Equilibrium with Consumer Adjustment to Choice

Matthew G. Nagler
CUNY Graduate Center
Equilibrium with Consumer Adjustment to Choice

Matthew G. Nagler

Working Paper 10

Ph.D. Program in Economics
CUNY Graduate Center
365 Fifth Avenue
New York, NY 10016
March 2016

I am grateful to Ben Ho, Fahad Khalil, Jacques Lawarrée, and seminar participants at the University of Toronto, University of Washington, Vassar College, and ISMS Marketing Science conference for helpful comments. Shay Culpepper provided excellent research assistance.

© 2016 by Matthew Nagler. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.
ABSTRACT

I present a spatial model of differentiated product markets in which consumers with heterogeneous tastes rationally improve their attitude towards the product they choose. Adjustment raises prices if adjustment facility is greater for consumers who initially prefer a product more (e.g., preferences and corresponding adjustments exhibit the halo effect). It lowers prices if instead easier adjustment for consumers with weaker initial preferences causes attitudinal regression to the mean. The theory explains higher prices in markets to the poor and less educated and so motivates re-examination of previously proposed solutions to the poor performance of those markets.
On rare occasions one does hear of a miraculous case of a married couple falling in love after marriage, but on close examination it will be found that it is a mere adjustment to the inevitable.

- *Emma Goldman*

1. INTRODUCTION

If you are going to do something, you are better off loving it. That is to say, individual choice is naturally complemented by the individual’s adjustment to the chosen object. Numerous intuitive examples suggest the commonplace nature of adjustment. Married couples grow fond of one another over time and more accepting of mutual differences. A man who has recently purchased a vacation time-share talks frequently about it to his friends, whereby he becomes more excited about it. A woman who, on reading an online retailer’s policies, is surprised to learn that in returning an outfit she will incur a substantial restocking fee, shrugs and decides she is satisfied with it. A consumer gets more out of his smartphone after a few months, having habituated to the apps available at his fingertips.

Recent behavioural and neural evidence indicates that something measurable is occurring in such situations. Across a range of experimental scenarios, individuals have been shown routinely to undergo a sort of mental re-positioning relative to choices they have made, changing not only their stated preferences, but also physiological
manifestations of their hedonic responses. The evidence supports a paradigm according to which choices not only reflect, but also create, preferences. (Ariely and Norton 2008).

In this paper I examine the effects of consumers’ adjustment on the equilibrium in differentiated product markets. As I shall discuss in detail below, adjustment matters because it affects prices. But the effects are not necessarily what one would intuitively expect – namely, that adjustment intensifies preferences and therefore unambiguously increases prices.

The idea that “tastes change” has been reflected in the recent behavioural economic literature on reference dependence; and it has long been accepted in the field of psychology, most notably in connection with the framework of cognitive dissonance. The former focuses on recognition of the role of the agent’s reference point in his (potentially variable) interpretation of and response to outcomes (e.g., Koszegi and Rabin 2006). The latter focuses on situations in which mental discord – typically due to an individual perceiving a discrepancy between an action he has taken and his preferences, beliefs, or identity – provides motivation for a change in mental position to justify the action (Festinger 1957). While the work in both areas has been highly influential, these literatures do not admit evidence, as in the stories above, that improving one’s “fit” with

---

1 Studies offering evidence of preference change based solely on subject ratings of chosen alternatives include Lieberman et al. (2001), Kitayama et al. (2004), Sharot et al. (2010), and Wakslak (2012). Studies that additionally measured changes using functional magnetic resource imaging (fMRI) of subjects’ brains include Sharot et al. (2009), van Veen et al. (2009), Izuma et al. (2010), Jarcho et al. (2011), Qin et al. (2011), Kitayama et al. (2013), and Izuma and Adolphs (2013).
a chosen object might be a routine, perhaps optimizing, part of the consumer’s decision process.²

In traditional economic theory, the consumer problem is generally conceived as involving choice under imperfect circumstances, in which options for action do not match perfectly with individuals’ preferences. Utility losses due to imperfect matching are routinely reflected in the modeling. For example, in Hotelling’s (1929) spatial model of differentiated products, consumers experience “transportation costs” when their tastes do not align perfectly with their chosen alternative. Given the standard assumption that tastes are fixed, consumers’ acceptance of the costs or losses associated with imperfect choice (i.e., without adjustment) is posited as optimising behaviour. Rational consumers assume moreover that they will not adjust to their choices, whence, the standard model predicts, they make choices accordingly.³ If, in reality, consumers do adjust, then both the positive and normative implications of the existing models are wrong. Models of consumer choice, updated to account for adjustment and for how the adjustment process is influenced by relevant market phenomena, could produce superior predictions of both behaviour and outcomes.

² Adjustment, as conceived here, has the goal of increasing what Thaler (1985) has termed acquisition utility – the net value of what one obtains from a decision. In contrast, reducing cognitive dissonance involves increasing Thaler’s transaction utility – one’s perception of the merits of a decision. Different goals lead adjustment and dissonance reduction to pursue different strategies: the dissonance-reducing agent, for example, reduces the utility associated with non-chosen alternatives, whereas an optimising adjuster need not.

³ In the motivated beliefs literature, agents rationally anticipate that their actions will create corresponding beliefs, and their choices reflect this realization (Bodner and Prelec 2003; Benabou and Tirole 2004, 2011; Dal Bo and Tervio 2013). However, none of these papers deals with the possibility that actions might create preferences.
The paper introduces rational taste change into the context of a Hotelling spatial model of differentiated product competition. Consumers differ as to their initial tastes for two competing products. A consumer can, at a cost, adjust to the product he intends to choose – in essence, “moving closer” to it, and thereby avoiding some of the transportation cost associated with imperfect taste matching. By incorporating adjustment as a step in a model of rational choice, the theory allows the induced outcomes to be subsumed into “final” preferences such that the conventional techniques for analysing choices, including the axioms of revealed preference, may be applied to them. This approach avoids many of the complications associated with previous efforts to model taste change.

Though adjustment implies intensification of preference, surprisingly prices do not rise unambiguously with increasing intensity of consumer adjustment. The direction and size of adjustment’s effect on equilibrium market prices depends on how consumers’ facility with adjustment varies based on the strength of their initial product preference. Adjustment lowers prices if the best opportunities to adjust exist for consumers with weaker initial preferences – that is, if final attitudes exhibit regression to the mean. It raises prices when adjustment facility is greater for consumers who initially prefer a product more – for example, if preferences and corresponding adjustments exhibit the so-called “halo effect.”

\[\text{I characterise adjustment as a process that is fully anticipated by the decision maker, entered into consciously, involves the weighing of costs and benefits, and results in outcomes with respect to which the decision maker has perfect foresight. I make these characterizations not because there is a preponderance of evidence supporting them, but because they constitute the simplest assumptions to make about choice behaviour. Rationality offers thus a benchmark that subsequent approaches may modify, relax, or elaborate on.}\]
That different patterns of adjustment facility across consumers imply different market outcomes has important implications not captured by existing theories of competition and consumer behaviour. The paper focuses on the particular cases presented by poor and less educated consumers. Traditional accounts blame high search costs and sparse retail distribution for the higher prices often found in markets populated by the poor and less educated. Thus it is typically predicted that entry by low-cost retailers and technological advances such as the Internet and mobile shopping apps will eventually resolve inequities. In showing that entrenched patterns of behaviour characterising disadvantaged consumers are responsible for the high prices they face, the adjustment model recasts the price differentials problem, motivating reconsideration of the validity of vaunted solutions and the role for public policy.

