Does Competition Lead to Customization?

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Abstract

This paper proposes a theory of competition and customization. When firms allocate their production to both custom-made and standardized products, the fraction of sales from the former will increase in the face of increased competition. Recent surveys conducted by the World Bank on Chinese firms provide a rare direct measure of customization that allows us to test the above-mentioned prediction. We find empirical results consistent with the prediction.

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1 Introduction

We study customization as a strategy firms use to cope with competition. We define customization as the costly alteration of a product to tailor it to clients' needs or tastes. One can buy a standardized kitchen cabinet which can be functional but does not perfectly fit the kitchen layout or the tone of the home's interior design. Alternatively, one can order a custom-made kitchen cabinet, functional *and* perfectly matching the interior design.[1]

We focus on customization because the World Bank Enterprise Surveys suggest that it is common in manufacturing.[2] Specifically, the surveys ask firms the percentage of their sales made exclusively to clients' unique specification, with the following remarks: "i.e. you cannot sell to other clients." In China, 41.3% of total sales across all 1,511 manufacturing firms surveyed in 2003 (reporting figures for 2002) belongs to customized products. Of the 1,041 Thai manufacturing firms and 1,080 Malaysian manufacturing firms surveyed in 2007 (reporting figures for 2006), these figures are 44.2% and 39.5%, respectively. While such a percentage varies considerably across industries, customization is generally a non-negligible part of any industry.[3]

In Section 2, we offer a theoretical mechanism through which competition leads to customization. In a spatial competition model à la Hotelling (1929) and Salop (1979), competition intensifies when there is an increase in the number of firms because firms locate closer to one another. What these firms offer, therefore, become less differentiated in the eyes of the consumers. As such, their price competition intensifies. We show that such an increase in competition leads to *an increase in the fraction of sales from customization*. We also show that if this increased competition is caused by a larger market size, firms have an even stronger incentive to customize. The intuition is that custom-made products allow the firm to exercise greater market power over their clients relative to the case where it only offers a standardized product. Customization, therefore, makes the erosion of the firm's profit less dramatic when competition intensifies. Our result remains robust to a number of alternative modeling assumptions.

[1] Customization differs from product proliferation. Polo Ralph Lauren, for example, engages in product proliferation by providing numerous varieties of clothing in color, size, style, etc. More varieties raise the chance of finding a good match but does not eliminate the chance that consumers do not find the ideal clothes they desire. Customization refers to tailor-made clothes, in which case the tailor measures the client's body for exact sizes and asks about the exact colors and styles that the clients desire.

[2] The percentage of customized sales out of total sales for an industry or for all manufacturing firms in a country so reported are calculated as the weighted average of such percentage per firm, where the weights are the sales of each firm. The more specific surveys from which these figures are calculated are the Productivity and Investment Climate Study Thailand (PICS-2007), Productivity and Investment Climate Study Survey 2, Malaysia 2007, and World Bank Investment Climate Survey for China.

[3] This percentage is higher than 14% for 7 out of 9 manufacturing industries in China.

In section 3, we use the detailed firm-level information from the World Bank Enterprise Survey for China in 2003 (for convenience, we call this the *Survey for Chinese Enterprises*; hereafter SCE) to test the prediction that increased competition leads to a larger share of customized sales. The effect of competition on customization has seldom been investigated empirically, primarily due to the difficulty of measuring customization.[4] The SCE asks firms about the proportion of their own sales that is custom-made, providing us a direct measure of customization, which has not been available previously. The SCE also enables us to measure competition using each firm's proportion of its competitors' output that is produced locally.

Consistent with our model, we find increased competition to be significantly associated with a higher degree of customization. This result is robust to the inclusion of more controls, using instrumental variable estimation, using fractional logit, outliers, and using alternative measure of competition. To gauge the economic significance of this result, we calculate that a one standard deviation increase in our competition measure is associated with a 7.58% increase in the percentage of custom-made products/services, or 18.72% relative to the mean of the proportion of customized sales.

