

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

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Context can influence decisions. This malleability of choice is usually invoked as evidence that people do not maximize stable preference orderings. In a market equilibrium, however, context conveys payoff-relevant information to consumers. Consequently, these consumers rationally violate naïve formulations of standard choice theoretic principles. I identify informational asymmetries under which apparently anomalous behaviors, namely the compromise effect and choice overload, arise as market equilibria. Firms respond to consumers' contextual inference; in case of the compromise effect, a firm may introduce premium loss leaders (expensive goods of overly high quality that increase the demand for other goods). (JEL D11, D83, M31)

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 a context effect if her choice between two alternatives systematically depends on the presence of other options. An extensive literature demonstrates context effects in laboratory settings. One of the most widely studied context effects is the compromise effect (Itamar Simonson 1989),¹ which 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. Figure 1 shows the compromise effect obtained by Simonson (1989). This tendency to avoid extreme options has been credited with affecting decisions ranging from the demand for wine (Daniel L. McFadden 1999) to voting (Kaisa Herne 1997) and investing (Shlomo Benartzi and Richard H. 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* (Dirk van Eetvelde, Carl Geens, and Peer Harrington 2002) and *Information Rules* (Carl Shapiro and Hal R. Varian 1999).

Another behavior that is seemingly inconsistent with a well-defined preference ordering is choice overload. In choice overload experiments (e.g., Sheena S. Iyengar and Mark Lepper 2000), customers are less likely to make a purchase if more products are added to the choice set.

More broadly, marketing research reveals that minor changes in the decision-making environment can have a substantial impact on what people buy. This malleability of behavior is usually

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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., John R. Doyle et al. 1999).

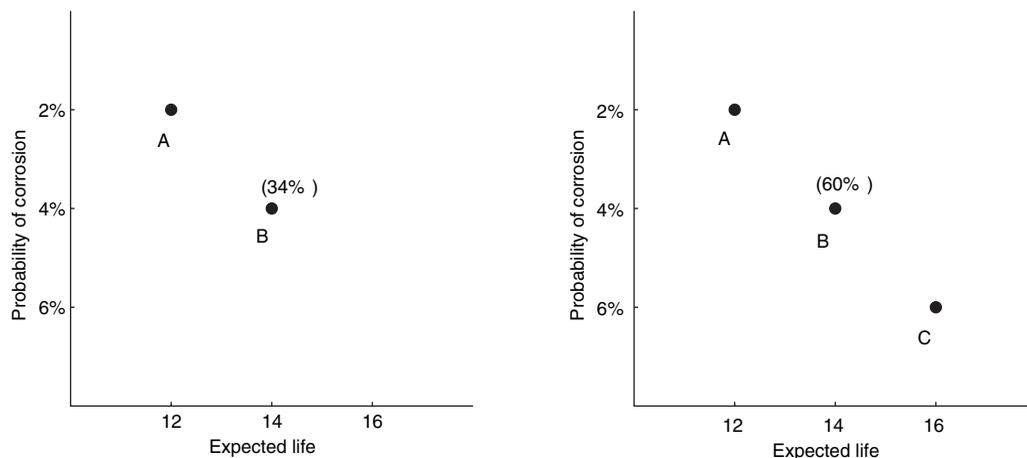


FIGURE 1. COMPROMISE EFFECT WITH CALCULATOR BATTERIES

Notes: Numbers in parentheses indicate percentage of subjects choosing the alternative. The difference is significant at $p < 0.05$.

Source: Simonson (1989).

presented as evidence against stability of preferences and as an invitation to consider alternative, psychologically richer, theories of choice (e.g., Paul Slovic 1995). However, a recognition that *the context may contain information* suffices to reconcile these apparent anomalies with standard utility-maximizing behavior. In this paper, I develop a model where uninformed consumers learn payoff-relevant information by observing what goods are available.² The tendency to select the middle option thus 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. Thus, *contextual inference* parsimoniously explains seemingly disparate behavioral anomalies.

In examining each incarnation of contextual inference as an apparent behavioral anomaly, I first consider a situation where market context, i.e., the product line,³ 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 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 this proposition not only establishes that the compromise effect can arise in equilibrium; it also makes clear and testable predictions on the ex post optimality of the inconsistent choices.

² Similarly, a firm's decision to present its products in a particular manner may convey information, leading to *framing effects* (see Craig R. M. McKenzie and Jonathan D. Nelson (2003) for evidence on the informational content of frames).

³ In accordance with the prevalent use in the existing literature, I use the word "context" throughout the paper to mean simply 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.

When many consumers are uninformed, the firm may try to manipulate consumers' beliefs through the set of varieties it offers.⁴ In particular, I establish that the firm may introduce *premium loss leaders*—expensive goods of overly high quality which, though unprofitable on their own, greatly improve the demand for other goods. Importantly, however, the presence of the informed consumers ensures that the firm has a greater incentive to introduce a high-quality good when it is more valuable, so there is always some information in the product line. Therefore, even when the informational content of the product line is reduced because the firm actively tries to exploit uninformed consumers' ignorance, and the uninformed consumers actively react to this attempt at manipulation, compromise effect still remains an equilibrium outcome.

The second half of the paper examines choice overload. I first 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 varieties are introduced, so the average popularity of the available varieties is decreasing in the breadth of the product line. Consequently, the uninformed consumer's expected surplus is greater when there are fewer options. In response, 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 debates on Social Security and Medicare reform. Moreover, the interpretation of context-sensitivity in terms of inference yields a rich set of testable predictions. In Section IV, I discuss some possible directions for future empirical research on choice overload.

Admittedly, not every instance of context and framing effects is likely a consequence of fully 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 Daniel Kahneman 1974; Dan Ariely, George F. Loewenstein, and Dražen Prelec 2003).⁶ In these anchoring experiments, the authors attempt to make it transparent to the subjects that the anchor has no informational value, yet the subjects seem unable to refrain from reacting as if the frame harbors information.⁷ One limitation of the contextual inference model is that it cannot account for these phenomena.⁸

This paper relates to several streams of literature. The idea that context effects may stem from rational inference, though largely unexplored, is not new. Duncan R. Luce and Howard Raiffa (1957) and Amartya Sen (1993) informally observe that a choice set may contain information. Birger Wernerfelt (1995) develops the idea formally and demonstrates that consumers' ignorance of their absolute, and knowledge of their relative, tastes can lead to the compromise effect.⁹ This observation plays the central role in my analysis of the compromise effect and motivates the paper overall. In contrast to Wernerfelt (1995), however, I consider a setting where the informational content of the product line arises endogenously even though the firm attempts to manipulate consumers' beliefs. Other papers examine contextual inference in various settings. Roland

⁴ 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" (Mark Oldman 2004).

⁵ See the discussion in Simonson and Amos Tversky (1992) and Tversky and Simonson (1993).

⁶ Anchoring refers to the tendency of judgments and preferences to be affected by irrelevant, randomly generated numbers that are made salient.

⁷ For example, Ariely, Loewenstein, and Prelec (2003) demonstrate that asking subjects whether they would be willing to buy a bottle of wine for a dollar figure equal to the last two digits of their Social Security number makes their subsequent willingness to pay for that bottle sensitive to this number: subjects with a higher Social Security number are willing to pay more for the wine.

⁸ Future research on the formation of subjects' beliefs in experimental settings may reveal the extent to which some type of inappropriate contextual transfer explains these results.

⁹ Prelec, Wernerfelt, and Florian Zettelmeyer (1997) experimentally examine this mechanism.

Bénabou and Jean Tirole (2003) demonstrate that an agent's inference about the task from the incentive structure can generate a trade-off between intrinsic and extrinsic motivation. Bharat N. Anand and Ron Shachar (2004) empirically study how the information implicit in a TV network's decision to air particular shows induces brand loyalty. Gil Kalai, Ariel Rubinstein, and Ran Spiegler (2002) consider inference more abstractly and establish bounds on the size of the implicit state space that is needed to rationalize specific behaviors.