The rest of this paper is structured as follows. Section 2 introduces the model. Section 3 examines the model’s equilibrium. Section 4 focuses on implications of the theory. Section 5 concludes and discusses opportunities for future research. The Appendix contains proofs of all lemmas and propositions.

2. A MODEL

Consider two products, indexed 0 and 1, each produced by an independent firm correspondingly named. The firms are located at opposite ends of a segment of length 1 representing the product space. Following Hotelling’s model (1929), each consumer is characterised by a location \( x \in [0,1] \), identifying his relative taste for the two products. Consumers are assumed distributed on this segment according to an arbitrary distribution
function $F$ with full support and continuous density function $f$. They buy at most one unit of a single product. I assume the baseline utility of a consumer at $x$ buying product $j$ to be given by
\begin{equation}
U_x = V - p_j - t|x - j|
\end{equation}
where $V$ is the common reservation price for the product, $p_j$ is the price of product $j$, and $t$ parameterises the utility loss due to $j$’s not being the consumer’s ideal choice – the standard “transportation” cost, linear in the consumer’s distance from $j$.

Suppose that the consumer faces the possibility of adjusting to a product, defined as in effect relocating on the segment to be closer to it, thereby paying less transportation cost. The process is quite naturally viewed as an incremental one, involving incremental investment of costly or aversive effort that pays off with an incremental improvement in attitude toward the product. Consistent with this incremental view, let us posit an adjustment marginal cost function associated with product $j$, $g^j(i, x) > 0$, where $i$ is the distance from $x$ and closer to $j$’s position. One may view this function as representing a set of adjustment curves $G^j := \left\{ g^j(i) = g^j(i, x) : x \in [0, 1] \right\}$ characterised by differing values of $x$, whereby each curve represents the cost, at each state of attitude improvement $i$, of incremental “movement toward” $j$ for the consumer located initially at $x$. Let us refer to $G^j$ as an adjustment map for product $j$. Figure 1 illustrates an adjustment map for product 0.

< INSERT FIGURE 1 APPROXIMATELY HERE >
For clearer analysis of the effects of adjustment, let us write
\[ g^j(i,x,\theta) = \bar{g}^j(i,x) + \theta, \quad j = 0,1, \]  
where \( \theta \equiv g^0(0,\frac{1}{2}) > 0 \) is the initial marginal adjustment cost with respect to product 0 for a consumer located at \( x = \frac{1}{2} \). \( \theta \) serves as a benchmark level of adjustment cost, hence an exogenous shifter of \( g \) where \( \frac{\partial g^j}{\partial \theta} = 1 \). The effects of \( \theta \) are symmetric across products and consumers; variations in this variable can cleanly increase or decrease adjustment intensity. Accordingly, one may think of decreases (increases) in \( \theta \) as exogenous “increases (decreases) in adjustment.”

Adjustment maps observe the following regularity conditions:

**Assumption 1 (Continuity of adjustment cost in x and i).** \( g^0(i,x) \) and \( g^1(i,x) \) are defined on \( [0,x) \times [0,1) \rightarrow \mathbb{R}^+ \) and \( [0,1-x) \times [0,1) \rightarrow \mathbb{R}^+ \), respectively, and continuous on their support.

**Assumption 2 (Convexity of adjustment curves).** \( g^j_i > 0 \) and \( g^j_x > 0 \), for \( j = 0,1 \).

**Assumption 3 (Preference dominance).** For all \( x \in [0,1] \), \( -\frac{\partial g^0}{\partial x} < \frac{\bar{g}^0}{\partial x} \) (and \( \frac{\partial g^1}{\partial x} < \frac{\bar{g}^1}{\partial x} \)).

The last of these specifies in effect that the more preferred a product is initially, the lower the marginal cost of adjustment at any particular location achieved through accumulated

\(^5\) To keep notation simple, I will generally write \( g'(i,x) \), suppressing the argument \( \theta \), except where relevant to a particular part of the analysis.
adjustment. This “dominance” condition implies that an individual who initially prefers a product more than another individual finds it less costly to achieve a given attitude toward that product through adjustment than the other individual. The condition gives rise to adjustment maps of non-crossing nested contours, similar to well-behaved indifference maps. It follows that adjustment results in greater achieved attitude the greater the individual’s initial proximity to a product.

Extending Assumption 2, assume that adjusting to the point where a product is viewed as ideal is infinitely costly. Thus, while someone might get quite comfortable with a product at finite cost, one cannot get perfectly comfortable. I adopt this because it is sensible, does not meaningfully sacrifice generality, and avoids corner cases:

**Assumption 4 (Asymptotic adjustment).** \( \lim_{i \to x} g^0(i,x) = \infty \) (and \( \lim_{i \to 1-x} g^1(i,x) = \infty \)).

For consumers for whom adjustment is preferred with respect to a given product relative to leaving one’s attitude fixed, it is possible to define the notion of *adjustment productivity*: how much attitude improvement with respect to the product the consumer will attain, given his preferences, his particular capabilities at adjusting to it, and the transportation cost (i.e., his opportunity cost of adjusting). Define the set

\[ X_j(t) = \{ x : g^j(0,x) < t \} ; \text{since } g^j(0,x) \text{, while continuous, is not required to be monotonic in } x, \ X_j(t) \text{ may contain (compact) gaps. One may then define the implicit function } i^{*j}(x,t) \text{ on } X_j(t) \times \{ t > 0 \} \to \mathbb{R}^+ \text{ such that } g^j(i^{*j}(x,t),x) = t \text{ as consumer } x \text{’s} \]
“adjustment productivity given $t$. ” Note that, for $x \not\in X_j(t)$, $i^*(x,t)=0$. Thus the adjustment model nests non-adjustment as a sub-case (i.e., $X_j(t)=\emptyset$).

The following lemma advances some useful results that follow from the definition of adjustment productivity:

**Lemma 1.** (i) $i^*_x<1$ (and $i^*_{x^1}>-1$); (ii) $i^*_x=-i^*_0=1/g^0_0>0$ (and $i^*_{x^1}=-i^*_1=1/g^1_1>0$).

Accounting for adjustment, the utility of a consumer at $x$ buying product 0 is given by

$$U_0 = V - p_0 - t\left[x - i^*_0(x,t)\right] - \int_0^{i^*_0(x,t)} g^0(i,x)di$$

and, for a consumer at $x$ buying product 1, by

$$U_1 = V - p_1 - t\left[1 - x - i^*_1(x,t)\right] - \int_0^{i^*_1(x,t)} g^1(i,x)di$$

One can see that utility losses accruing to choosing a non-ideal product equal the sum of adjustment cost and transportation cost components and are a function of the consumer’s adjustment productivity. Figure 2 displays these losses graphically as areas under the adjustment and transportation cost curves.\(^6\)

