, New York.

Madrian, B. C., and D. F. Shea (2001): "Power of Suggestion: Inertia in 401(k) Participation and Savings Behavior," *Quarterly Journal of Economics*, 116(4), 1149–1187.

Mc Fadden, D. L., and K. E. Train (1996): "Consumers' Evaluation of New Products: Learning from Self and Others," *Journal of Political Economy*, 104(4), 683–703.

McFadden, D. L. (1999): "Rationality for Economists," *Journal of Risk and Uncertainty*, 19(1-3), 73–105.

McFadden, D. L., and G. K. Leonard (1993): "Issues in the Contingent Valuation of Environmental Goods: Methodologies for Data Collection and Analysis," in *Contingent Valuation: A Critical Assessment*, ed. by J. A. Hausman, vol. 220 of *Contributions to Economic Analysis*, pp. 165–208. Elsevier Science, New York.

McMillan, R. (2005): "Different Flavor, Same Price: The Puzzle of Uniform Pricing for Differentiated Products," Working Paper.

Milgrom, P. R., and J. Roberts (1986): "Price and Advertising Signals of Product Quality," *Journal of Political Economy*, 94(4), 796–821.

Mussa, M., and S. Rosen (1978): "Monopoly and Product Quality," *Journal of Economic Theory*, 18(2), 301–317.

Nelson, P. (1974): "Advertising as Information," *Journal of Political Economy*, 82(4), 729–754.

North, A. C., D. J. Hargreaves, and J. McKendrick (1997): "In-Store Music Affects Product Choice," *Nature*, 390(6656), 132.

Oldman, M. (2004): "Don't Sniff the Cork!," Uncorked. www.vault.com.

Orbach, B. Y., and L. Einav (2005): "Uniform Prices for Differentiated Goods: The Case of the Movie-Theater Industry," Harvard Law and Economics Discussion Paper No. 337.

Orhun, A. Y. (2005): "Optimal Product Line Design When Consumers Exhibit Choice Set Dependent Preferences," Working Paper.

Plott, C. R., and K. Zeiler (2005): "Asymmetries in Exchange Behavior Incorrectly Interpreted as Evidence in Prospect Theory," Social Science Working Paper 1230.

Prelec, D., B. Wernerfelt, and F. Zettelmeyer (1997): "The Role of Inference in Context Effects: Inferring What You Want from What Is Available," *Journal of Consumer Research*, 24(1), 118–125.

Rabin, M. (2002): "Inference by Believers in the Law of Small Numbers," *Quarterly Journal of Economics*, 117(3), 775–816.

Rabin, M., and J. Schrag (1999): "First Impressions Matter: A Model of Confirmatory Bias," *Quarterly Journal of Economics*, 114(1), 37–82.

Redelmeier, D. A., and E. Shafir (1995): "Medical Decision Making in Situations That Offer Multiple Alternatives," *Journal of the American Medical Association*, 273(4), 302–305.

Salgado, M. (2005): "Choosing to Have Less Choice," Working Paper.

Salop, S., and J. E. Stiglitz (1977): "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion," *Review of Economic Studies*, 44(3), 493–510.

Samuelson, W., and R. J. Zeckhauser (1988): "Status Quo Bias in Decision Making," *Journal of Risk and Uncertainty*, 1(1), 7–59.

Sarver, T. (2005): "Anticipating Regret: Why Few Options May Be Better," Working Paper.

Schlag, K. H. (2004): "Competing for Boundedly Rational Consumers," Working Paper.

Schmalensee, R. (1978): "A Model of Advertising and Product Quality," *Journal of Political Economy*, 86(3), 485–503.

Schwartz, B. (2004): "The Tyranny of Choice," *Scientific American*, 290(4), 70–75.

Sen, A. (1993): "Internal Consistency of Choice," *Econometrica*, 61(3), 495–521.

Shapiro, C., and H. R. Varian (1999): *Information Rules*. Harvard Business School Press, Boston, MA.

Simonson, I. (1989): "Choice Based on Reasons: The Case of Attraction and Compromise Effects," *Journal of Consumer Research*, 16(2), 158–174.

Simonson, I., and A. Tversky (1992): "Choice in Context: Tradeoff Contrast and Extremeness Aversion," *Journal of Marketing Research*, 29(3), 281–295.

Slovic, P. (1995): "The Construction of Preference," *American Psychologist*, 50(5), 364–371.

Smith, G. E., and T. T. Nagle (1995): "Frames of Reference and Buyers' Perception of Price and Value," *California Management Review*, 38(1), 98–116.

Spence, M. (1976): "Product Differentiation and Welfare," *American Economic Review*, 66(2), 407–414.

Strotz, R. H. (1955): "Myopia and Inconsistency in Dynamic Utility Maximization," *Review of Economic Studies*, 23(3), 165–180.

Tirole, J. (1988): *The Theory of Industrial Organization*. MIT Press, Cambridge, MA.

Tversky, A., and D. Kahneman (1974): "Judgment under Uncertainty: Heuristics and Biases," *Science*, 185(4157), 1124–1131.

Tversky, A., and E. Shafir (1992): "Choice Under Conflict: The Dynamics of Deferred Decision," *Psychological Science*, 3(6), 358–361.

Van Eetvelde, D., C. Geens, and P. Harrington (2002): *101 Ways to Increase Sales*. Indicator, Ashford, UK.

Waldfogel, J. (2003): "Preference Externalities: An Empirical Study of Who Benefits Whom in Differentiated-Product Markets," *RAND Journal of Economics*, 34(3), 557–68.

Wernerfelt, B. (1995): "A Rational Reconstruction of the Compromise Effect: Using Market Data to Infer Utilities," *Journal of Consumer Research*, 21(4), 627–633.

Wolinsky, A. (1983): "Prices as Signals of Product Quality," *Review of Economic Studies*, 50(4), 647–658.