This paper also relates to the marketing literature on context effects (e.g., Ran Kivetz, Oded Netzer, and V. Srinivasan 2004; A. Yesim Orhun forthcoming). In that line of research, however, agents are exogenously assumed to have preferences that depend on the choice set, while I consider context-dependence that arises endogenously through inference.

The results presented here also build on the industrial organization literature on the influence of asymmetric information on market structure. The well-known insight that informed consumers can exert a positive externality on the uninformed ones (e.g., Steven Salop and Joseph E. Stiglitz 1977) plays a role in the analysis of the compromise effect. The choice overload results, however, reveal a limitation of this intuition and establish that uninformed consumers' surplus can *decrease* as the number of the informed consumers increases.

Finally, this paper relates to the work on behavioral or boundedly rational industrial organization.¹⁰ The last few years have witnessed a profusion of papers that analyze the question of how firms will respond to consumers who exhibit some particular behavioral anomaly (e.g., Stefano DellaVigna and Ulrike Malmendier 2004; Paul Heidhues and Botond Kőszegi 2005, forthcoming; Xavier Gabaix and David Laibson 2006; Spiegler 2006; Kfir Eliaz and Spiegler 2007). In contrast to this line of research, I derive nonclassical behavior as a phenomenon that arises under standard preferences. In that vein, the choice overload section of this paper is closely related to concurrent work by Franklin B. Norwood (2006) and Dmitri Kuksov and J. Miguel Villas-Boas (2007) who also demonstrate that rational consumers with standard preferences can be better off with fewer options.

The remainder of the paper is structured as follows. In Section I, I develop a general model of contextual inference. Section II applies the model to the compromise effect and establishes the possibility of premium loss leaders. Section III demonstrates that, under an appropriate informational asymmetry, uninformed consumers obtain a greater surplus from a strictly smaller choice set. Section IV concludes.

I. A Model of Contextual Inference

There is a continuum of consumers and a single firm. The consumers are indexed by i . Let X be the 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 $u(\theta_i, s, x) - p_x + \varepsilon_{ix}$ from purchasing variety x at price p_x , where ε_{ix} are independent and identically distributed shocks with $E[\varepsilon_{ix}] = 0$.¹¹ Utility from variety x thus depends on the consumer's individual type, $\theta_i \in \Theta$, and the global preference parameter, $s \in S$. Each consumer i has unit demand and an outside option x_0 .

The global preference parameter s is the key component of the model. The interpretation of s depends on the particular application; I will discuss it in greater detail later on. A fraction

¹⁰ See Glenn Ellison (2006) for a survey.

¹¹ These utility shocks are needed only in Section IIB, for the result on premium loss leaders, where they ensure that demand is continuous in beliefs. Each consumer i knows ε_{ix} for all x .

$\alpha \in [0, 1)$ of consumers do not know s . This fraction is independent of the type. The uninformed share a common prior π over S and the firm knows the uninformed have this prior. The firm has some information about s and chooses a product line $M \subseteq X$ given its costs. I assume that prices are exogenous. This assumption greatly simplifies the exposition and increases the transparency of the mechanisms that drive the results. An earlier version of this paper (Kamenica 2006) derives the results in a setting with endogenous prices.¹²

The firm's strategy may depend on its information about s , so the uninformed consumers rationally update their beliefs about s based on the firm's behavior, forming a posterior $\pi(s|M)$.¹³ The consumers know the distribution, but not the realization of the fixed costs. Also, I assume the uninformed cannot observe the behavior of other consumers.¹⁴

The solution concept is *Perfect Bayesian Equilibrium* with the *D1* criterion (Jeffrey Banks and Joel Sobel 1987; In-Koo Cho and David Kreps 1987). The *D1* criterion is an equilibrium refinement widely used in signalling games. It requires that if the set of uninformed consumers' mixed responses that make the firm willing to deviate to some disequilibrium action a when $s = s'$ is strictly smaller than the set of such responses when $s = s''$, then the uninformed consumers 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. In fact, without *D1*, when most consumers are uninformed, *any* product line M can be supported as an equilibrium outcome by off-equilibrium beliefs that interpret a deviation to any $M' \neq M$ as evidence that goods in M' are undesirable.

I can now introduce some of the ideas from the introduction in formal terms. To simplify notation, let $\hat{u}(\theta, x|M)$ denote the average¹⁵ expected utility from purchasing x for the uninformed consumers of type θ given the information that the firm introduced M , i.e., $\hat{u}(\theta, x|M) = \int_S u(\theta, s, x) d\pi(s|M) - p_x$. This notation does *not* imply that utility depends on the choice set: the product line enters expected utility only through its influence on beliefs.

A consumer engages in *contextual inference* if $\pi(s|M) \neq \pi(s)$. Note that a straightforward, testable prediction of the model is that we would not observe any of the aforementioned anomalies if consumers were convinced that the choice set is randomized and therefore does not reflect any information that the firm possesses. When the firm selects the product line optimally, however, context effects will arise if consumers' posterior affects their relative valuations, i.e., if there are x and x' such that when they are available from some product line M , x is preferred, $\hat{u}(\theta, x|M) > \hat{u}(\theta, x'|M)$, but the presence of an additional option, y , provides information that makes x' more desirable, $\hat{u}(\theta, x|M \cup \{y\}) < \hat{u}(\theta, x'|M \cup \{y\})$.

The compromise effect is a specific example of a context effect. Let $>$ denote a partial ordering on \mathbb{R}^2 defined by $(a_1, a_2) > (a'_1, a'_2)$ if $a_1 > a'_1$ and $a_2 > a'_2$. For example, a_1 might be the quality of a good and a_2 its price; in that case, $>$ provides a natural ordering in the price-quality space. We say that uninformed consumers of type θ exhibit the compromise effect if there are x_0, x_1, x_2 in \mathbb{R}^2 such that $x_0 > x_1 > x_2$ and $x_1 = \arg \max_x \hat{u}(\theta, x|\{x_0, x_1, x_2\})$, but $\hat{u}(\theta, x_0|\{x_0, x_1\}) >$

¹² With endogenous prices an additional element is needed to ensure that the information in prices does not fully reveal s . Accordingly, the treatment in Kamenica (2006) requires retail cost shocks that reduce the informational content of prices.

¹³ Extensive laboratory evidence suggests people make systematic mistakes in their inferences. In particular, the cursed equilibrium model (Erik Eyster and Matthew Rabin 2005) or the analogy-based expectation equilibrium model (Philippe Jehiel 2005) could be relevant in this setting. Additionally, experimental evidence suggests that, apart from their mistakes in inference, many people exhibit limited "strategic sophistication": they do not take into account other players' incentives (Miguel Costa-Gomes, Vincent P. Crawford, and Bruno Broseta 2001). I utilize a standard equilibrium notion, however, to demonstrate that my results do not require any unconventional assumptions.

¹⁴ Previous research has explored learning from others (e.g., McFadden and Kenneth E. Train 1996; Patrick Bolton and Christopher Harris 1999; Dirk Bergemann and Juuso Välimäki 2000).

¹⁵ The average is over the ε_{ix} 's. Recall that $E[\varepsilon_{ix}] = 0$.

$\hat{u}(\theta, x_1 | \{x_0, x_1\})$ or $\hat{u}(\theta, x_2 | \{x_1, x_2\}) > \hat{u}(\theta, x_1 | \{x_1, x_2\})$. That is, a good is chosen if it is the middle option, but not as a part of a pair. Recall that Figure 1 depicts an example of the compromise effect.¹⁶

Finally, uninformed consumers of type θ engage in rational choice overload if there are two choice sets M and M' , with $M \subsetneq M'$ s.t. $\max_{x \in M} \hat{u}(\theta, x | M) > \max_{x \in M'} \hat{u}(\theta, x | M')$.¹⁷ In other words, the maximum obtainable utility from a smaller choice set is strictly greater than the maximum obtainable utility from the superset.

Subsequent sections provide concrete examples of how these phenomena may arise.

II. Hedonic Interpretation of Quality: The Compromise Effect and the Premium Loss Leader

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?¹⁸ Similarly, in order 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.¹⁹ Extracting information from the set of available options, however, may lead consumers to violate the naïve formulation of the Weak Axiom of Revealed Preference. The first subsection demonstrates how this inference can lead to the compromise effect in a market equilibrium.