Loginova (2010) and Loginova and Wang (2011) have crafted out interesting models of customization. To model customizing, we follow Loginova and Wang (2011), which assumes that investing in customization technology allows firms to offer a set of clients their ideal product varieties. Our model differs from Loginova and Wang in at least three aspects. First, to focus on customization, we do not consider the case in which one firm's product is superior to others in the eyes of all consumers. Second, as data show that firms sell both customized and standardized products, we extend the notion of customization in Loginova and Wang to include customization for only a subset of clients. Third, we opt for Salop's circumference instead of a Hotelling interval, so as to incorporate endogenous entry and therefore the level of competition and the ensuing impact on customization.[5] The way in which we model customized products is also similar in spirit to Alexandrov's (2008) "fat products," which mean that firms can develop products that cover an interval in the space of characteristics. Different from Alexandrov, however, our analysis distinguishes between customized and standardized products and focuses on the effect of competition on the relative intensity of customization.

It is worth emphasizing that customization is conceptually different from product dif-

[4]In addition, Holmes and Schmitz (2010) stress the difficulty of measuring competition as well. As we will discuss in Section 3, our competition measure allows us to circumvent a few common problems of measuring competition.

[5]A circumference with uniformly distributed customers makes no location a priori better than another. Hence, the study of the entry of firms can be more tractable.

ferentiation. For example, in a spatial competition framework, greater entry usually reduces product differentiation, which, in turn, reduces market power and is not in line with the purpose of customization. Our model makes an explicit distinction between differentiation and customization by assuming that a firm, beside choosing its locations in the product space as an effort to *differentiate itself from other firms*, can exert extra effort to *customize its product to a set of consumers*. We show that under increased competition, even though firms become less differentiated due to larger entry, their shares of sales from customized products increase.[6]

The difficulty of measuring customization may be a reason behind its relatively thin empirical research. The closest study of ours is Holmes and Stevens (2012), which estimates a structural model in which an industry is divided between a "primary segment" and a "specialty segment" using confidential plant-level data in the US. Their interpretation of the specialty segment is that these are plants that produce customized products. They estimate that "in most industries, more than half of the plants in an industry can be classified as being specialty segment plants." This U.S. estimate echoes our descriptive statistics mentioned earlier that customization accounts for a significant portion in manufacturing. Their quantitative results show that in the face of a surge in import competition (say, from China), the specialty segment tends to grow significantly more important as a percentage of domestic shipments. They also document the greater survival of plants in specialty segments relative to those in primary segments in the face of fiercer competition. These findings are consistent with our theoretical and empirical results that competition tends to drive up the relative importance of customization. An important message of their study is that there seem to be systematic differences between customized and standardized production, and these differences can have deep economic implications, such as those on theories of firm heterogeneity.[7]

Our paper complements Holmes and Stevens (2012) in two ways. First, instead of assuming that a plant makes either a standardized or custom-made product, firms in our model can produce both standardized and custom-made products. In other words, firms decide their relative intensity of customization. Second, even though they find some

[6]The discussion here pertains to the distinction between customization and horizontal product differentiation. It is interesting to note that Shaked and Sutton (1982) have shown that quality (vertical) differentiation can help to relax price competition.

[7]They show that specialty segment plants are generally smaller, more numerous, and geographically more diffuse, and ship more locally. In the face of fiercer import competition, standard theories of firm heterogeneity predict that large plants are more robust to competition, as they have higher productivity. Their results show that large plants are the hardest hit by competition, rather than the small plants predicted by standard theories. Hence, their results show that it is important to look beyond productivty for explaining firm heterogeneity, and customization is one important dimension as it explains the facts well.

relatively direct evidence of customization in a few industries, they fall short of making a direct link between customization and specialty segments for all industries. In contrast, our data allow us to measure and study customization directly.

