Brand familiarity and product knowledge in customization

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I adopt Hotelling’s model with two firms. Each consumer has a most preferred variety and possesses a certain level of category-specific knowledge. When a firm offers customization, consumers must interact with the firm to create their products. Consumers familiar with the brand can do this seamlessly, whereas consumers unfamiliar with the brand have difficulty expressing their individual needs (the difficulty decreases with consumers’ knowledge). The firms first simultaneously decide whether to customize, then engage in price competition. Although customization makes the products less differentiated, the frictions caused by consumer co-design activities relax price competition. Customization by one of the firms occurs in equilibrium.

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1 Introduction

Mass customization is the capability to produce individually tailored products without significantly compromising cost efficiency.1 Advances in Internet-based information technologies and manufacturing flexibility have made customization a reality in many product categories. For example, Dell builds to order notebook and desktop computers; Nike and Adidas allow consumers to create their most preferred athletic pair of shoes; apparel vendor Lands’ End offers custom-crafted pants and shirts; and Timbuk2 customizes messenger bags and backpacks.

Considerable attention has been paid to customization in operations management and information systems studies. A number of papers have analyzed customization theoretically, drawing upon the existing published literature on spatial and horizontal product differentiation.2 Customization enables firms to take advantage of consumers’ desire for

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1 See Pine (1993) and Tseng and Jiao (2001) for examples and implementation of mass customization.

2 The study of horizontal differentiation dates back to Hotelling (1929), and is extended by Lancaster (1966, 1979) and Salop (1979).
ideal varieties, but reduces differentiation and intensifies price competition. Indeed, if two or more firms offer a consumer the product that completely matches the consumer’s tastes, then competition leads to marginal cost pricing (Syam, Ruan, and Hess 2005; Bernhardt, Liu, and Serfes 2007; Mendelson and Parlaktürk 2008).

Customization differs from the strategy of offering as many variants as possible. With customization, the consumer interacts with the firm to create his/her product. In other words, the consumer must specify the characteristics of the product during design, fabrication and assembly. Although these co-design activities are the necessary prerequisites of customization in order to fulfil the needs of individual customers, they can also lead to frustration and information overload. Consumers often lack the knowledge and skills to transfer their needs into concrete product specification (Huffman and Kahn 1998; Piller, Schubert, Koch, and Moslein 2005; Dellaert and Stremersch 2005; Arora et al. 2008). Even a simple product like a pair of NIKeiD shoes becomes a rather complex product if one has to decide explicitly between style, width and cushioning options for the insole, and among fabrics for the outsole and color options. Therefore, critical to co-design are brand familiarity and category-specific knowledge of the consumer (Alba and Hutchinson 1987; Bendapudi and Leone 2003; Jiang 2004; Simonson 2005; Ghosh, Dutta, and Stremersch 2006; Randall, Terwiesch, and Ulrich 2007).

In this paper I challenge the assumption commonly applied in the theoretical literature that consumers possess sufficient knowledge to map their preferences into appropriate product characteristics. I adopt the standard Hotelling model with two firms competing for a continuum of consumers. Consumers are heterogeneous in two dimensions. Each consumer has a most preferred variety and possesses a certain level of category-specific knowledge. Initially, the firms produce standard products located at the end points of the variety interval. Half of the consumers buy from one firm, and the other half from the other firm. Suppose one of the firms offers customization. Consumers familiar with the brand (as they have purchased from this firm in the past) can easily transfer their needs into appropriate characteristics of this brand. Consumers unfamiliar with the brand have difficulty in expressing their preferences. Category-specific knowledge is crucial here. Knowledgeable consumers are more capable of analyzing information than less knowledgeable ones, and the products they develop better match their preferences.

The timeline of the game is as follows. First, the firms simultaneously decide whether to offer customization. After customization decisions are made, the firms engage in price competition. Consumers decide which products to purchase, and the profits are realized.