Moreover, when consumers rely on context to decide what to purchase, firms may have an incentive to distort their product line in order to increase the demand for their most profitable varieties.²⁰ In particular, they may introduce an expensive good of overly high quality that is unprofitable on its own but greatly increases the demand for other products. The second subsection demonstrates the possibility of such premium loss leaders.

A. Goldilocks and the Three Goods: The Compromise Effect

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.

I begin by imposing some structure on the model from Section II. There are only three technologically feasible varieties, $\{x_0, x_1, x_2\} = X$, defined by their quality q_j , marginal cost c_j , stochastic

¹⁶ Note that I define the compromise effect in terms of \hat{u} , rather than as a violation of regularity in market shares (as in Figure 1). However, unless the variance of ε_{ix} is excessive, this definition does imply a violation of regularity.

¹⁷ $M \subsetneq M'$ denotes that M is a proper subset of M' , i.e., $M \subseteq M'$, but $M \neq M'$.

¹⁸ 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 understanding the utility equivalent of the additional five lumens.

¹⁹ Shapiro and Varian (1999) also refer to firm behavior that exploits the compromise effect as "Goldilocks pricing."

²⁰ Edward L. 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.

fixed cost K_j , and price p_j , with $q_j < q_k$, $c_j < c_k$, and $p_j < p_k$ whenever $j < k$.²¹ Hence, from the consumers' perspective, the goods have a natural ordering in the price-quality space. The discussion of the compromise effect is with respect to this ordering. 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 two types of consumers who differ in the intensity of their taste for quality. In particular, $\theta_i \in \{\theta^l, \theta^h\} = \Theta$ with $0 < \theta^l < \theta^h$, and consumer i obtains utility $\theta_i s q_j - p_j + \varepsilon_{ij}$ from purchasing a product of quality q_j for price p_j .²² Let λ^l denote the fraction of consumers of type θ^l . Note that the consumer's type captures the consumer's relative position in the distribution of tastes for quality.²³ Each consumer knows her own type and the overall distribution of tastes. The utility shocks, ε_{ij} 's, are independently drawn from an atomless distribution on $[0, \xi]$ where $\xi > |(\theta s q_k - p_k) - (\theta s q_l - p_l)|$ for any θ, s, k , and l . In other words, any product may be the best for a consumer of any type. These utility shocks are not needed for establishing the possibility of the compromise effect, but they ensure that more favorable beliefs about s increase demand in a continuous fashion, which will be useful in the next subsection. The fixed costs, which provide exogenous variation in the product line, are independent and identically distributed with an atomless distribution on $[0, \bar{K}]$. Finally, I assume $(p_2 - p_1)/(q_2 - q_1) > (p_1 - p_0)/(q_1 - q_0)$; otherwise, no consumer would ever prefer x_1 to both x_0 and x_2 .

The global preference parameter s captures the hedonic value of quality. For example, suppose 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 an 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 capture 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 $u = \theta s q - p$ with the emphasis on the units: $u \$ = \theta (\$/\text{brightness}) \times s (\text{brightness}/\text{lumens}) \times q \text{ lumens} - p \$$ in the case of flashlights, or $u \$ = \theta (\$/\text{speed}) \times s (\text{speed}/\text{Mhz}) \times q \text{ Mhz} - p \$$ 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.²⁴

This preference parameter determines which product is optimal for which type. In particular, assume $S = \{s, \bar{s}\}$. When s is low ($s = s$), x_1 is optimal for the high types while the low types prefer x_0 .²⁵ When s is high ($s = \bar{s}$), x_1 is optimal for the low types while x_2 is optimal for the high types.²⁶ Both s and \bar{s} occur with positive probability.

²¹ If prices and qualities were endogenous, the considerations of price discrimination (Michael Mussa and Sherwin Rosen 1978; Tirole 1988, ch. 3) would substantially complicate the model in a direction orthogonal to the topic of this paper.

²² The multiplicative functional form is of no consequence and is utilized merely for ease of exposition.

²³ 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.

²⁴ An alternative to this modelling approach would be to assume that the qualities are random and correlated. The current formulation would then be equivalent to the special case of perfect correlation.

²⁵ Of course, in the presence of utility shocks, some consumers will not prefer the variety that is optimal for their type.

²⁶ Formally,

$$\begin{aligned} \theta_h s q_0 - p_0 &> \theta_h s q_j - p_j \quad \forall j \neq 0, \\ \theta_h s q_1 - p_1 &> \theta_h s q_j - p_j \quad \forall j \neq 1, \end{aligned}$$

while

$$\begin{aligned} \theta_h \bar{s} q_1 - p_1 &> \theta_h \bar{s} q_j - p_j \quad \forall j \neq 1, \\ \theta_h \bar{s} q_2 - p_2 &> \theta_h \bar{s} q_j - p_j \quad \forall j \neq 2. \end{aligned}$$

Equivalently,

$$\begin{aligned} s &\in \left[\frac{p_1 - p_0}{\theta_h (q_1 - q_0)}, \min \left\{ \frac{p_1 - p_0}{\theta_l (q_1 - q_0)}, \frac{p_2 - p_1}{\theta_h (q_2 - q_1)} \right\} \right], \\ \bar{s} &\in \left[\max \left\{ \frac{p_1 - p_0}{\theta_l (q_1 - q_0)}, \frac{p_2 - p_1}{\theta_h (q_2 - q_1)} \right\}, \frac{p_2 - p_1}{\theta_l (q_2 - q_1)} \right]. \end{aligned}$$

The firm can produce x_1 and x_2 . The lowest quality good, x_0 , is the outside option for each consumer. We can think of it as a generic brand produced by an unmodelled competitive industry. This outside option is always available to the consumers.²⁷ I will abuse the notation slightly and include x_0 in the expressions for the posterior, even though it is not introduced by the firm and thus provides no information about s .

The firm knows s and solves

$$\max_M \sum_{j: x_j \in M} D(x_j; M, s)(p_j - c_j) - K_j,$$

where M is the set of varieties the firm offers and $D(x_j; M, s)$ is the expected demand for x_j given product line M and the preference parameter s .

Now, suppose the following hold:

- A1. With positive probability the firm introduces surplus-maximizing goods: $\{x_1, x_2\}$ in \bar{s} , and $\{x_1\}$ in \underline{s} ;
- A2. With positive probability the fixed cost for any particular variety is sufficiently high that the firm does not introduce that variety.

Later in this subsection I discuss the conditions that guarantee such behavior by the firm. For now, note that A2 is merely an assumption on the support of the distribution of fixed costs. Ensuring A1, however, is more complicated since it is possible, for reasons of price discrimination, that the firm will not introduce a good in \bar{s} even if its fixed cost is zero.

Finally, I assume that the prior probability of \underline{s} is sufficiently high that if the firm introduces only x_1 , the expected utility of this product for the low-type consumers is below that of the outside option, i.e., $\hat{u}(\theta^l, x_0 | \{x_0, x_1\}) > \hat{u}(\theta^l, x_1 | \{x_0, x_1\})$. This supposition precludes the situation where the low types select the middle option (x_1) from $\{x_0, x_1\}$ on a priori grounds.²⁸ Under these assumptions, we obtain the following proposition:

PROPOSITION 1: *In any equilibrium, the uninformed consumers of type θ^l exhibit the compromise effect with positive probability.*

All proofs are relegated to the Appendix. The basic intuition behind the result, however, is straightforward. When x_0 and x_1 are the only varieties offered, the uninformed θ^l do not know which one is better for them. If $s = \underline{s}$, x_0 is optimal, but if $s = \bar{s}$, x_0 is inferior to x_1 . However, the product line does not reveal whether $s = \underline{s}$ or $s = \bar{s}$: x_2 could be absent because $s = \underline{s}$ or because K_2 is large. The uninformed θ^l thus select a variety that is not always ex post optimal. In particular, $\hat{u}(\theta^l, x_0 | \{x_0, x_1\}) > \hat{u}(\theta^l, x_1 | \{x_0, x_1\})$ whether $s = \underline{s}$ or $s = \bar{s}$. Whenever the uninformed θ^l consumers are offered three varieties, however, they know that $s = \bar{s}$ and that the middle option is optimal. Hence, they exhibit the compromise effect.²⁹ Importantly, as the next subsection will

The inequality $(p_2 - p_1)/(q_2 - q_1) \geq (p_1 - p_0)/(q_1 - q_0)$ guarantees these two intervals are nonempty.