Also related is Mazzeo (2002) who empirically examines the motels along interstate highways in the US and finds that motels within larger clusters (thus facing greater competition) have incentives to reduce competition through different product choices (different in quality). This paper differs from Mazzeo (2002) in at least two ways. First, we examine customization per se, whereas the product choice examined by Mazzeo is more of product differentiation. Second, we go beyond a particular industry to demonstrate that our prediction generally holds among several manufacturing industries.

2 A Theory of Competition and Customization

In this section, we use a model to illustrate how competition affects customization. Our model is a Hotelling/Salop type of spatial competition model with a possibility to customize. As is typical in such models, we assume uniformly distributed consumers on a unit circumference, and hence each consumer is an atom-less agent whose unilateral action does not affect the market outcome. In Section 2.3, we show that the result of the model remains robust to modeling assumption that include large clients and a richer bargaining framework between them and firms.

2.1 Model Setup

Consider a market in which each product i is characterized by $x_i \in (0, 1]$ on a circumference. There is a continuum of clients of total mass D and according to their ideal varieties $x \in (0, 1]$ distributed uniformly on the circumference. A client of type x derives utility $v - td(x - x_i) - p_i$ from buying one unit of product i, where v is a positive constant, t is a taste parameter, p_i is the price of product i, and $d(x - x_i)$ is the distance between x and x_i on the circumference.[8] We assume that v is sufficiently large that all clients find a product that yields a positive payoff in equilibrium.[9]

[8] We follow the literature by considering the case that the consumers know their ideal varieties when they order customized products. The same treatment is also taken in Loginova (2010), Loginova and Wang (2011), Dewan, Jing, and Seidmann (2003), Bernhardt, Liu, and Serfes (1995), Mendelson and Parlaktürk (2008), and Syam, Ruan, and Hess (2005). As far as we know, only Syam, Krishnamurthy, and Hess (2008) consider the relatively new type of customization sales in which consumers may have no clue what they want prior to the customization sales.

[9] Note that the model does not impose any restriction on the number of attributes across which firms' products can differ. Cabral (2000) gives examples showing that if a product consists of multiple attributes

There is a large number of ex ante identical potential entrants. Each entrant pays an entry cost ϕ. As in Salop (1979) and Syverson (2004), we assume that all entering firms are evenly spaced; with n firms, each firm is $1/n$ distance away from its two neighboring firms.[10] For ease of presentation, assume that each firm operates with a zero marginal cost of production.[11] Suppose that the closest firms to a client of type x are firm A to the left and firm B to the right. Hence the utility that x enjoys from buying the standardized products of firm A and firm B is $v - td\,(x, x_A) - p_A^G$ and $v - t(\frac{1}{n} - d\,(x, x_A)) - p_B^G$, respectively.

Investing in product-customization technology allows a firm to sell clients their ideal varieties beyond the firm's location. That is, if a client who is located at x is offered a customized product with price p, the client's utility from the product is $v - p$. Given the same price p, the utility from a standardized product from firm i is $v - td\,(x, x_i) - p$. Consuming a customized product increases the consumer's utility by $td\,(x, x_i)$ relative to consuming a standardized one. Customized products, therefore, can in principle be sold at higher prices relative to their standardized counterparts. We denote s to be a firm's *customization scope* if it can produce a customized product for every client up to a distance of s away (on both sides) from its location. For each firm i, choosing customization scope $s_i \geq 0$ costs $C\,(s_i) = \int_0^{s_i} c\,(x)\,dx$, where $c\,(x)$ is the fixed cost of customization for a customer per se who is x distance from the firm. Assume that $c(\cdot)$ is differentiable, strictly increasing, and strictly convex and that $c\,(0) = 0$. That is, the cost of customization increases in distance at a rate that is faster than a linear one (i.e., increasing marginal cost in distance). For clients beyond a distance of s_i away from firm i, however, the firm can sell only a standardized product. Firms set prices for the customized clients individually instead of applying a uniform price.

The game involves three stages.

Stage 1 (entry): potential entrants decide whether to enter.