\(^6\) Note that the setup in (2) and (3) is isomorphic to a traditional Hotelling model with nonlinear transportation costs. The rationale for layering adjustment into the model explicitly (i.e., by means of the “adjustment map”) is so that its effects may be seen distinctly.
Following Bloch and Manceau (1999), but extended to the adjustment case, I impose what is in effect a restriction on the size of $V$ relative to $t$ and to the rate of change of $g^0$ with respect to $x$:

**Assumption 5.** 
$$V - t \left[ x - i^0(x) \right] - \int_0^{i^0(x)} g^0(i,x) di \Bigg\} F(x) \text{ is increasing for all } x \in [0,1].$$

The assumption is a sufficient condition for the market to be covered under adjustment:

**Lemma 2.** *Given Assumption 5, the market is covered in equilibrium.*

The location $x_E^*$ of the indifferent consumer under adjustment can be derived by setting $U_0 = U_1$. Thus it is defined implicitly by

$$\Theta(x_E^*,t,p_0,p_1) \equiv p_1 - p_0 + t - 2tx_E^* - t \left[ i^1(x_E^*,t) - i^0(x_E^*,t) \right] + \int_0^{i^1(x_E^*,t)} g^1(i,x_E^*) di - \int_0^{i^0(x_E^*,t)} g^0(i,x_E^*) di = 0 \quad (4)$$

Based on this, market shares for the two products are defined by $D_0 = F(x_E^*)$ and $D_1 = 1 - F(x_E^*)$.

There are two periods. In the first, firms choose prices, taking each other’s prices as given. In the second, consumers choose products and adjust to the product they choose; they receive utility, and the firms earn profits. The equilibrium concept used for evaluating the game is subgame perfect Nash.
Given demand, profits of the firms are given by

\[
\Pi_0 = p_0 F(x_E^*) \quad \Pi_1 = p_1 \left\{1 - F(x_E^*)\right\}
\]

As a final assumption, I employ a variant on a distributional restriction by Caplin and Nalebuff (1991), which they showed constitutes a sufficient condition for the existence of a unique equilibrium in a broad class of games. Bloch and Manceau (1999) demonstrated the use of the Caplin-Nalebuff assumption in a Hotelling model of product differentiation with a generic distribution of consumers. The present variant generalises that assumption to the model involving adjustment by imposing a set of complementary restrictions on the consumer distribution \(f\) and the adjustment functions \(g^j\). In the Appendix, it is demonstrated that the assumption applies to a rather general set of \(f\) and \(g\) functional form combinations.

**Assumption 6.** \(F(\cdot)\) is log concave in \(p_0\) (and \(1 - F(\cdot)\) is log concave in \(p_1\)).

### 3. EQUILIBRIUM

We focus on firm 0’s problem. Differentiating firm 0’s profit equation in (5) with respect to price yields

\[
\frac{\partial \Pi_0}{\partial p_0} = F(x_E^*) + p_0 f(x_E^*) \frac{\partial x_E^*}{\partial p_0}
\]
where $\frac{\partial x^*_E}{\partial p_0}$ is derived by applying Cramer’s rule to (4),\(^7\)

\[
\frac{\partial x^*_E}{\partial p_0} = \frac{1}{-2t + \int_0^{i'(x^*_E)} \frac{dg}{dx^*_E} di - \int_0^{i'(x^*_E)} \frac{dg}{dx^*_E} di} < 0
\]

Using (6), one obtains $(\partial \Pi_0 / \partial p_0)_{p_0=0} = F(x^*_E)_{p_0=0} > 0$ : non-zero demand for product 0 is guaranteed at $p_0 = 0$ by $t > 0$ and $g^i(i,x) > 0$. Moreover,

$(\partial \Pi_0 / \partial p_0)_{p_0=0} = P_0 f(0) (\partial x^*_E / \partial p_0) < 0$, where $p_0\big|_{x^*_E=0} > 0$. Because, following from Assumption 6, $-F(x^*_E) / f(x^*_E) \frac{dx^*_E}{dp_0}$ must be decreasing in $p_0$, it follows that:

**Proposition 1.** There exists a unique pure strategy Nash equilibrium in prices $(p^*_0, p^*_1)$

where the prices are given by $p^*_0 = -F(x^*_E) / f(x^*_E) \frac{dx^*_E}{dp_0}$ and $p^*_1 = \left[1 - F(x^*_E) / f(x^*_E) \frac{dx^*_E}{dp_0}\right]$.\(^8\)

In the context of the unique price equilibrium one may draw conclusions about the effects of adjustment on the price sensitivity of demand and, ultimately, prices.

Consider a case in which adjustment and demand are symmetric across products so that any influence of adjustment on relative demand is eliminated and we may focus on non-

\[^7\text{As a notational simplification, I write throughout } \frac{dx^*_E}{dx} \text{ for } \frac{dx^*_E}{dx} \left(i, x^*_E\right) \text{ and } \frac{d^2 x^*_E}{dx^2} \text{ for } \frac{d^2 x^*_E}{dx^2} \left(i, x^*_E\right), \text{ the first and second derivatives of } G^i \text{ with respect to } x \text{ evaluated at } X^*_E.\]

\[^8\text{This represents essentially the extension of Bloch and Manceau’s (1999) Proposition 2 to the adjustment case.}\]
sectoral effects. Focusing on product 0, recognizing that \( D_0 = F(x_E^*) \) and using (7), one obtains

\[
\frac{\partial D_0}{\partial p_0} = \frac{f(x_E^*)}{\sqrt{t'(i^*)} - \left[ -2t + \int_0^{i^*} \frac{dg^1}{dx_E^*} di - \int_0^{i^*} \frac{dg^0}{dx_E^*} di \right]}
\]

Differentiation with respect to \( \theta \) leads to the following result:

**Proposition 2.** Consider a symmetric case in adjustment. Adjustment increases the price sensitivity of product demands when consumers’ adjustment facility diminishes with stronger initial product preference. It decreases the price sensitivity of demands when consumers’ adjustment facility increases with stronger initial product preference.

Proposition 2 provides our first glimpse into the forces that govern competitive equilibrium under adjustment. General intuition can be drawn from (8), which reduces to the constant \(-\frac{f(x_E^*)}{2t}\) in the no-adjustment, traditional Hotelling case (i.e., with \( i^* = 0 \)). The nature of the departure of (8) from that case can be seen to depend on the signed rate at which marginal adjustment costs for each product change with the indifferent consumer’s position \( x_E^* \), moderated by the indifferent consumer’s adjustment productivity with respect to the corresponding product. The expression makes evident what we find in the formal result: greater adjustment intensity enables increased
expression of price sensitivity effects that depend on how adjustment facility varies with strength of initial product preference.

Consider Figure 3. The first panel of the figure shows a symmetric adjustment map in which the curves grow steeper as as one moves from $x^*_E$ toward positions of stronger initial preference. The second panel shows a symmetric map in which the curves at first grow flatter. In both cases, the curves must eventually become increasingly steep as one approaches $x = 0$ or $x = 1$; this follows from Assumption 4. What is critical to our result, however, is what happens near $x^*_E$. If the curves grow steeper with stronger initial preference, a price increase for a product moves to the margin previously-inframarginal consumers who find adjustment less productive at improving their attitude than the consumer at $x^*_E$. These consumers, if they switched products, would forgo higher total costs (i.e., transportation plus adjustment costs) from the product they left than would a consumer with the same adjustment facility as the consumer at $x^*_E$. Given symmetry, they would also incur lower total costs from their new product relative to a consumer with the same adjustment facility as the consumer at $x^*_E$. Thus an adjustment map with this particular shape sets up an increased incentive for switching, whence demand is more price-sensitive, all else equal. The more intensively consumers engage in adjustment, the more relative adjustment facility conditions consumers’ decisions, and so the stronger the described effect.