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3 I do not allow the firms to offer customized products in addition to their standard products. The role of standard products in customization competition are studied in Dewan, Jing, and Seidmann (2003) and Syam and Kumar (2006).

4 Sequential customization decisions are analyzed in Dewan, Jing, and Seidmann (2003). One of their main findings is that the early adopter of customization always achieves an advantage and may be able to deter entry by choosing its customization scope strategically.

5 I assume that customizing firms are restricted to uniform pricing strategies. Obviously, the idea of setting a different price for each variant of a customized product is very appealing. Although some firms do engage in price customization (e.g. Dell and Ford), many firms practice uniform pricing. For example, Lands’ End charges $74 for a pair of jeans regardless of the options chosen and Timbuk2’s price is not linked to color and fabric selections.
Because the goal of the present paper is to investigate how the frictions caused by consumer co-design activities affect competition, I consider a benchmark setting in which consumers always get their ideal varieties when they purchase from a customizing firm. Within this benchmark setting the firms have dominant strategies not to offer customization. In the model with frictions, firms are able to avoid disastrous price competition. I show that customization by one of the firms occurs in equilibrium.

The paper that is closest in spirit to the present study is Syam, Krishnamurthy, and Hess (2008). The authors construct an analytical model of consumers’ uncertain preferences and anticipate regret in the context of customization. Prior to making a purchase, the consumer has a “fuzzy” ideal point. Only after the product has been purchased and used does the consumer learn his/her true ideal point. The regret is captured by the loss in utility, if any, from buying the customized product compared to what the standard product would have provided. The authors’ findings imply that there always exist a segment of consumers who prefer the standard product to the customized product, even though the customizing firm offers every possible product design at the same price.

The rest of the paper is organized as follows. In the next section I introduce the model. Section 3 is devoted to the benchmark setting. An equilibrium analysis is presented in Section 4. Concluding remarks are provided in Section 5. Proofs of all propositions are relegated to the Appendix.

2 The model

Two firms compete in a market with heterogeneous consumers. Firm A produces brand A and firm B produces brand B. Each firm has a standard product located on the Hotelling line of length one, firm A at $x_A = 0$ and firm B at $x_B = 1$. Investing $k \geq 0$ into customization technology allows a firm to offer products that more closely match consumers’ preferences. For simplicity, I assume that both standard and customized products are produced with zero marginal costs.

Consumers are heterogeneous in two dimensions. Each consumer is identified by a point $(x, y)$ in the unit square $[0, 1] \times [0, 1]$, where $x$ is the consumer’s most preferred variety and $y$ measures his/her knowledge of the product category. In addition to these two intrinsic characteristics, the consumer also possesses the derived characteristic of brand familiarity due to previous interactions with the firms. As such, brand familiarity is a function of the firms’ locations at 0 and 1 and the consumer’s earlier choice to buy from the nearest firm.\(^6\) Hence, I assume that the consumer is familiar with brand A if $x \leq 1/2$ and with brand B if $x > 1/2$.

Consumer $(x, y)$ derives utility

$$v - tx - p_A$$

\(^6\) Here I implicitly assume that in the past the firms engaged in the standard Hotelling competition, and, hence, charged the same prices.
when he or she buys firm A’s standard product at price $p_A$. Here, $v$ is a positive constant and $t$ measures the marginal disutility from consuming products away from $x$. Similarly, the consumer derives utility

$$v - t(1 - x) - p_B$$

when he or she purchases firm B’s standard product.

Next, suppose one of the firms, say firm A, offers customization. Consumers familiar with brand A (i.e. consumers with $x \leq 1/2$) are capable of transferring their needs into appropriate brand A characteristics. Hence, they get their ideal varieties and derive utility $v - p_A$.