²⁷ One can also easily construct a version of the model where the firm produces all the goods. The current version simplifies the demonstration of premium loss leaders.

²⁸ The expression, in terms of the primitives, for this restriction on $\pi(\underline{s})$ is cumbersome, though conceptually simple.

²⁹ In contrast, the θ^h types, by always choosing the highest quality available, never select a variety that is suboptimal, given their taste, to another available variety. The information in the product line always reveals which of the available

demonstrate, the result in Proposition 1 does not rely on nonstrategic behavior by the firm: even when there are many uninformed consumers, so the firm distorts the product line in order to manipulate their beliefs, the uninformed low types still exhibit the compromise effect.

Now, consider the assumptions that are needed to ensure condition A1: that the firm will introduce both x_1 and x_2 in \bar{s} when fixed costs are sufficiently low.³⁰ This behavior is not immediately guaranteed, as there exist prices under which the firm's profit is greater if it excludes a socially optimal good even when its fixed cost is zero. One way to ensure that this does not happen is to presume (i) that the prices maximize firm's profits given that both goods are introduced and (ii) that markups are increasing in quality, i.e., $(p_1, p_2) \in \arg \max_{\hat{p}_1, \hat{p}_2} \sum_{j=1}^2 D(x_j; \{x_0, x_1, x_2\}, \bar{s})(\hat{p}_j - c_j)$ and $(p_2 - c_2) > (p_1 - c_1)$.

The analysis behind Proposition 1 reveals several intuitions. First, it establishes that information contained in the product line may lead to the compromise effect in a market equilibrium, as in Wernerfelt (1995). A similar line of reasoning can be used to explain the attraction effect (Joel Huber, John W. Payne, and Christopher Puto 1982).³¹ Additionally, the analysis yields a normative ranking of inconsistent choices in the case of the compromise effect: those choices made within a larger context are the better ones *ex post*.³² This implication is exactly opposite of the claim made by Christopher K. Hsee (2000). He argues that consumption always takes place in a separate evaluation mode and that, consequently, choices made with limited comparison are superior *ex post*.

These predictions are testable. For example, 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.

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, for example, the research on joint-separate evaluation preference reversals (e.g., Max H. Bazerman, Loewenstein, and Sally Blount White 1992). A joint-separate evaluation preference reversal obtains when an option (A) is generally preferred to its alternative (B) if each is presented separately 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 0.01 percent and capacity of 20 CDs, while the other (B) had THD of 0.003 percent 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, "For most CD changers on the market, THD ratings range from 0.002 percent (best) to 0.012 percent (worst)." The subjects were assigned to six conditions, with three evaluation modes (joint evaluation, separate evaluation of A, or separate evaluation of B) by two 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

goods is best for them, so they never exhibit the compromise effect.

³⁰ As noted earlier, one can easily ensure condition A2 by supposing that $\bar{K} > (p_j - c_j)$ for all j . Also, it is trivial that the firm will introduce x_1 in \underline{s} when K_1 is sufficiently close to zero.

³¹ The attraction effect refers to the finding that, given two multiattribute alternatives (say A and B), the addition of a third option (C), which is dominated on all attributes by one existing alternative (B) but not the other (A), increases the appeal of the now dominating alternative (B).

³² This holds in the particular model I have used to generate the compromise effect. More generally, it is possible to construct an example with more goods and more types where quality of information does not increase with the breadth of the product line.

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.³³ If we think of q as the THD value, uncertainty about s neatly captures the intuition behind this experiment.³⁴ Uncertainty about s can also be used to interpret results on scope neglect (e.g., William H. Desvousges et al. 1992), and the experiments on “travelling indifference curves” (Aimee Drolet, Simonson, and Tversky 2000).

B. Firm's Manipulation of Consumers' Beliefs: The Premium Loss Leader

Since the uninformed consumers' demand for a particular good can increase with the presence of another good, the firm may manipulate its product line to increase the demand for its more profitable varieties. Gerald E. Smith and Thomas T. 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.” Here, I examine the possibility that the firm, in equilibrium, introduces such a premium loss leader: a good of exceptionally high quality, unprofitable on its own, whose purpose is simply to boost the sales of more moderate varieties. To examine this possibility, let there be a positive measure of uninformed consumers, i.e., $\alpha \in (0, 1)$.³⁵ With this exception, I maintain the model and the assumptions of the previous subsection.

The idea behind the possibility of a premium loss leader is as follows. The demand by the informed consumers for x_2 is greater when s is greater, so the introduction of x_2 *credibly* signals a higher s . Consequently, the demand by the uninformed consumers for x_1 is greater if x_2 is introduced, which leads the firm to introduce this high-quality good even if it is not profitable per se. In fact, the firm will introduce x_2 even when it is socially inefficient to do so (when $s = \underline{s}$).

Note that, by assumption of equilibrium play, the uninformed are fully aware of the fact that the firm is distorting the product line in an attempt to manipulate their beliefs. Therefore, they are less likely to purchase a good relative to the benchmark case with no distortion, discussed in Section IIA. Still, there is no equilibrium in which the firm never introduces a premium loss leader.

To demonstrate this formally, let $\Pi(x_j; M, s)$ denote the firm's per se profit from selling x_j , i.e., $\Pi(x_j; M, s) = D(x_j; M, s)(p_j - c_j) - K_j$. Recall that $D(x_j; M, s)$ is the expected demand for good x_j given product line M and preference parameter s . Then, the following proposition states that the temptation to manipulate the beliefs of the uninformed leads the firm to introduce x_2 even when its per se profit is negative.

PROPOSITION 2: *In any equilibrium, there exists a threshold fraction of consumers of low type, $\hat{\lambda}^l < 1$, s.t. if $\lambda^l > \hat{\lambda}^l$, with positive probability the firm introduces the highest quality good even when its per se profit is negative.*

³³ Specifically, in low-information separate evaluation conditions, mean willingness to pay (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, mean WTP values were \$186 and \$222 ($p < 0.01$) in joint evaluation mode and \$177 and \$222 ($p < 0.01$) in separate evaluation mode.

³⁴ In the model the goods have a single-dimensional quality and a price, while the experiment utilizes goods with a two-dimensional quality. The more easily interpretable quality dimension, i.e., the CD capacity, plays the role of the price.

³⁵ It is important to have at least some informed consumers ($\alpha < 1$). Without their presence, the *D1* criterion does not eliminate equilibria based on “threat beliefs.”

It is necessary to assume that a sufficiently high fraction of consumers are of the low type because high types who switch from buying x_1 to buying x_2 when x_2 is introduced decrease the marginal profit from x_2 relative to the per se profit from x_2 . Consequently, in the absence of consumer inference, the per se profit from x_2 needs to be *strictly positive* in order for the introduction of x_2 to be profitable. Assuming that λ' is high reduces the extent of this cannibalization.

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 \bar{s} . Such a commitment, however, would not be credible: if $s = \underline{s}$ and K_2 is low relative to α , the firm would increase its profit by introducing x_2 and thus suggesting that $s = \bar{s}$. That said, if the firm were somehow able to implement the policy of revealing s to the uninformed consumers, it would choose to do so.

Note that even though the firm's distortion of the product line reduces its informational content (since the firm may introduce x_2 even in \underline{s}), it does not eliminate it entirely: the firm is still more likely to introduce x_2 in \bar{s} than in \underline{s} . This credibility of x_2 as a signal of \bar{s} is precisely why Proposition 2 holds, even though the uninformed consumers are perfectly aware of the firm's attempt to manipulate their beliefs. Hence, the residual informational content of the product line still leads some uninformed consumers to switch from x_0 to x_1 when x_2 is introduced, so the intuition about the compromise effect from the previous subsection holds even when a positive measure of consumers are uninformed.