< INSERT FIGURE 3 APPROXIMATELY HERE >
Consider, on the other hand, what occurs when the adjustment map has the shape displayed in the second panel of the figure. Then, a price increase moves to the margin previously-inframarginal consumers who find adjustment more productive than the consumer at \( x^*_E \). These consumers, if they switched products, would forgo lower total costs from the product they left than would a consumer with the same adjustment facility as the consumer at \( x^*_E \). Given symmetry, they would also incur higher total costs from their new product relative to a consumer with the same adjustment facility as the consumer at \( x^*_E \). Thus demand is less price sensitive, all else equal, when the adjustment map has this particular shape. As with the steepening map, the more intensively consumers engage in adjustment, the stronger the described effect.

The implications of adjustment for price levels follow directly from Proposition 2, in view of the price equations given in Proposition 1.

**Proposition 3.** Consider a symmetric case in adjustment. Adjustment decreases prices when consumers’ adjustment facility diminishes with stronger initial product preference. It increases prices when consumers’ adjustment facility increases with stronger initial product preference.

As with Proposition 2, Proposition 3’s intuition has to do with switching. Because price increases encourage more rapid switching when adjustment maps steepen, firms naturally find it less profitable to increase prices under such circumstances. The opposite is true when adjustment maps flatten toward the extremes. Adjustment intensity, which
conditions the relative size of the role adjustment costs play in consumers’ decisions, determines the degree to which the variation of adjustment facility with strength of initial preference influences firms’ decisions over price.

Note that the effects of adjustment behaviour on price sensitivity and price levels that we have just derived offer quite a general result. They do not depend on the distribution of consumers: the model has posited a general distribution function. They depend only how the progression of marginal adjustment costs of consumers over the adjustment process varies depending upon the relative strength of their initial preferences, as represented by the shape of the adjustment map.

Finally, let us generalise to the adjustment case the classic Hotelling result on the price effect of product differentiation:

**Proposition 4 (Product differentiation).** Consider a symmetric case with respect to the two firms. (i) Prices increase with $t$. (ii) The effect of $t$ on prices is less (greater) relative to the no-adjustment case when consumers’ adjustment facility decreases (increases) with stronger initial product preference. (iii) $t$ intensifies the effects of adjustment on price.

An increment to $t$ increases the market power of the firms directly, as in the classic model; additionally it increases the importance of consumer adjustment, causing the price effects of adjustment to be more pronounced. Thus, if adjustment curves become steeper as one moves toward positions of extreme preference, an increase in product differentiation causes prices to rise more slowly than they would in the no-adjustment
case, due to the offsetting effects of the expressed adjustment. If adjustment curves become flatter toward the extremes, an increase in product differentiation causes prices to rise faster than they would in the no-adjustment case, for the same reason. In all cases the sign of the effect of product differentiation on prices remains unambiguously positive.

4. IMPLICATIONS OF THE THEORY

4.1. Two adjustment regimes: regression to the mean and the halo effect

What do the patterns of marginal adjustment cost represented by the maps shown in the two panels of Figure 3 signify in terms of real-world behaviour? When should one expect adjustment behaviour to be characterised by pattern in the top panel, and when the pattern in the bottom panel?

One may think of adjustment quite generally as drawing upon current experiences and exposures to information, as well as the data from past exposures stored in memory, as resources for attitude change (Crano and Prislin 2006). Consider first a simple case in which individuals have no innate differences in attitudes or abilities to adjust, and in which ability to adjust and exposure to information supportive to attitude are uncorrelated with current attitude. In such a case an individual’s stronger (weaker) initial positive attitude toward an object must accrue to having received prior positive (negative) exposures in support of that attitude. How easy further adjustment will be for an individual will depend on which exposures have already occurred – in essence, draws
without replacement – versus which have not. Thus those individuals with a weak initial preference for an object should possess the greatest pool of not-previously-drawn positive exposures, representing the greatest unexploited opportunities to adjust. Meanwhile, those with the most intense initial preferences will have exhausted (i.e., drawn without replacement) the most persuasive information and arguments available to foster adjustment. It follows in this scenario that individuals with weaker initial preferences will find adjustment less costly, while those with stronger initial preferences will find it more costly. Consistent with the top panel of Figure 3, such an adjustment cost structure would be characterised by attitudes tending to converge following adjustment. I refer to this as the \textit{regression to the mean} (RTTM) regime.

Now consider a case in which individuals may or may not exhibit innate differences in attitude toward an object, but where the ability to adjust and/or exposure to information supportive to attitude correlate with one’s currently having a strong positive attitude. This would logically follow if, say, judgments or information availability in memory are biased in the direction of one’s current attitude. In this case individuals would find adjustment easier the stronger their initial preferences. Thus a strong positive initial impression of an object would correlate with the building of yet a stronger positive attitude, consistent with the bottom panel in Figure 3. A well-documented phenomenon that epitomises this is the \textit{halo effect}, according to which individuals infer unknown qualities of an object based on their existing overall impressions.\footnote{\textsuperscript{10} See, e.g., Nisbett and Wilson (1977).}

\footnote{\textsuperscript{9} Since attitude change may quite generally be viewed as occurring dynamically over the whole life of the individual, the term “initial” should be interpreted as relative to the point in time at which a consumer decision is imminent, whence motivated decision-complementary adjustment would commence.}

\footnote{\textsuperscript{10} See, e.g., Nisbett and Wilson (1977).}
The characteristic that distinguishes RTTM adjustment from halo effect adjustment is the scope of the information and persuasive arguments that individuals rely upon under each. Specifically, the biasing that affects halo effect adjusters is tantamount to a constraint on the scope of information relied upon. To see this intuitively, consider that in Figure 3 it is possible to convert any set of symmetric adjustment maps based on the bottom pattern to a set observing the top pattern simply by lowering the more extreme portions of the inner adjustment curves and thereby reducing their slopes. Thus one may think of the halo effect pattern, quite generally, as reflecting a failure of relatively indifferent individuals to “see” opportunities for more facile adjustment that those who already strongly prefer the object see. In effect, halo effect adjusters with initial weak impressions exhibit a kind of myopia.

What observable factors can explain this tendency toward constrained information sourcing? While others may be possible, I propose two accounts that point to answers to this question. One possibility, supported by evidence from psychological research, is that the halo effect adjusters are going with their initial impressions because their cognitive resources are limited and it is simply easier to do so than to come up with new information or arguments that go beyond those impressions. Another possibility is that these individuals intrinsically prefer to draw information from their initial impressions. This might occur if individuals have preferences not just over goods and services, but over information sources for making judgments regarding goods and services. Such a preference might induce an individual to rely on initial impressions heavily, even if doing

---

11 See Kahneman (2011), Chapter 7; and, for a classic application to how people assess others’ personalities, Asch (1946).
so reduces his eventual consumption utility from the goods or services. The remainder of this section considers some observable factors that explain halo effect adjustment behaviour as a function either of individual cognitive resource limitations or intrinsic preference for initial impressions.