In contrast, consumers unfamiliar with brand A (i.e. consumers with $x > 1/2$) experience difficulties in mapping their preferences into brand A’s characteristics. Specifically, consumer $(x, y)$ derives utility

$$v - yt \frac{x}{2} - p_A, \quad x > \frac{1}{2}$$

from purchasing firm A’s customized product. The consumer’s knowledge of the product category, $y$, is crucial in this situation. Lower values of $y$ correspond to more knowledge. The smaller is $y$, the better the match for the consumer when he or she purchases a customized product of an unfamiliar brand. In the case $y = 0$ the consumer gets his/her preferred variety. If $y = 1$, the consumer is not able to benefit from customization.

Similarly, the utility of consumer $(x, y)$ from purchasing firm B’s customized product is

$$v - p_B$$

if $x > 1/2$ and

$$v - yt(1 - x) - p_B$$

if $x \leq 1/2$. The consumer is familiar with brand B in the former case, but unfamiliar in the latter.

Each consumer has a unit demand. I will assume that $v$ is large enough for all consumers to find a product that yields positive payoff in equilibrium. Consumers are uniformly distributed over the unit square $[0, 1] \times [0, 1]$ with a total mass equal to one. Equivalently, the two intrinsic characteristics of consumers (preferred variety $x$ and category-specific knowledge $y$) are mutually independent, uniform $[0, 1]$ random variables.

The game has two stages. The first stage is the customization stage, in which the firms simultaneously decide whether to customize. These decisions become observable after they are made. In the second stage the firms simultaneously choose prices, consumers decide which products to purchase, and profits are realized. The equilibrium concept applied is subgame perfect Nash equilibrium.
3 The benchmark

In this section I consider a benchmark setting in which consumers always get their ideal varieties when they purchase a customized product. Algebraically, all consumers have $y = 0$, so the consumer space becomes one-dimensional.

I will proceed using backward induction, starting with the pricing stage. There are four subgames to consider: both firms choose not to customize (NN), only firm A customizes (YN), only firm B customizes (NY) and both firms customize (YY).

Subgames NN and YY are straightforward. When no firm customizes, the equilibrium prices and profits are as in the standard Hotelling model. That is,

$$p_{NN}^A = p_{NN}^B = t \quad \text{and} \quad \Pi_{NN}^A = \Pi_{NN}^B = \frac{t}{2}.$$

Horizontal differentiation disappears when both firms customize, leading to the Bertrand outcome. Therefore, in subgame YY we have:

$$p_{YY}^A = p_{YY}^B = 0 \quad \text{and} \quad \Pi_{YY}^A = \Pi_{YY}^B = 0.$$

Next, suppose firm A is the only customizing firm (subgame YN). The consumer located at $x$ purchases from firm A if and only if

$$v - p_A > v - t(1 - x) - p_B.$$

Therefore, the marginal consumer type is

$$\hat{x} = 1 - \frac{p_A - p_B}{t}.$$

The firms’ profit functions are

$$\Pi_A(p_A, p_B) = \hat{x}(p_A, p_B)p_A \quad \text{and} \quad \Pi_B(p_A, p_B) = (1 - \hat{x}(p_A, p_B))p_B.$$

The first-order conditions yield

$$p_{YN}^A = \frac{2t}{3} \quad \text{and} \quad p_{YN}^B = \frac{t}{3}.$$

Under these prices, firm A serves two-thirds of the market and firm B serves one-third of the market. The resulting profits are

$$\Pi_{YN}^A = \frac{4t}{9} \quad \text{and} \quad \Pi_{YN}^B = \frac{t}{9}.$$

Compared to subgame NN, the decrease in horizontal differentiation intensifies price competition, leading to lower equilibrium prices.

Having analyzed the pricing stage, we move one step back to study the customization stage. The firms simultaneously choose between not customizing (N) and customizing (Y). This stage is represented by the matrix in Figure 1. It follows that the unique equilibrium is (N,N) for any value of $k$. In other words, customization does not occur in equilibrium under the benchmark setting.
4 Equilibrium analysis

I will first derive equilibrium prices and profits given the firms’ choices in the customization stage. Obviously, subgame NN leads to the equilibrium outcome of the standard Hotelling model.