Anecdotal evidence supports the existence of premium loss leaders. Consider the story, 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, and 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,³⁶ but the anecdote lends support to the prediction in Proposition 2.³⁷ Xerox has also been reported to increase the sales of its high-volume copier by introducing an additional, higher quality, version.³⁸ Rigorously demonstrating these phenomena is a worthwhile challenge for future empirical research.³⁹

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 Simon P. Anderson, Andre de Palma, and Jacques-Francois 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).

³⁶ At the time of this paper's writing, Williams-Sonoma offers a single bread-baking appliance for \$150.

³⁷ The 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. When only the \$275 variety was available, the uninformed customers presumed that $s = \underline{s}$, and only the high types bought from the firm. The introduction of the \$429 bread maker, however, led the uninformed to believe that $s = \bar{s}$ and thus pulled the low types into the market for the \$275 variety.

³⁸ "The Compromise Effect," *Washington Post*, January 27, 2002.

³⁹ There is another way in which inference might lead to a premium loss leader: the ability of a firm to produce a good of an extremely high quality might reveal a technological prowess that signals reliability of other products produced by that firm.

III. Choice Overload: Preference for Smaller Choice Sets

One of the simplest choice theoretic principles is that, in nonstrategic situations, you cannot be worse off having more options.⁴⁰ A burgeoning empirical literature in marketing and economics, however, documents violations of this principle.⁴¹ 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 percent of the potential customers in the limited-selection condition purchased a jam, while only 1.65 percent of those in the extensive-selection condition did so ($p < 0.001$). Peter Boatwright and Joseph C. Nunes (2001) report an experiment run by an online grocery store. The store reduced its product selection by roughly a half⁴² for a fraction of its customers (the experimental group)⁴³ 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 percent higher ($p < 0.0001$). Demonstrations of choice overload are not limited to the retail industry. A field experiment by Marianne Bertrand et al. (2005) reveals that offering a single loan instead of numerous ones increases take-up substantially. Iyengar, Gur Huberman, and Wei Jiang (2004) show that, on average, 75 percent of employees participate in a company 401(k) plan when there are only two funds available, but participation rate falls to roughly 60 percent when employees must choose among 59 funds. Other demonstrations of preference for smaller choice sets include Tversky and Eldar Shafir (1992) and Donald A. Redelmeier and Shafir (1995).⁴⁴

Iyengar and Lepper (2000) interpret their result as evidence for the hypothesis that smaller choice sets “may be more intrinsically motivating.” 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. 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 they face a smaller product line.

A. Contextual Inference Interpretation of Choice Overload

Suppose that there are N possible flavors of jam, $X = \{1, 2, \dots, N\}$, all with the same markup, $p - c > 0$, and the same price, p . Each consumer has a favorite flavor and obtains utility $\bar{u} > p$ from consuming it. The utility from consuming any flavor other than the favorite is zero. Let λ_x denote the fraction of the consumers whose favorite flavor is x . If $\lambda_x > \lambda_{x'}$ we say that x is *more popular* than x' .

Consumer i has unit demand and an outside option that yields utility $u_i(x_0) \stackrel{iid}{\sim} F$, where F is an atomless distribution whose support includes $[-p, \bar{u} - p]$. The continuous distribution of the outside option, along with this assumption on its support, ensures that if the uninformed consumers

⁴⁰ A notable exception arises if agents have self-control problems (e.g., Laibson 1997; Faruk Gul and Wolfgang Pesendorfer 2001). I abstract from these issues.

⁴¹ 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.

⁴² Depending on the product category, the assortment decreased by between 22 percent and 82 percent. The average decrease was close to 50 percent.

⁴³ 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.

⁴⁴ Barry 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.

obtain strictly greater expected utility from purchasing a jam, their aggregate demand will be strictly greater.

An informed consumer knows which flavor is her favorite. The firm knows the distribution of tastes. An uninformed consumer knows neither which flavor she likes nor the distribution of tastes.

Formally, let $\theta_i \in \Theta = \{1, 2, \dots, N\}$ denote the preferred flavor of consumer i and let $\lambda \in \Lambda$ be the distribution of tastes with no two flavors equally popular.⁴⁵ Then, we assume that (i) consumer i 's utility from consuming flavor x is $\bar{u}I_{\{\theta_i=x\}}$, (ii) each informed consumer i knows θ_i , (iii) the firm knows λ , and (iv) the uninformed have a uniform prior over $\Theta \times \Lambda$.⁴⁶

The following Lemma is the central building block of the analysis in this section.

LEMMA 3: *In any equilibrium, the firm always introduces the most popular flavors. Formally, if M_λ is an equilibrium product line when the distribution of tastes is λ , then $x \in M_\lambda$ and $\lambda_x > \lambda_{x'} \Rightarrow x' \in M_\lambda$.*

This Lemma relies on the homogeneity of markups. If less popular flavors had greater markups and uninformed were many, the firm might strategically introduce a generally undesirable flavor with a high markup. The analysis of such a situation is closely related to the analysis of premium loss leaders in the previous section: the product line would provide less, but still some, information about the popularity of its constituent varieties.

The most important implication of Lemma 3 is that the average popularity of the available flavors is decreasing in the breadth of the product line. Consequently, the uninformed consumers, who can do no better than to choose randomly from the available flavors, prefer smaller choice sets. Let $D^{unf}(M)$ be the demand by the uninformed consumers when the firm offers product line M .

PROPOSITION 4: *Suppose that in some equilibrium the firm introduces product line M_λ when the distribution of tastes is λ , while it never introduces product line M' . Moreover, suppose $|M_\lambda| < |M'|$. Then, if the firm were to deviate from its equilibrium strategy and introduce the larger product line M' , the demand by the uninformed consumers would be strictly lower: $D^{unf}(M_\lambda) > D^{unf}(M')$.*

Note that Proposition 4 relates the uninformed demand to product line breadth *within* an equilibrium. However, Lemma 3 also allows us to compare the demand by the uninformed across any two equilibria. For a given α , there is a unique equilibrium product line given a distribution of tastes, but we can compare equilibria across markets with different fractions of uninformed consumers:

PROPOSITION 5: *Suppose that M_λ and M'_λ are two equilibrium product lines given λ . The demand by the uninformed is strictly greater with the smaller product line. Formally, if $|M_\lambda| < |M'_\lambda|$, then $D^{unf}(M_\lambda) > D^{unf}(M'_\lambda)$.*

⁴⁵ Generically, no two flavors will be equally popular. Moreover, even if $\lambda_x = \lambda_{x'}$ for some $x \neq x'$, all the results go through, albeit with weak inequalities.

⁴⁶ This simple model is formally subsumed by the framework introduced in Section I. Let $S = R \times \Lambda$, $\Theta = \{1, 2, \dots, N\}$, and $u(\theta_i, x, s) = \bar{u}I_{\{\theta_i = r(x)\}}$, where $r \in R$ is a permutation of $\{1, 2, \dots, N\}$ and $\lambda \in \Lambda$ is a distribution of tastes. Then, if uninformed consumers do not know $s = r(\cdot) \times \lambda$ and the firm knows λ , we get the model above.

Propositions 4 and 5 have distinct empirical content. Proposition 4 makes a prediction about how the demand by the uninformed consumers would respond if an experimenter manipulated the product line in a fixed equilibrated market, while Proposition 5 makes a prediction about how the demand by the uninformed consumers varies across undisturbed equilibrated markets.

Note that the firm could 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, as long as more profitable firms are more likely to survive in the market. 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 markups may lead the firm to falsely label a high-margin product as popular.⁴⁷ Finally, we often do see retailers, especially reputable ones, provide information about the popularity of the products they sell. For example, Amazon.com provides the sale rank of every product it carries.