4.2. *Markets to the poor*

Recent research suggests that the poor experience challenges not only because of their limited financial resources, but also because of severely taxed resources of attention. Overwhelmed by the need to address pressing demands presented by overdue bills, unreliable child care, debts and the like, they find their attention compromised with respect to anything that is not immediately pressing. Diverse studies find that “bandwidth” constraints lead poor people to exhibit reduced fluid intelligence, working memory, and executive control (Mullainathan and Shafir 2013). In the context of the adjustment model, a bandwidth tax implies yet another challenge: those in poverty adjust to products based on the halo effect pattern and therefore, all else equal, pay higher prices than other people.

Bandwidth constraints imply that adjustment, which requires bandwidth, would be a luxury for the poor. More important for our purposes, however, the pattern of marginal adjustment costs faced by the poor is likely to be qualitatively altered by those constraints. Consistent with their tendency to attend primarily to what is immediately in front of them, it is reasonable to hypothesise that the poor would draw heavily on their
own initial impressions, rather than diverse external resources, when adjusting. Considering new persuasive arguments and new sources of information in support of a product – in essence, “getting the big picture” – is beyond the wherewithal of someone who is continually thinking about when her next paycheck is coming and how to allocate it among various urgent needs. A poor individual who is relatively indifferent to a product will, therefore, find it exceedingly hard to get more comfortable with that product. Put another way, myopia with respect to the good qualities of an indifferent object is particularly acute for those in poverty: it is hard, given taxed bandwidth, to see what is so good about a thing you had not previously considered carefully.

Whether the poor pay more for equivalent items than other people has long been debated in the literature. Conceptually there are factors that cut both ways. On the one hand, the poor face limited access to low-price outlets within their own neighborhoods, combined with mobility constraints that make it difficult for them to benefit from the greater array of distribution options available in wealthier areas. (Eckholm 2006, Fellowes 2006, Talukdar 2008.) On the other hand, financial scarcity motivates the poor to be more parsimonious and devote more effort to economizing relative to other people (Mullainathan and Shafir 2013, pp. 87-104). Additionally, a lower opportunity cost of time may induce the poor to invest more hours in the search process (Talukdar 2008). Evidence on the question is correspondingly mixed. Several studies indicate the poor pay higher prices, mainly because they make a substantial portion of their purchases at smaller, non-chain-based, higher-priced stores (Chung and Myers 1999, Prahalad and Hammond 2002, Talukdar 2008). Meanwhile, Borda et al. (2009) find in an extensive
study using Neilsen household-level data that, while the poor indeed make a substantial portion of their purchases at convenience stores, they buy so much more at low-priced superstores that they end up paying less on average. The authors of the study find, moreover, that the poor pay less on average at the same outlets than other people, because they are more likely to buy items on sale. Their findings corroborate the proposition that the poor are more motivated to save and so are more parsimonious than other people.

Critically, the focal conversation in the existing literature has to do with search and supply; that is, whether the poor’s benefits and costs of search, and their access to low-priced goods, differ significantly on balance from everyone else’s. On this basis, if in fact the poor pay more, it would be tempting to speculate that market forces, in time, will bring down prices for those in poverty. To the extent that the poor have traditionally had to abide high-priced convenience stores associated with so-called “food deserts” (i.e., neighborhoods bereft of supermarkets), inroads from superstores such as Wal-Mart would be expected to narrow price disparities. Solutions based on new technologies, such as online shopping and mobile apps that allow for store-to-store price comparisons without the need to travel, would bring down search costs and help close the price gap.

But predictions such as these ignore the cognitive dimension of the problem the poor face. The adjustment theory demonstrates that high search costs and sparse supply are not the only disadvantages suffered by the poor in goods markets. Correspondingly, innovations that have reduced search costs and improved supply over the past generation and that continue to make improvements in these areas are not a panacea for those in poverty.
To eliminate the disadvantages of the poor, one must go to the heart of the problem: their deficit of bandwidth. Many of the policy suggestions advanced by Mullainathan and Shafir (2013) aimed at clearing bandwidth for the poor could help improve their plight in goods markets. Note that, per the discussion above, the bandwidth deficit poses a problem for the poor not because of its direct effect on the decision processing capabilities of the individual consumer. Rather it is for the counterintuitive reason that this deficit influences the way in which adjustment capabilities are distributed across the mass of consumers based on relative strength of preference. This bears emphasis, because it is normal for one to think of prices being kept low by the vigilance and good judgment of individual consumers. Corresponding to the ecological nature of the problem, the benefits of bandwidth-clearing policies flow from a beneficial change to the distribution of relative adjustment capabilities rather than – as would seem most intuitive – from impacts on the quality of individual decisions.

4.3. Other constrained individuals

The poor are not the only group characterised by the sort of cognitive tax that results in halo effect adjustment. Anyone whose cognitive resources are severely taxed should experience the adjustment myopia hypothesised. People under substantial stress, for example, will tend to “tunnel,” paying attention only to immediately pressing matters and ignoring opportunities for gain that are not immediately in front of them. People who are extremely busy, or who are highly focused on other forms of scarcity, such as
loneliness, may behave similarly.\textsuperscript{12} When markets are dominated by such individuals, the predicted price and price sensitivity effects corresponding to halo effect adjustment should appear. The greater the proportion of taxed individuals present in the market, the stronger the effects.

4.4. \textit{Markets to the less educated}

The adjustment theory also admits the provocative conclusion that personality affects market outcomes. Openness to experience, one of the dimensions in the Five-Factor Model of personality, characterises individuals who exhibit an intrinsic interest in a variety of experiences and a “fluid style of consciousness” (McRae 2004). An individual with this personality type would be unusually capable at getting comfortable with objects with respect to which he had not previously formed a strong positive impression (e.g., new or previously untried products). The implication is that a market dominated by individuals rating highly on openness to experience should be epitomised by the RTTM adjustment pattern and should tend to have lower prices. Meanwhile, a market largely consisting of people less open to experience might tend toward the halo effect pattern and have higher prices.

The degree of openness may explain price patterns typically attributed to other factors. As a trait that has been related to intelligence and knowledge (Wiggins 1996), its absence may explain the higher prices often paid by less educated individuals (e.g.,

\textsuperscript{12} For an extensive taxonomy of groups that exhibit intense cognitive scarcity, see Mullainathan and Shafir (2013).
Hausman and Sidak 2004). The traditional explanation of why the less educated pay more has focused on lack of facility with search: those with fewer years of schooling find information processing more challenging and so should be expected to have a harder time getting the best product deals (Schmidt and Spreng 1996). But a policy based on the logic of search costs, such as training in consumer skills, would fail to address the personality effect. That is, the less educated, even when trained thus, would likely remain more dogmatic and less tolerant of ambiguity, hence less receptive to new things (McRae 2004). Markets dominated by the less educated accordingly could exhibit persistently high prices even when individuals are treated with targeted consumer education.

Increasing competition has been proposed as an alternative way of addressing the high prices paid by the less educated (Hausman and Sidak 2004). In the adjustment model, increased competition manifests as lower transportation costs, which lead to lower prices. Proposition 4 indicates that markets exhibiting the halo effect pattern are more sensitive to variation in transportation costs, all else equal. There is reason, therefore, to believe that increased competition would indeed be an effective remedy for markets dominated by less educated individuals.