Now suppose that both firms customize (subgame YY). In contrast to the Bertrand outcome obtained in the benchmark, the two distinctive components of the model, brand familiarity and category-specific knowledge, create differentiation between the firms’ customized products, relaxing price competition. The firms set their prices above marginal costs, \( p_{YY}^A = p_{YY}^B > 0 \). Because the firms’ prices are equal in equilibrium, consumers with \( x \leq 1/2 \) buy from firm A and the rest from firm B. In other words, all consumers get their preferred varieties! Specifically, we have the following proposition.

**Proposition 1 (Equilibrium prices in subgame YY)  Suppose both firms customize. Then the equilibrium prices and profits are**

\[
p_{YY}^A = p_{YY}^B = \frac{t}{2 \ln 2} \approx 0.72 t
\]

and

\[
\Pi_{YY}^A = \Pi_{YY}^B = \frac{t}{4 \ln 2} \approx 0.36 t.
\]

Consumers with \( x \leq 1/2 \) purchase from firm A and consumers with \( x > 1/2 \) purchase from firm B.

Subgames NY and YN lead to symmetric results. Therefore, it suffices to study one of them, subgame YN. As in the benchmark, firm A (the customizing firm) sets a higher price than firm B in equilibrium. In Proposition 2 I show that the difference between the equilibrium prices is less than \( t/2 \), which implies that none of the consumers familiar with brand A will switch to brand B. Indeed, even consumers with \( x = 1/2 \) (among all consumers familiar with brand A, these consumers are the closest to firm B’s standard
product) derive higher utility from purchasing firm A’s customized product than firm B’s standard product:

\[ p_{YN}^A - p_{YN}^B < \frac{t}{2} \implies v - p_{YN}^A > v - \frac{t}{2} - p_{YN}^B. \]

However, some knowledgable consumers familiar with brand B will buy from firm A. Given \( x > 1/2 \), consumer \((x, y)\) will purchase firm A’s customized product if

\[ v - yt - p_{YN}^A > v - t(1 - x) - p_{YN}^B \]

or

\[ y < \frac{t(1 - x) - p_{YN}^A + p_{YN}^B}{tx}. \]

This is illustrated in Figure 2.

**Proposition 2** (Equilibrium prices in subgame YN) Suppose firm A customizes and firm B does not. Then the equilibrium prices and profits are

\[
\begin{align*}
    p_{YN}^A &\approx 1.39 t \\
    p_{YN}^B &\approx 1.14 t \\
\end{align*}
\]

and

\[
\begin{align*}
    \Pi_{YN}^A &\approx 0.77 t \\
    \Pi_{YN}^B &\approx 0.51 t. \\
\end{align*}
\]

Consumers with \( x \leq 1/2 \), as well as consumers with

\[
x \in \left(\frac{1}{2}, \frac{t - p_{YN}^A + p_{YN}^B}{t}\right)
\]

and

\[ y < \frac{t(1 - x) - p_{YN}^A + p_{YN}^B}{tx}, \]

purchase from firm A; the rest purchase from firm B.
Proceeding with backward induction, we analyze the firms’ equilibrium customization choices in the first stage of the game. The customization stage is presented by the matrix in Figure 3. Hence, we have the following proposition.

**Proposition 3** (Equilibrium customization choices)  
If $k < 0.27t$, $(N,Y)$ and $(Y,N)$ are the two pure-strategy Nash equilibria; if $k > 0.27t$, $(N,N)$ is the unique equilibrium.

Recall that in the benchmark setting no firm customizes in equilibrium, even though all consumers get their most preferred varieties when they purchase from a customizing firm. Here, customization is not frictionless, yet customization by one of the firms occurs in equilibrium for sufficiently small values of $k$!