The mechanism behind the results above depends on the assumption that consumers’ tastes are not uniformly distributed. In a different model, however, consumers might benefit from a smaller product line even with a uniform distribution of tastes.⁴⁸ In particular, if consumers search across multiple goods, a smaller product line might increase the *variance* of the utility from available goods and thus make consumers’ searches more productive. Note that under both popularity and variance mechanisms, consumers infer aspects of the set of goods offered (their popularity or the variance of their fit) from the firm’s decision to introduce them.⁴⁹

A common alternative hypothesis that attempts to explain choice overload argues that cognitive costs reduce the desirability of excessive choice sets (e.g., John T. Gourville and Dilip Soman 2005).⁵⁰ Most treatments of this hypothesis, however, seem not to recognize that a 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).⁵¹ 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. The model in this section provides one concrete microfounded difference, namely popularity.

The contextual inference mechanism provides some insight into when we should expect to observe choice overload. First, it suggests that the reason the smaller product line is offered will have a strong influence on consumers’ behavior. For example, suppose that one store offers a large product line while another offers a smaller product line because its other goods are sold out. Then, the inference mechanism implies the demand will necessarily be lower in the latter store since its goods are less popular on average. Also, if the uninformed consumers’ uncertainty is not about their preferred flavor, but rather about the general desirability of the good (\bar{u}), then the presence of a large choice set will be a positive signal about general valuation and will *increase*

⁴⁷ As noted earlier, such a situation is closely related to the analysis of premium loss leaders.

⁴⁸ I am grateful to an anonymous referee for this observation.

⁴⁹ The popularity mechanism, utilized in this paper, also drives the results in James A. Mirrlees (1987), who solves for the set of options a benevolent government should introduce if consumers’ choices are subject to errors, and in Norwood (2006), who exogenously imposes that the most popular varieties are the ones introduced, each by a different firm, and then examines whether the increased price competition provides sufficient compensation. Kuksov and Villas-Boas (2007) demonstrate choice overload in a model that implicitly utilizes both the popularity and the variance mechanisms.

⁵⁰ Another proposed explanation of choice overload argues that presence of more goods can increase *decision conflict* and thus reduce consumers’ willingness to select any of the goods offered (Tversky and Shafir 1992).

⁵¹ See Ben Irons and Cameron Hepburn (2007) and Todd Sarver (2008) for treatments of choice overload under regret.

the demand by the uninformed. Furthermore, we might expect to see heterogeneity across consumers in their susceptibility to choice overload. In particular, uninformed consumers who know they have *atypical* tastes⁵² will be especially unlikely (even relative to the informed consumers) to purchase a good from a small product line, because they will know it does not include the niche product that they might like.⁵³ Finally, as I mentioned above, the inference model predicts that providing credible information about the market shares of the available products will eliminate choice overload.

B. Firm's Response and Policy Implications

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 firm faces a trade-off between serving the informed and the uninformed. Consequently, the equilibrium product line is decreasing in the measure of the uninformed consumers.

A direct consequence of this comparative static is that the uninformed consumers' welfare, which is decreasing in $|M|$, is increasing in α . In other words, the uninformed are *worse off* when there are more informed consumers in the market. The informed, in turn, 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 (Joel Waldfogel 2003; Lisa 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*. Henrik Cronqvist and Thaler (2004) discuss the Swedish experience with Social Security privatization, emphasizing the seemingly negative effects of numerous fund options. Iyengar and Kamenica (2006) demonstrate that the presence of many funds adversely affects allocation as well as participation decision in 401(k) plans. 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.⁵⁴ 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.

IV. 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 consum-

⁵² For instance, I can usually be fairly certain that I will not enjoy a blockbuster movie.

⁵³ In the model, the assumption that the prior is uniform over Θ implies that each uninformed consumer expects herself to be typical.

⁵⁴ "Choice Overload Burdens Daily Life," *USA Today*, January 5, 2004.

ers make better choices. But, the information revelation is far from perfect, and contextual inference sometimes leads consumers to engage in seemingly anomalous behaviors.

In response to consumer inference, firms may attempt to manipulate the informational content of their product lines and induce supply distortions. I demonstrate that a monopolist may introduce a premium loss leader and that the presence of uninformed consumers can reduce the number of varieties offered. Future theoretical research might consider a dynamic model that allows for the product line to in turn influence what proportion of the consumer population is uninformed. Since consumers' information may depend on their consumption in the previous period, the product line in one time period might have an impact on the proportion of the uninformed consumers in the next.

Contextual inference theory also suggests a number of directions for empirical research. Do firms introduce 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 consumers with more typical preferences more prone to choice overload? These are but some of the empirical questions whose answers may help us better understand the role and the scope of contextual inference in markets.

APPENDIX

A. Proof of Proposition 1

PROOF:

Fix some equilibrium. Since $K_2 = 0$ is a measure zero event, the firm will almost surely exclude x_2 in \underline{s} . When $s = \bar{s}$, however, assumptions A1 and A2 guarantee that consumers face $\{x_0, x_1\}$ with positive probability and that they face $\{x_0, x_1, x_2\}$ with positive probability. Hence, $\pi(\bar{s} | \{x_0, x_1, x_2\}) = 1$.

This implies

$$\hat{u}(\theta^l, x_1 | \{x_0, x_1, x_2\}) > \max \{ \hat{u}(\theta^l, x_0 | \{x_0, x_1, x_2\}), \hat{u}(\theta^l, x_2 | \{x_0, x_1, x_2\}) \}.$$

Recall that by assumption $\hat{u}(\theta^l, x_0 | \{x_0, x_1\}) > \hat{u}(\theta^l, x_1 | \{x_0, x_1\})$. Hence, uninformed consumers of type θ^l exhibit the compromise effect when $s = \bar{s}$, which happens with positive probability.

B. Proof of Proposition 2

PROOF:

Fix some equilibrium. To prove the proposition, we first establish that the uninformed consumers' expectation of s is strictly greater if x_2 is present than if it is not (Step 1). Then, the continuity in the distribution of the utility shocks guarantees that, as long as λ^l is sufficiently high, the overall demand for x_1 will be strictly greater if x_2 is introduced (Step 2). This additional benefit of introducing x_2 means that it will sometimes be profitable to introduce x_2 even if its per se profit is somewhat negative (Step 3).

Step 1: We begin by demonstrating that the uninformed consumers' expectation of s is strictly greater if x_2 is present than if it is not. Formally, we want to show that $\pi(\bar{s} | \{x_0, x_1, x_2\}) > \pi(\bar{s} | \{x_0, x_1\})$ (it is also the case that $\pi(\bar{s} | \{x_0, x_2\}) > \pi(\bar{s} | \{x_0\})$, but this inequality does not play a role in the proof). First, we demonstrate the weak inequality: that it cannot be the case that the presence of x_2 leads the uninformed to lower their expectation of s . Suppose the contrary: $\pi(\bar{s} | \{x_0, x_1, x_2\}) < \pi(\bar{s} | \{x_0, x_1\})$. Let $\mathcal{M}(s, K_1, K_2)$ denote the firm's product line strategy as a function of s and the realizations of fixed costs. Then, either (i) the firm never introduces x_2 or (ii) there are \hat{K}_1 and

\hat{K}_2 such that $\mathcal{M}(\underline{s}, \hat{K}_1, \hat{K}_2) = \{x_1, x_2\}$ but $\mathcal{M}(\bar{s}, \hat{K}_1, \hat{K}_2) = \{x_1\}$. However, if (i) is the case, the off-equilibrium beliefs that imply $\pi(\bar{s} | \{x_0, x_1, x_2\}) < \pi(\bar{s} | \{x_0, x_1\})$ do not satisfy the *D1* criterion. To see this, note that holding the reaction from the uninformed consumers constant, firm's marginal profit from introducing x_2 is lower in \underline{s} than in \bar{s} . Therefore, the set of uninformed reactions that make the introduction of x_2 more profitable than the equilibrium strategy of never introducing it is greater in \bar{s} than in \underline{s} . Hence, *D1* does not permit off-equilibrium beliefs that suppose $\pi(\bar{s} | \{x_0, x_1, x_2\}) < \pi(\bar{s} | \{x_0, x_1\})$. Now, we need to rule out case (ii): that there is some level of fixed costs (\hat{K}_1, \hat{K}_2) at which x_2 is introduced in \underline{s} but not in \bar{s} . Consider the deviation to remove x_2 from $\mathcal{M}(\underline{s}, \hat{K}_1, \hat{K}_2)$. For that deviation not to be profitable, it must be the case that