Stage 2 (customization): firms simultaneously decide their own customization scope.

that are all vertically differentiated, the product itself can be horizontally differentiated where customers' preferences towards the different varieties differ. Cabral (2000, p. 206) states, "most, if not all, real-world examples combine elements of horizontal and vertical product differentiation. In fact, whenever products are defined by more than one characteristic, even if consumers agree that more of each characteristic is better (vertical differentiation), insofar as different consumers value different characteristics differently, we have a case of horizontal product differentiation."

[10] A micro-foundation for Salop's even spacing is provided by Vogel (2008), who shows that mixed-strategy pricing in an auxiliary game can eliminate the possibility of firms undercutting their opponents on price. Under this setup, with the same marginal cost, firms choose to be equi-distant from neighboring firms.

[11] In the Appendix, we show that a positive marginal cost does not alter the main results.

Stage 3 (pricing): with their previous decisions as common knowledge, firms simultaneously choose prices. Customers decide which products to purchase, and profits are realized.

We use backward induction to solve for the subgame perfect equilibrium. Our data shows that firms sell both customized and standardized products. Accordingly, we assume that $c(s)$ increases in s sufficiently fast such that $c\left(\frac{1}{2n}\right) > \frac{Dt}{2n}$ holds. As will be explained, the condition that $c\left(\frac{1}{2n}\right) > \frac{Dt}{2n}$, together with other above-mentioned conditions on c, ensures that the optimal s_i is unique and $s_i \in \left(0, \frac{1}{2n}\right)$. Because $s_i < \frac{1}{2n}$, no two competing neighboring firms' customization scopes overlap, and some consumers must purchase standardized products.

2.2 Analysis

2.2.1 Pricing

Given n evenly spaced firms and customization investments s_i, $i \in \{1, 2, ..., n\}$, we can solve the pricing decisions by looking at a Hotelling duopoly problem in which two firms, A and B, are located at the two end points of $[0, 1/n]$.[12]

Customer $x \in [s_A, \frac{1}{n} - s_B]$ chooses between the two firms in buying a standardized product, i.e., $\max\left\{v - tx - p_A^G, v - t\left(\frac{1}{n} - x\right) - p_B^G\right\}$. A client of type $\tilde{x}$ who is indifferent between the two choices is given by

$$\tilde{x} = \frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}. \tag{1}$$

Note that, for now, $\tilde{x}$ in the above formula may be outside the interval $[s_A, \frac{1}{n} - s_B]$. We show that, indeed, $\tilde{x} \in [s_A, \frac{1}{n} - s_B]$ shortly.

For a client $x \in [0, s_A]$, in addition to the choice of two standardized products from A and B, she can also buy the customized product offered by firm A. Her problem becomes $\max\ \left\{v - tx - p_A^G, v - t\left(\frac{1}{n} - x\right) - p_B^G, v - p_A^x\right\}$. Having sunk customization investment $C(s_A)$, firm A would set price $p_A^x = \min\left\{tx + p_A^G, t\left(\frac{1}{n} - x\right) + p_B^G\right\}$ to capture the sales from $[0, s_A]$. In equilibrium, $p_A^x = tx + p_A^G$. In other words, the firm's pricing of its customized product is constrained by the price of its own standardized product. To see

[12] d'Aspremont, Gabszewicz, and Thisse (1979) show that equilibrium may not exist in the pricing stage if the distance between two neighboring firms is *so close* that *undercutting* the price of neighboring firms is optimal. This issue arises in Salop's setup if n is too large or t is too small. To avoid this problem, we assume a sufficiently large t or a sufficiently large entry cost ϕ, such that n is small. An alternative is to resort to the possibility of mixed-strategy pricing in the auxiliary game proposed by Vogel (2008), who proves the existence of a pure-strategy price equilibrium under such a possibility.