5. CONCLUSION

This paper has presented a new theory of differentiated product markets in which attitude adjustment complements consumer choice. I have laid out a model whose core construct – the adjustment map – provides a general setup for analysing how differences
in the distribution of adjustment capabilities across consumers endowed with different initial preferences lead to different market outcomes. The theory provides specific predictions for markets dominated by poor consumers, other cognitively taxed consumers, and less educated consumers. These cases offer but a few illustrations of the competitive market effects that follow from this behavioural phenomenon. The economic relevance of adjustment goes beyond its effects on prices in a competitive market to areas yet to be considered.

The process of understanding the implications of consumer adjustment has thus only been initiated, and there are a number of useful directions for further research. Let me suggest two in closing. Taking the theory to data either in the lab or by an appropriate field experiment could offer a proof of concept and allow measurement of the model’s predicted effects. An ideal study would quantify the size of effects predicted on the basis of adjustment relative to factors traditionally recognised as affecting price levels. The role of product differentiation as a mediating factor could be explicitly examined.

Additionally, the recognition that complementary adjustment is an element of the consumer decision process naturally motivates a re-examination of the role of advertising. Several studies suggest that it may be appropriate to think of advertising as facilitating consumer self-persuasion.\textsuperscript{13} Within the adjustment theory’s framework, advertising might be contextualised as reducing – and, more generally, restructuring – the

\textsuperscript{13} See Ehrlich et al. (1957) and Mills (1965) for evidence of consumers’ use of advertising to reduce the cognitive dissonance experienced following a purchase. The motivated use of advertising by consumers is discussed conceptually in the uses and gratifications literature: see O’Donohoe (1994), Ko et al. (2005), Aitken et al. (2008), and Phillips and McQuarrie (2010).
costs of adjustment. By means of the framework, a future analysis might effectively take a fresh look at advertising’s effects on competitive market equilibrium and welfare.

APPENDIX

A. APPLICABILITY OF LOG CONCAVITY OF $F(.)$ IN $p_j$

In this section, I show that log concavity of $F(.)$ in $p_0$ – a critical condition for the existence of an interior equilibrium in prices – may be met (1) for the general class of symmetric adjustment map pairs for any symmetric distribution $f$, and (2) for an example of a non-symmetric adjustment map pair when $f$ is Beta distributed with shape parameters $(\alpha, \beta) = (3, 3)$. The main issue in the case of non-symmetric map pairs is that, approaching the extreme locations $x = 0$ and $x = 1$, consumers’ marginal adjustment costs approach infinity for the nearby product. Thus, unless marginal adjustment costs for the distant product similarly grow without limit, sensitivity of demand to price rises precipitously at the extremes, making it potentially profitable for firms to attempt to drop price from any candidate interior maximum to a low enough level to take the whole market. This situation is avoided if the density of consumers at the extremes is sufficiently low, as with some log-concave distributions such as the Beta. So, to summarise, an interior price equilibrium will result whenever the incentive to de-stabilise such an equilibrium is mitigated by adjustment symmetry; or when there are not enough consumers with extreme tastes for firms to want to de-stabilise an interior price equilibrium despite non-symmetry.
We may define the log concavity of \( F(.) \) in \( p_0 \) as \( f(x_E^*)\frac{\partial x_E^*}{\partial p_0} / F(x_E^*) \) being decreasing in \( p_0 \) or, equivalently, \(-F(x_E^*)/f(x_E^*)\frac{\partial x_E^*}{\partial p_0} \) decreasing in \( p_0 \). This gives rise to the following necessary and sufficient condition:

\[
(A1) \quad \frac{\partial^2 x_E^*}{\partial p_0^2} < \frac{f(x_E^*)}{F(x_E^*)} < \frac{f'(x_E^*)}{f(x_E^*)}
\]

Using (7),

\[
\frac{\partial^2 x_E^*}{\partial p_0^2} = \left[-2t + \int_0^{i^0(i_E)} \frac{dg^i}{dx_E} di - \int_0^{i^0(i_E)} \frac{dg^0}{dx_E} di\right]^2.
\]

\[
\int_0^{i^0(i_E)} \left[ \int_0^{i^0(i_E)} \frac{d^2 g^1}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} \frac{d^2 g^0}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} + \frac{d^1 g^1}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} \frac{d^0 g^0}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} - \frac{d^1 g^i}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} \frac{d^0 g^0}{dx_E^2} \frac{\partial x_E^*}{\partial p_0} \right] di
\]

whence (A1) may be re-written

\[
(A2) \quad -\frac{\partial x_E^*}{\partial p_0} \left[ \int_0^{i^0(i_E)} \frac{d^2 g^1}{dx_E^2} di - \int_0^{i^0(i_E)} \frac{d^2 g^0}{dx_E^2} di + \frac{d^1 g^1}{dx_E^2} \frac{i^0}{dx_E^2} - \frac{d^0 g^0}{dx_E^2} \frac{i^0}{dx_E^2} \right] < \frac{f(x_E^*)}{F(x_E^*)} < \frac{f'(x_E^*)}{f(x_E^*)}
\]

where \( \frac{\partial x_E^*}{\partial p_0} \), which is not a function of \( i \), has been pulled out of the integrals.

Consider first the set of pairs of \textit{symmetric} adjustment maps, \( \{ \mathcal{G}^0, \mathcal{G}^1 \} \). For each adjustment curve in \( \mathcal{G}^0 \) corresponding to a given location \( x \in (0,1) \), the corresponding curve in \( \mathcal{G}^1 \) would be its mirror image about \( x \). An example of a subset of such pairs, for \( j = 0,1 \) and \( \rho \in [-1,1] \), is given by
Map pairs corresponding to the values $\rho = 1$ and $\rho = -1$ are shown in Figure 4.

\[ g' = \begin{cases} \frac{-x}{2(x-i)} & \text{for } x \in [0, \frac{1}{2}] \\ \frac{\rho x}{2(x-i)} + \frac{1-\rho}{2-i} & \text{for } x \in [\frac{1}{2}, 1] \\ \frac{\rho (1-x)}{2(1-x-i)} + \frac{1-\rho}{2-i} & \text{for } x \in [\frac{1}{2}, \frac{3}{2}] \\ \frac{1-x}{2(1-x-i)} & \text{for } x \in [\frac{3}{2}, 1] \end{cases} \]

With symmetric adjustment map pairs, and symmetric distribution $f$, the following conditions hold: (i) $d\tilde{g}^0_k / d\tilde{e}_k = d\tilde{g}^1_k / d\tilde{e}_k$, (ii) $d^2\tilde{g}^0_k / d\tilde{e}_k^2 = d^2\tilde{g}^1_k / d\tilde{e}_k^2$, (iii) $i^*0 = i^*1$, (iv) $i^*_x = i^*_x$, and (v) $f'(x^*_E) = 0$. It may be verified, based on these, that the necessary and sufficient condition (A2) above for log concavity is met, whence log concavity of $F(x(p_0))$ holds for any symmetric distribution $f$.