This apparently surprising result deserves an explanation. On the one hand, customization by one or both firms reduces differentiation between their products, thus increasing price competition. On the other hand, the customizing firm can appropriate the gains by consumers from customization. These gains are lower in the present model compared to the benchmark, as some consumers experience difficulties transferring their needs into concrete product specification. Does this imply that because the benchmark yields $(N,N)$ as the unique equilibrium, then the present model should also result in no customization? A first instinct might be to say yes, but the formal analysis says no, for the following reason.

Consumers’ heterogeneity in category-specific knowledge (in the benchmark all consumers have $y = 0$) adds to product differentiation, thus softening the detrimental effect of customization on price competition. Brand familiarity also helps the customizing firm by creating a loyal customer base. These two additional effects make customization more appealing in the present model than in the benchmark. Provided that $k$ is sufficiently small, $(Y,N)$ and $(N,Y)$ are the two pure-strategy equilibria.\(^7\) As a final note, observe that the aforementioned effects are not strong enough to yield customization by both firms as an equilibrium outcome.

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\(^7\) Obviously, there is also a mixed-strategy Nash equilibrium.
5 Concluding remarks

The existing theoretical studies explore how customizing firms escape disastrous price competition. For example, Dewan, Jing, and Seidmann (2003) develop a model of product customization on a circle, in which two exogenously located firms choose customization scopes (arc segments). The firms do not compete head-to-head, as the scopes are disjointed. Syam, Ruan, and Hess (2005) endow products with two attributes, and the firms in a duopoly decide which attributes to customize. In equilibrium, each firm customizes one and the same attribute, thus minimizing price rivalry. In Loginova and Wang (2010) one firm has a quality advantage over the other. Vertical differentiation relaxes price competition. As the difference between the firms’ qualities increases, the equilibrium changes from no customization, to customization by the higher quality firm, to customization by both firms.

The present paper has offered another explanation of why firms customize, focusing on consumers rather than on customization technology. The key assumption is that consumers do not always possess sufficient knowledge to specify the characteristics of the product that perfectly match their needs. Although customization makes the products less differentiated, the frictions caused by consumer co-design activities work in the opposite direction to relax price competition. Customization by one of the firms occurs in equilibrium.

In the present paper the firms choose their prices simultaneously. One interesting extension is to model the pricing stage as a price leadership game, which is formally analyzed in Yano and Komatsubara (2006). The main result of Yano and Komatsubara is that the technologically superior firm tends to act as the price leader. In the context of customization, this result implies that when following customization by one firm only, the customizing firm would become the price leader in the pricing stage.

Appendix

Proof of Proposition 1: Let $p_A^{YY} = p_B^{YY} = p$ and consider a unilateral deviation by firm A. If firm A decreases its price by $\epsilon$, then some consumers will switch from firm B to firm A. These are consumers with small $y$:

$$v - ytx - p_A > v - p_B$$

or

$$y < \frac{p_B - p_A}{tx} = \frac{\epsilon}{tx}.$$  

Therefore, firm A’s market increases (firm B’s market decreases) by

$$\int_{1/2}^{1} \frac{\epsilon}{tx} dx = \frac{\epsilon \ln 2}{t},$$


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as illustrated in Figure 4. Firm A’s new profit is
\[
\left( \frac{1}{2} + \frac{\epsilon \ln 2}{t} \right) (p - \epsilon) = \frac{p}{2} + \epsilon \left( \frac{p \ln 2}{t} - \frac{1}{2} \right) - \frac{\epsilon^2 \ln 2}{t}.
\]
Equilibrium requires that firm A has no incentives to deviate; hence, it must be that case that
\[
\frac{p \ln 2}{t} - \frac{1}{2} = 0
\]
or
\[
p = \frac{t}{2 \ln 2}.
\]