this, suppose on the contrary that $t\left(\frac{1}{n}-x\right)+p_B^G < tx+p_A^G$, which implies that $\tilde{x} < s_A$, and all clients in $(s_A, \frac{1}{n}]$ will purchase products from firm B. As long as $\tilde{x} < s_A$, increasing p_B^G would benefit B because the clients in $(s_A, \frac{1}{n}]$ will continue to buy from it. Thus, equilibrium price p_B^G must satisfy the condition that $\tilde{x} \geq s_A$, which, in turn, means that $t\left(\frac{1}{n}-x\right)+p_B^G \geq tx+p_A^G$ for all $x \in [0, s_A]$. Hence, $p_A^x = tx + p_A^G$. A similar argument for firm B implies that $\tilde{x} \leq \frac{1}{n} - s_B$, implying that $\tilde{x} \in [s_A, \frac{1}{n} - s_B]$.

Assume that the market size (or indeed the density) $D = 1$ for ease of exposition. We will make D a general number when we discuss the impact of market size. Using (1), we write firm A's profit as a function of p_A^G and p_B^G:

$$\begin{aligned}
\pi_A(p_A^G; p_B^G) &= (\tilde{x} - s_A)\, p_A^G + \int_0^{s_A} p_A^x dx, \\
&= \left(\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t} - s_A\right) p_A^G + \int_0^{s_A} \left(tx + p_A^G\right) dx, \qquad (2)\\
&= \left(\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}\right) p_A^G + \int_0^{s_A} tx dx. \qquad (3)
\end{aligned}$$

This expression implies that customization, or the lack thereof, has no effect on how optimal price p_A^G is determined, given p_B^G. The first-order condition for p_A^G is the same as that for a standard Hotelling problem, which is also the case for p_B^G. These solutions are $\widehat{p}_A^G\left(p_B^G\right) = \frac{t}{2n} + \frac{p_B^G}{2}$ and $\widehat{p}_B^G\left(p_A^G\right) = \frac{t}{2n} + \frac{p_A^G}{2}$. Thus, the equilibrium price pair is $\left(\frac{t}{n}, \frac{t}{n}\right)$, and $\tilde{x} = \frac{1}{2n}$.

2.2.2 Customization stage

Plugging equilibrium price pair $\left(\frac{t}{n}, \frac{t}{n}\right)$ into (2), the equilibrium profit of firm i from investing $C\left(s_i\right)$ is thus

$$\begin{aligned}
\pi_i\left(s_i\right) &= \left(\frac{1}{2n} - s_i\right)\frac{t}{n} + \frac{ts_i^2}{2} + \frac{ts_i}{n} - C\left(s_i\right) \qquad (4)\\
&= \frac{t}{2n^2} + \frac{ts_i^2}{2} - C\left(s_i\right). \qquad (5)
\end{aligned}$$

The optimal customization scope, s_i^*, satisfies $ts_i^* = C'\left(s_i^*\right) = c\left(s_i^*\right)$. This condition says that the cost of customizing for the marginal consumer, s_i^*, equals the the gains from customization, ts_i^*. Since $c'\left(0\right) < t$, $c\left(s\right) < ts$ holds in a neighborhood of 0. Thus, $s_i = 0$ is never optimal. That c increases fast enough so that that $c(\frac{1}{2n}) > \frac{t}{2n}$ implies that an s_i^* satisfying $ts_i^* = c\left(s_i^*\right)$ exists. That c is strictly convex guarantees the uniqueness of s_i^*.

Does increased competition lead to a larger share of sales from customization? Dividing the sum of the second and third terms by that of the first three terms in (4) gives the share of sales from customization:

$$r = \frac{s_i^2 n^2 + 2ns_i}{s_i^2 n^2 + 1}, \tag{6}$$

which is strictly increasing in n. Increasing n intensifies price competition. The resulting low prices decrease the sales of both the customized and standardized products, but disproportionately more so for the sales of the standardized products. To see this, notice that the second term in (4) does not depend on n. In other words, the sales of customized products are more robust to increased competition precisely because firms can price-discriminate each of the clients offered customized products.