Consider now an example of a non-symmetric adjustment map pair, given by $g^0(i,x) = x/2(x-i)$ and $g^1(i,x) = (1-x)/2(1-x-i)$ for $x \in [0,1]$. These functions have the property that $g^0(0,x) = g^1(0,x) = 1/2$. Observe further that $i^*0(x,t) = \frac{2t+1}{2t} x$ is defined for $t \geq \frac{1}{2}$, whence $i^* < x$; similarly $i^*1(x,t) = \frac{2t+1}{2t} (1-x)$, whence $i^* < 1-x$. We also have $i^*_x^0 = \frac{2t+1}{2t}$ and $i^*_x^1 = -\frac{2t+1}{2t}$. We evaluate the left-hand side of (A2) at $i = 0$ (i.e., the position at which the indifferent consumer evaluates his decision between product options) for all $x \in [0,1]$, using integration by parts:
\[
\int_0^1 \frac{d^2 g^1}{dx^2} di - \int_0^1 \frac{d^2 g^0}{dx^2} di + \frac{dg^1}{dx} i^1 - \frac{dg^0}{dx} i^0 \\
= \int_0^{2t-1/2} \frac{i}{(1-x-i)^2} di - \int_0^{2t-1/2} \frac{i}{(x-i)^2} di + \frac{i}{2(1-x-i)^2} \left( -\frac{2t-1}{2t} \right) - \frac{-i}{2(x-i)^2} \left( \frac{2t-1}{2t} \right) \\
= \left[ \frac{i}{2(1-x-i)^2} - \frac{1}{2(x-i)} \right]^{2t-1/2}_{0} - \left[ \frac{i}{2(x-i)^2} - \frac{1}{2(1-x-i)} \right]^{2t-1/2}_{0} \\
= \frac{(4t^2 - 4t + 1)(2x - 1)}{2x(1-x)} \\
\]

where

\[
\frac{\partial g^0}{\partial x} = \frac{-i}{2(x-i)^2} \leq 0; \quad \frac{\partial^2 g^0}{\partial x^2} = \frac{i}{(x-i)^3} \geq 0 \\
\]

and

\[
\frac{\partial g^1}{\partial x} = \frac{i}{2(1-x-i)^2} \geq 0; \quad \frac{\partial^2 g^1}{\partial x^2} = \frac{i}{(1-x-i)^3} \geq 0 \\
\]

Substituting into (7) for our example functions we obtain \( \frac{\partial z_i}{\partial \theta} = -1/(1 - \ln \frac{1}{2t}) \), whence we may re-write the left-hand side of (A2) as

\[
(A5) \quad -\frac{\partial z_i}{\partial \theta} \left[ \int_0^{i^0} \frac{d^2 g^1}{dx^2} di - \int_0^{i^0} \frac{d^2 g^0}{dx^2} di + \frac{dg^1}{dx} i^1 - \frac{dg^0}{dx} i^0 \right] = \frac{(4t^2 - 4t + 1)(2x - 1)}{2x(1-x)(1-\ln \frac{1}{2t})} \\
\]

Now assume \( f \) is distributed Beta with shape parameters \( (\alpha, \beta) = (3, 3) \). We have:
\[
f(x) = \frac{[x(1-x)]^2}{\int_0^1 [u(1-u)]^2 \, du}; \quad F(x) = \frac{\int_0^x [u(1-u)]^2 \, du}{\int_0^1 [u(1-u)]^2 \, du}
\]

\[
\Rightarrow f'(x) = \frac{2x(1-x)(1-2x)}{\int_0^1 [u(1-u)]^2 \, du}
\]

Thus,

\[
\frac{f'(x_E^*)}{f(x_E^*)} = \frac{2x(1-x)(1-2x)}{[x(1-x)]^2} = \frac{\int_0^x [u(1-u)]^2 \, du}{\int_0^1 [u(1-u)]^2 \, du}
\]

(A6)

\[
= \frac{2(1-2x)}{x(1-x)} \cdot \frac{30[1-x]^2}{x[6x^2 - 15x + 10]}
\]

One may verify using (A5) and (A6) that (A2) holds for all \( x \in (0,1) \), and for any \( t > \frac{1}{2} \).

B. PROOFS AND DERIVATIONS OF LEMMAS, PROPOSITIONS, AND REMARKS

**Derivation of Lemma 1.** Beginning with the expression \( g^j(i^j(x,t,\theta), \theta, x) = t \) which implicitly defines \( i^j \), and totally differentiating (here, for \( j = 0 \)),

\[
g_{i^0}^0 di^0 = -g_{x^0}^0 dx - g_{\theta^0}^0 d\theta + dt \iff g_{i^0}^0 dt^0 = -g_{x^0}^0 dx - d\theta + dt
\]

Using Cramer’s rule, it follows from Assumption 3 that

\[
i_{x_0}^0 (x, A_0) = -\frac{g_{x_0}^0}{g_{i^0}^0} < \frac{g_{\theta^0}^0}{g_{i^0}^0} = 1
\]

Also using Cramer’s rule one obtains
Corresponding results can be derived along the same lines for \( j = 1 \).

**Proof of Lemma 2.** The proof is an extension of the proof of Bloch and Manceau’s (1999) Lemma 1. Suppose that the market is not covered, that is, at equilibrium prices \( (p^*_0, p^*_1) \) there exists a consumer \( x \) for whom

\[
V - p^*_0 - t \left[ x - i^{*0}(x) \right] \geq 0 \quad \text{and} \quad \int_0^{i^{*0}(x)} g^0(i, x) \, di < 0
\]

\[
V - p^*_1 - t \left[ 1 - x - i^{*1}(x) \right] \geq 0 \quad \text{and} \quad \int_0^{i^{*1}(x)} g^1(i, x) \, di < 0
\]

One can show these prices do not constitute a Nash equilibrium, in that firm 0 can increase its profit by lowering its price \( p_0 \) without altering the profit, hence strategy, of firm 1. Begin by noting that, under \( (p^*_0, p^*_1) \), because there is a consumer for whom neither good provides nonnegative utility somewhere between the firms, the profit of firm 0 can be written

\[
\Pi_0 = p^*_0(x_0) F(x_0) = \left \langle V - t \left [ x_0 - i^{*0}(x_0) \right ] - \int_0^{i^{*0}(x_0)} g^0(i, x_0) \, di \right \rangle F(x_0)
\]

where \( x_0 \) is the position of the consumer who, at prices \( (p^*_0, p^*_1) \), is just indifferent between buying product 0 and buying nothing. By assumption, \( \partial \Pi_0 / \partial x_0 > 0 \). Now note that
\[ \frac{\partial p_0}{\partial x_0} = -t + t^i \left( i^0, x_0 \right) i^0 - \int_0^{\iota^0(\theta)} \frac{dg_0}{dx_0} \, di \]

\[ = -t - \int_0^{\iota^0(\theta)} \frac{dg_0}{dx_0} \, di < -t + \int_0^{\iota^0(\theta)} \frac{dg_0}{di} \, di \]

\[ = -t + g \left( i^0 \left( x_0 \right), x_0 \right) - g \left( 0, x_0 \right) = -g \left( 0, x_0 \right) < 0 \]

which follows from Assumption 3. Since \( \frac{\partial \Pi}{\partial x_0} = \left( \frac{\partial \Pi}{\partial p_0} \right) \left( \frac{\partial p_0}{\partial x_0} \right) \), it follows that \( \frac{\partial \Pi}{\partial p_0} < 0 \). Therefore a small downward deviation in the price \( p_0 \) from \( p_0^* \) increases firm 0’s profits while not affecting firm 1’s profits. This contradicts the assertion that \( \left( p_0^*, p_1^* \right) \) constitute an equilibrium.