$$\sum_{j=1}^2 \left[D^{\text{inf}}(x_j; \{x_1, x_2\}, \underline{s}) + D^{\text{unf}}(x_j; \{x_1, x_2\}) \right] (p_j - c_j) - \hat{K}_2 > D^{\text{inf}}(x_1; \{x_1\}, \underline{s}) (p_1 - c_1) + D^{\text{unf}}(x_1; \{x_1\}) (p_1 - c_1),$$

where $D^{\text{inf}}(x_j; M, s)$ is the expected demand by the informed for x_j given M and s , and $D^{\text{unf}}(x_j; M)$ is the expected demand by the uninformed for x_j given M . Rearranging this inequality yields

$$(1) \quad \left[\frac{\sum_{j=1}^2 D^{\text{inf}}(x_j; \{x_1, x_2\}, \underline{s}) (p_j - c_j) -}{D^{\text{inf}}(x_1; \{x_1\}, \underline{s}) (p_1 - c_1)} \right] - \hat{K}_2 > \left[\frac{D^{\text{unf}}(x_1; \{x_1\}) (p_1 - c_1) -}{\sum_{j=1}^2 D^{\text{unf}}(x_j; \{x_1, x_2\}) (p_j - c_j)} \right].$$

But, the profit from the informed from selling $\{x_1, x_2\}$ relative to selling $\{x_1\}$ is greater in \bar{s} than in \underline{s} :

$$(2) \quad \left[\frac{\sum_{j=1}^2 D^{\text{inf}}(x_j; \{x_1, x_2\}, \bar{s}) (p_j - c_j) -}{D^{\text{inf}}(x_1; \{x_1\}, \bar{s}) (p_1 - c_1)} \right] > \left[\frac{\sum_{j=1}^2 D^{\text{inf}}(x_j; \{x_1, x_2\}, \underline{s}) (p_j - c_j) -}{D^{\text{inf}}(x_1; \{x_1\}, \underline{s}) (p_1 - c_1)} \right].$$

Therefore, as we can see by combining inequalities (1) and (2), it must be the case that were the firm to add x_2 to $\mathcal{M}(\bar{s}, \hat{K}_1, \hat{K}_2)$, the gain from the sales of x_2 would outweigh the decreased uninformed demand for x_1 , i.e.,

$$\left[\frac{\sum_{j=1}^2 D^{\text{inf}}(x_j; \{x_1, x_2\}, \bar{s}) (p_j - c_j) -}{D^{\text{inf}}(x_1; \{x_1\}, \bar{s}) (p_1 - c_1)} \right] - \hat{K}_2 > \left[\frac{D^{\text{unf}}(x_1; \{x_1\}) (p_1 - c_1) -}{\sum_{j=1}^2 D^{\text{unf}}(x_j; \{x_1, x_2\}) (p_j - c_j)} \right].$$

Hence, we must have $x_2 \in \mathcal{M}(\bar{s}, \hat{K}_1, \hat{K}_2)$ and we have reached a contradiction.

We have now established that $\pi(\bar{s} | \{x_0, x_1, x_2\}) \geq \pi(\bar{s} | \{x_0, x_1\})$.

Next, we show this inequality is strict. Suppose, to the contrary, $\pi(\bar{s} | \{x_0, x_1, x_2\}) = \pi(\bar{s} | \{x_0, x_1\})$. If this equality holds because x_2 is never introduced in equilibrium, the firm can profitably deviate by introducing x_2 in \bar{s} when K_2 is low, as its profits from the informed consumers would

increase and the equality implies that there would be no adverse reaction from the uninformed. If the equality holds because the firm is equally likely to introduce x_2 in \underline{s} and \bar{s} , then either (i) the firm could profitably deviate by increasing the probability of introduction in \bar{s} and decreasing it in \underline{s} , or (ii) the firm introduces x_2 with probability 1, in which case it sometimes introduces it even when its per se profit is strictly negative.

Step 2: We have now established that the uninformed consumers' expected value of s is strictly greater if x_2 is present than if it is not, i.e., $\pi(\bar{s} | \{x_0, x_1, x_2\}) > \pi(\bar{s} | \{x_0, x_1\})$. Because the utility shocks, ε_{ij} 's, are identically and independently drawn from an atomless distribution on $[0, \xi]$ with $\xi > |(\theta s q_k - p_k) - (\theta s q_l - p_l)| \forall \theta, s, k, l$, we know that more favorable beliefs about s translate into strictly higher demand for x_1 by the uninformed low types. Hence,

$$\lim_{\lambda^l \rightarrow 1} D^{unf}(x_1; \{x_1, x_2\}) - D^{unf}(x_1; \{x_1\}) > 0.$$

As for the informed, they never buy x_2 in \underline{s} , so $D^{inf}(x_1; \{x_1, x_2\}, \underline{s}) = D^{inf}(x_1; \{x_1\}, \underline{s})$. In \bar{s} , however, the high types switch from x_1 to x_2 when x_2 is introduced. Hence, for any $\lambda^l < 1$, $D^{inf}(x_1; \{x_1, x_2\}, \bar{s}) < D^{inf}(x_1; \{x_1\}, \bar{s})$. As this inequality stems from the behavior of high types, it disappears as λ^l goes to 1. Hence, for all s ,

$$\lim_{\lambda^l \rightarrow 1} D^{inf}(x_1; \{x_1, x_2\}, s) - D^{inf}(x_1; \{x_1\}, s) = 0.$$

Therefore, since $\alpha > 0$, and D^{unf} and D^{inf} are continuous in λ^l , we know that $\exists \hat{\lambda}^l < 1$ s.t. if $\lambda^l \in (\hat{\lambda}^l, 1)$, $\forall s$:

$$\begin{aligned} D(x_1; \{x_1, x_2\}, s) &= \\ D^{unf}(x_1; \{x_1, x_2\}) + D^{inf}(x_1; \{x_1, x_2\}, s) &> \\ D^{unf}(x_1; \{x_1\}) + D^{inf}(x_1; \{x_1\}, s) &= \\ D(x_1; \{x_1\}, s). \end{aligned}$$

Step 3: First, note that since markups are positive,

$$D(x_2; \{x_1, x_2\}, s)(p_2 - c_2) > 0 > [D(x_1; \{x_1\}, s) - D(x_1; \{x_1, x_2\}, s)](p_1 - c_1).$$

Then, since K_2 has an atomless distribution on $[0, \bar{K}]$ with $\bar{K} > (p_2 - c_2)$, there is a positive probability that K_2 is realized such that

$$0 > D(x_2; \{x_1, x_2\}, s)(p_2 - c_2) - K_2 > [D(x_1; \{x_1\}, s) - D(x_1; \{x_1, x_2\}, s)](p_1 - c_1).$$

When that is the case, the per se profit from x_2 is negative but the firm still introduces it.

C. An Auxiliary Lemma

The following auxiliary lemma will be helpful for the proof of Lemma 3.

LEMMA 6: Suppose M^0 is a product line that is never introduced in equilibrium. Suppose M' s.t. $|M'| = |M^0|$ is a product line introduced in equilibrium when M^0 contains the most popular flavors. Then, off-equilibrium beliefs specify that if M^0 is introduced, it must be the case that $\sum_{x \in M^0} \lambda_x > \sum_{x \in M'} \lambda_x$.

PROOF:

Fix some equilibrium. Let $\Pi^{eq}(\lambda)$ denote the firm's profit on the equilibrium path when the distribution of tastes is λ . Let $\Pi^{inf}(M, \lambda)$ denote the firm's profit from the informed if it introduces M when the distribution of tastes is λ . Let $\Pi^{unf}(M)$ denote the firm's profit from the uninformed if it introduces M (the profit from the uninformed does not depend on the distribution of tastes).

Let $T \equiv \{\lambda \in \Lambda : \sum_{x \in M^0} \lambda_x > \sum_{x \in M'} \lambda_x\}$. We know M' is introduced in equilibrium for some $\tau \in T$. Fix any $\nu \notin T$.