**Proof of Proposition 2.** It is expected that in equilibrium the customizing firm (firm A) will set a higher price than the non-customizing firm (firm B). Furthermore, competition will keep the difference between the two prices rather small. Therefore, I will restrict my attention to \(p_A\) and \(p_B\) that satisfy
\[
p_B < p_A < p_B + \frac{t}{2}.
\]
(1)
In this case, none of the consumers familiar with brand A will buy firm B’s standard product. However, some of the consumers familiar with brand B will buy firm A’s customized product:
\[
v - yt x - p_A > v - t(1 - x) - p_B
\]
or
\[ y < \frac{t(1 - x) - p_A + p_B}{tx}, \]
as illustrated in Figure 2. Let \( S(p_A, p_B) \) denote the number of these consumers,

\[
S(p_A, p_B) = \int_1^{\frac{1 - p_A - p_B}{t}} \frac{t(1 - x) - p_A + p_B}{tx} \, dx
\]
\[
= \frac{1}{2} - \left(1 - \frac{p_A - p_B}{t}\right) \left(1 - \ln \left(2 \left(1 - \frac{p_A - p_B}{t}\right)\right)\right).
\]

The firms’ profit functions are, therefore,

\[
\Pi_A(p_A, p_B) = \left(\frac{1}{2} + S(p_A, p_B)\right) p_A
\]
and

\[
\Pi_B(p_A, p_B) = \left(\frac{1}{2} - S(p_A, p_B)\right) p_B.
\]

Taking the first-order conditions leads to the system of equations

\[
\begin{cases}
\frac{\partial S}{\partial p_A} p_A + \frac{1}{2} + S = 0, \\
- \frac{\partial S}{\partial p_B} p_B + \frac{1}{2} - S = 0,
\end{cases}
\]
where

\[
\frac{\partial S}{\partial p_A} = -\frac{\partial S}{\partial p_B} = -\frac{1}{t} \ln \left(2 \left(1 - \frac{p_A - p_B}{t}\right)\right).
\]

Let
\[ z = 1 - \frac{p_A - p_B}{t}. \]

Note that (1) implies \( z \in (1/2, 1) \). Then

\[ S = \frac{1}{2} - z(1 - \ln(2z)) \]
and

\[
\frac{\partial S}{\partial p_A} = -\frac{\partial S}{\partial p_B} = -\frac{\ln(2z)}{t}.
\]
The first-order conditions can be rewritten as

\[
\begin{align*}
-\frac{\ln(2z)}{t} p_A + 1 - z(1 - \ln(2z)) &= 0, \\
-\frac{\ln(2z)}{t} p_B + z(1 - \ln(2z)) &= 0.
\end{align*}
\] (2)

Subtracting the first equation from the second and substituting

\[
\frac{p_A - p_B}{t} = 1 - z
\]

yields

\[
\ln(2z)(1 - z) - 1 + 2z(1 - \ln(2z)) = 0.
\] (3)

There is only one solution to (3) on \((1/2, 1)\), approximately equal to \(z^* \approx 0.74\). The equilibrium prices can be found from (2),

\[
p_{YN}^A = \frac{1 - z^*(1 - \ln(2z^*))}{\ln(2z^*)} t \approx 1.39 t
\]

and

\[
p_{YN}^B = \frac{z - z^* \ln(2z^*)}{\ln(2z^*)} t \approx 1.14 t.
\]

Observe that the equilibrium prices satisfy the educated guess (1) made earlier. The equilibrium value of \(S\) is

\[
S^* = \frac{1}{2} - z^*(1 - \ln(2z^*)) \approx 0.05 t.
\]

Hence, the equilibrium profits are

\[
\Pi_{YN}^A = \left(\frac{1}{2} + S^*\right) p_{YN}^A \approx 0.77 t
\]

and

\[
\Pi_{YN}^B \left(\frac{1}{2} - S^*\right) p_{YN}^B \approx 0.51 t.
\]

References