**Proof of Proposition 2.** Differentiating (8) with respect to \( \theta \) yields

\[
\frac{\partial^2 D_0}{\partial p_0 \partial \theta} = - \left[ f \left( x_E^* \right) \right] \left[ -2t + \int_0^{\iota^1(\theta)} \frac{dg_1}{dx_E} \, di - \int_0^{\iota^0(\theta)} \frac{dg_0}{dx_E} \, di \right] \]

\[
\left[ \frac{dg_1}{dx_E} \left( i^1 + i^1 \frac{\partial x_E^*}{\partial \theta} \right) + \int_0^{\iota^1(\theta)} \frac{\partial^2 g_1}{\partial x_E^2} \, di + \frac{d^2 g_0}{dx_E^2} \frac{\partial x_E^*}{\partial \theta} \right] \]

\[
- \int_0^{\iota^0(\theta)} \left( \frac{\partial^2 g_0}{\partial x_E^2} \frac{\partial x_E^*}{\partial \theta} + \frac{d^2 g_0}{dx_E^2} \frac{\partial x_E^*}{\partial \theta} \right) \, di \]

In the symmetric case, \( \frac{\partial x_E^*}{\partial \theta} = 0 \); therefore \( \frac{\partial^2 g_0}{\partial x_E^2} \frac{\partial x_E^*}{\partial \theta} = \frac{\partial^2 g_1}{\partial x_E^2} \frac{\partial x_E^*}{\partial \theta} = 0 \), and we can simplify the above to
\[
\frac{\partial^2 D_0}{\partial p_0 \partial \theta} = f\left(x^*_E\right) \left( \frac{d g^0}{d x^*_E} - \frac{d g^1}{d x^*_E} \right) t^0_{i_0} \left[ -2t + \int_0^{i^0_{(i^*_E, A_i)}} \frac{d g^1}{d x^*_E} \, di - \int_0^{i^0_{(i^*_E, A_i)}} \frac{d g^0}{d x^*_E} \, di \right]^2
\]

We signed \( i^0_{i_0} \) negative in Lemma 1; this means that \( \frac{\partial^2 D_0}{\partial p_0 \partial \theta} \) takes the sign of \( \frac{d g^1}{d x^*_E} - \frac{d g^0}{d x^*_E} \), thus the effect of adjustment on price sensitivity of demand takes this sign.

**Proof of Proposition 3.** Using \( p^*_0 = -F\left(x^*_E\right) / f\left(x^*_E\right) \frac{\partial \tilde{x}^*_E}{\partial p_0} \), and noting that symmetry makes \( F\left(x^*_E\right) / f\left(x^*_E\right) \) constant in \( \theta \):

\[
\frac{\partial p^*_0}{\partial \theta} = F\left(x^*_E\right) / f\left(x^*_E\right) \frac{\partial \tilde{x}^*_E}{\partial p_0} \frac{\partial^2 \tilde{x}^*_E}{\partial p_0 \partial \theta} \frac{\partial^2 x^*_E}{\partial \theta^2}
\]

\[
= F\left(x^*_E\right) / f\left(x^*_E\right) \frac{\partial \tilde{x}^*_E}{\partial p_0} \frac{\partial^2 x^*_E}{\partial \theta^2} \left( \frac{d g^0}{d x^*_E} - \frac{d g^1}{d x^*_E} \right) t^0_{i_0} \left[ -2t + \int_0^{i^0_{(i^*_E, A_i)}} \frac{d g^1}{d x^*_E} \, di - \int_0^{i^0_{(i^*_E, A_i)}} \frac{d g^0}{d x^*_E} \, di \right]^2
\]

which takes the sign of \( \frac{d g^1}{d x^*_E} - \frac{d g^0}{d x^*_E} \).

**Proof of Proposition 4.** Begin with the expression for \( p^*_0 \) in Proposition 1,

\[
p^*_0 = -F\left(x^*_E\right) / f\left(x^*_E\right) \frac{\partial \tilde{x}^*_E}{\partial p_0} \text{. Because } \frac{\partial \tilde{x}^*_E}{\partial \theta} = 0 \text{ in the symmetric case, it follows that}
\]

\[
F\left(x^*_E\right) / f\left(x^*_E\right) \text{ is invariant in } t \text{. So, using Lemma 1 and } \frac{\partial \tilde{x}^*_E}{\partial \theta} = 0 
\]
\[
\frac{\partial p_0^*}{\partial t} = - \frac{F(x_E^*)}{f(x_E^*)} \left\{ -2 + \int_0^i \frac{\partial^2 g^1}{\partial x^1 \partial t} \, di - \int_0^i \frac{\partial^2 g^0}{\partial x^0 \partial t} \, di \right\}
+ \frac{\partial g^1}{\partial x^1} \left( i_{t^1}^{e^1} + i_{t^0}^{e^0} \right) - \frac{\partial g^0}{\partial x^0} \left( i_{t^0}^{e^0} \right)
\]
\[
= \frac{F(x_E^*)}{f(x_E^*)} \left( 2 - \frac{\partial g^0}{\partial x^0} i_{t^0}^{e^0} + \frac{\partial g^1}{\partial x^1} \right) = \frac{F(x_E^*)}{f(x_E^*)} \left[ 2 - \frac{\partial g^0}{\partial x^0} \left( 1/g_{t^1}^{e^1} \right) + \frac{\partial g^1}{\partial x^1} \right]
\]

(A7)

Given Assumption 3, this may be signed positive. The no-adjustment case yields

\[\frac{\partial p_0}{\partial t} = 2F(x)/f(x),\]
consistent with Bloch and Manceau (1999). Clearly

\[\frac{\partial p_0}{\partial t} > 2F(x)/f(x)\]

corresponds to \(\frac{\partial g^0}{\partial x^0} > 0\) and \(\frac{\partial g^1}{\partial x^1} < 0\), while \(\frac{\partial p_0}{\partial t} < 2F(x)/f(x)\)

when \(\frac{\partial g^0}{\partial x^0} < 0\) and \(\frac{\partial g^1}{\partial x^1} > 0\).

Finally, given that (A7) neatly decomposes into a direct effect of product
differentiation without adjustment and an indirect effect through adjustment, the signing
relationships given above indicate that \(t\) positively mediates the effects of adjustment on
price. That is, the larger \(t\), the more intense the effects of adjustment on price.

REFERENCES

Aitken, Robert, Brendan Gray, and Robert Lawson, “Advertising Effectiveness from a


Asch, S. E., “Forming Impressions of Personality,” Journal of Abnormal and Social
Psychology, 41 (1946), 258-290.

Economy, 112 (2004), 848-886.


Figure 1
An Adjustment Map

\[ g^0(\bar{x}, i) \]
Figure 2
Components of Utility Loss from Selecting Non-ideal Product 0
Figure 3
Steepening vs. Flattening Adjustment Maps
Figure 4
Symmetric Adjustment Map Pairs

\[ \rho = 1 \]

\[ \rho = -1 \]