Let Π^δ denote the firm's profit from the uninformed consumers when the firm introduces M^0 and the uninformed consumers play the mixed action δ . Define $A^0(\nu) \equiv \{\delta : \Pi^\delta \geq \Pi^{eq}(\nu) - \Pi^{inf}(M^0, \nu)\}$ and $A(\tau) \equiv \{\delta : \Pi^\delta > \Pi^{eq}(\tau) - \Pi^{inf}(M^0, \tau)\}$. In other words, $A^0(\nu)$ is the set of mixed responses by the uninformed consumers that make the deviation to M^0 at least as profitable as the equilibrium strategy when the distribution of tastes is ν , while $A(\tau)$ is the set of mixed responses by the uninformed consumers that make the deviation to M^0 strictly more profitable than the equilibrium strategy if the distribution of tastes is τ . If $A^0(\nu) \subsetneq A(\tau)$, the D1 criterion prohibits off-equilibrium beliefs that put any weight on ν . Hence, if $A^0(\nu) \subsetneq A(\tau)$, under off-equilibrium beliefs M^0 necessarily contains more popular flavors than M' .

Note that $\tau \in T$ implies $\Pi^{inf}(M', \tau) < \Pi^{inf}(M^0, \tau)$ and $\nu \notin T$ implies $\Pi^{inf}(M', \nu) \geq \Pi^{inf}(M^0, \nu)$. Hence,

$$\Pi^{inf}(M', \nu) - \Pi^{inf}(M^0, \nu) > \Pi^{inf}(M', \tau) - \Pi^{inf}(M^0, \tau).$$

Let M^ν denote a product line introduced in equilibrium when the distribution of tastes is ν . Then,

$$\begin{aligned} \Pi^{EQ}(\nu) - \Pi^{inf}(M^0, \nu) &= \Pi^{inf}(M^\nu, \nu) + \Pi^{unf}(M^\nu) - \Pi^{inf}(M^0, \nu) \\ &\geq \Pi^{inf}(M', \nu) + \Pi^{unf}(M') - \Pi^{inf}(M^0, \nu) \\ &= \Pi^{inf}(M', \nu) - \Pi^{inf}(M^0, \nu) + \Pi^{unf}(M') \\ &> \Pi^{inf}(M', \tau) - \Pi^{inf}(M^0, \tau) + \Pi^{unf}(M') \\ &= \Pi^{inf}(M', \tau) + \Pi^{unf}(M') - \Pi^{inf}(M^0, \tau) \\ &= \Pi^{EQ}(\tau) - \Pi^{inf}(M^0, \tau). \end{aligned}$$

That completes the proof as

$$\Pi^{EQ}(\nu) - \Pi^{inf}(M^0, \nu) > \Pi^{EQ}(\tau) - \Pi^{inf}(M^0, \tau)$$

implies $A^0(\nu) \subsetneq A(\tau)$.

D. Proof of Lemma 3

PROOF:

Fix some equilibrium. Then suppose, contrary to the Lemma's claim, that given some distribution of tastes $\hat{\lambda}$, the firm, with a positive probability, offers a product line M' s.t. $x' \in M'$ and $x'' \notin M'$ even though $\hat{\lambda}_{x'} < \hat{\lambda}_{x''}$. Let $n = |M'|$. Consider a deviation where the firm instead always introduces

$$M^0 = \underset{M \text{ s.t. } |M|=n}{\operatorname{arg\,max}} \sum_{x \in M} \hat{\lambda}_x$$

when the distribution of tastes is $\hat{\lambda}$. The profit from the informed consumers would clearly be strictly greater under this deviation. Therefore, it must be the case that $\Pi^{unf}(M') > \Pi^{unf}(M^0)$. We want to show this cannot be the case.

There are two possible cases: (i) M^0 is an out-of-equilibrium action, and (ii) M^0 is sometimes introduced in equilibrium.

Case (i): By Lemma 6, we know the off-equilibrium beliefs specify $\sum_{x \in M^0} \lambda_x > \sum_{x \in M'} \lambda_x$. Since $|M^0| = |M'|$, this implies that $\Pi^{unf}(M^0) > \Pi^{unf}(M')$ and we've reached a contradiction.

Case (ii): Let (M_k) be the set of subsets of X that have n elements and are sometimes introduced in equilibrium. Without loss of generality, order the M_k so that $\Pi^{unf}(M_{k+1}) \geq \Pi^{unf}(M_k)$. Let $k^* \equiv \min \{k : \Pi^{unf}(M_{k+1}) > \Pi^{unf}(M_k)\}$. Since $\Pi^{unf}(M') > \Pi^{unf}(M^0)$, we know $\{k : \Pi^{unf}(M_{k+1}) > \Pi^{unf}(M_k)\}$ is not an empty set, so k^* exists. Note that $\Pi^{unf}(M_k) \geq \Pi^{unf}(M_{k^*})$ for all k and $\Pi^{unf}(M') > \Pi^{unf}(M_{k^*})$.

Now, since M_{k^*} is an equilibrium action, the uninformed beliefs that induce $\Pi^{unf}(M') > \Pi^{unf}(M_{k^*})$ must correctly reflect the fact that the firm introduces M_{k^*} even when its elements are not the n most popular flavors. Therefore, there exists $\lambda^* \in \Lambda$ and $M^* \neq M_{k^*}$ with $|M^*| = n$ s.t. M_{k^*} is introduced with positive probability when the distribution of tastes is λ^* even though the elements of M^* are the n most popular flavors under λ^* . Now, consider a deviation to always introduce M^* when the distribution of tastes is λ^* . Clearly, the profit from the informed consumers would be greater under this deviation. Therefore, it must be that $\Pi^{unf}(M^*) < \Pi^{unf}(M_{k^*})$. If M^* is an out-of-equilibrium action, this contradicts Lemma 6. If M^* is sometimes introduced in equilibrium, $\Pi^{unf}(M^*) < \Pi^{unf}(M_{k^*})$ contradicts $\Pi^{unf}(M_k) \geq \Pi^{unf}(M_{k^*}) \forall k$.

E. Proof of Proposition 4

PROOF:

Suppose M_λ is introduced in equilibrium when the distribution of tastes is λ and M' is never introduced in equilibrium. Lemma 3 guarantees that M_λ contains the most popular flavors. Therefore, even under the most favorable off-equilibrium beliefs that assume M' contains the most popular flavors, $|M'| > |M_\lambda|$ implies that

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

Moreover, since she has a uniform prior, an uninformed consumer is indifferent between the available flavors, so her expected utility from consuming any flavor is proportional to the average popularity in the menu. Therefore, her expected utility from consuming a good from M_λ is strictly greater than her expected utility from consuming a good from M' . Since F , the distribution of the outside options, is an atomless distribution whose support includes $[-p, \bar{u} - p]$, the strictly greater expected utility from M_λ yields strictly greater demand: $D^{unf}(M_\lambda) > D^{unf}(M')$.

F. Proof of Proposition 5

PROOF:

Let M_λ and M'_λ be any two equilibrium product lines given λ with $|M_\lambda| < |M'_\lambda|$. Since M_λ and M'_λ are equilibrium product lines, Lemma 3 guarantees they each contain the most popular flavors and $M_\lambda \subset M'_\lambda$.

Hence, an uninformed consumer knows that the average popularity of flavors in M_λ is strictly greater than in M'_λ :

$$E_{\pi(\cdot|M_\lambda)} \frac{1}{|M_\lambda|} \sum_{x \in M_\lambda} \lambda_x > E_{\pi(\cdot|M'_\lambda)} \frac{1}{|M'_\lambda|} \sum_{x \in M'_\lambda} \lambda_x.$$

Moreover, since she has a uniform prior, an uninformed consumer is indifferent between the available flavors so her expected utility from consuming any flavor is proportional to the average popularity in the menu. Therefore, her expected utility from consuming a good from M_λ is strictly greater than her expected utility from consuming a good from M'_λ . Since F , the distribution of the outside options, is an atomless distribution whose support includes $[-p, \bar{u} - p]$, the strictly greater expected utility from M_λ yields strictly greater demand: $D^{unf}(M_\lambda) > D^{unf}(M'_\lambda)$.

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