The optimal customization scope, s_i^*, gives an alternative way to see how increased competition leads to a larger share of sales from customization. Since s_i^* is such that $ts_i^* = c(s_i^*)$, the optimal customization scope does not depend on n. Meanwhile, as n increases, the number of clients still buying standardized products, $\frac{1}{n} - 2s_i^*$, necessarily decreases, or, put differently, the proportion of clients offered customized products, $2s_i^*/(\frac{1}{n}) = 2ns_i^*$, necessarily increases.

2.2.3 Market size and customization

What induces an increase in competition? We offer one potential reason: a larger market. Relax $D = 1$ to a general $D > 0$. As is standard, increasing D weakly increases the number of firms n (*weakly* because n is an integer number). We omit these uninteresting details, and simply denote such a relation by $n^*(D)$, knowing that it is weakly increasing in D and the number of entrants depends on the entry cost ϕ.

As the magnitude of D does not affect pricing, the profit of firm i in the customization stage is

$$\begin{aligned} \pi_i(s_i) &= D\left\{\left[\frac{1}{2n^*(D)} - s_i\right]\frac{t}{n^*(D)} + \frac{ts_i^2}{2} + \frac{ts_i}{n}\right\} - C(s_i) \\ &= D\left[\frac{t}{2\left[n^*(D)\right]^2} + \frac{ts_i^2}{2}\right] - C(s_i). \end{aligned} \tag{7}$$

The first-order condition is

$$Dts_i^* = c(s_i^*). \tag{8}$$

Hence, the optimal customization scope, denoted by $s_i^*(D)$, must be strictly increasing in D. Similar to the arguments above, the condition $c(\frac{1}{2n}) > \frac{Dt}{2n}$, together with other conditions on c, ensures that a unique $s_i^*(D) \in \left(0, \frac{1}{2n}\right)$ exists. The formula for the share of sales from customization from (7) is the same as (6), except that now $n = n^*(D)$ and $s_i = s_i^*(D)$. Increasing D raises n^*, which leads to a larger r if there is no change in s_i^*, for the same reason discussed previously. In addition, because s_i^* also increases in D, the increase in r is even larger. We summarize our results in the following proposition.

Proposition 1. *(a) An exogenous increase in competition, i.e., an increase in the number of firms n, leads to a larger share of sales from customization, r, whereas each firm i's customization scope s_i^* remains unchanged, which also implies that the proportion of clients offered customized products, $2ns_i^*$, increases in n. (b) An endogenous increase in competition induced by a larger market size D leads to both a larger share of sales from customization, r, and larger customization scope, s_i^*.*

These results are robust to alternative assumptions in three different parts of the model. We sketch the main intuitions below and delegate detailed proofs and discussions to the Appendix.

Instead of zero variable costs, we can easily incorporate positive variable costs. Suppose that the marginal cost is a *constant* $a + \delta \geq 0$, where $a \geq 0$ is the marginal cost of producing standardized products, and $\delta \geq 0$ allows for the possibility that customized products are more costly to produce. As such, the equilibrium price pair for the standardized products increases from $\left(\frac{t}{n}, \frac{t}{n}\right)$ to $\left(\frac{t}{n} + a, \frac{t}{n} + a\right)$. The customized price remains tx above the standardized price, i.e., $p_A^x = p_A^G + tx$, leaving the customization benefit unchanged at tx. As the customization scope is determined by the location s_i^* such that the customization benefit equals to the customization cost, the corresponding equation changes from $ts_i^* = c\left(s_i^*\right)$ to $ts_i^* = c\left(s_i^*\right) + \delta$. Whereas the existence of $\delta > 0$ reduces the incentive to customize, the number of firms n is still not involved in the determination of s_i^*. Hence, Proposition 1 continues to hold.

We have assumed that firms first make their customization decisions before pricing. Suppose they make their customization and pricing decision at the same time. For firm A, this means subtracting $C\left(s_A\right)$ from (3), and firm A chooses p_A^G and s_A simultaneously to maximize $\pi_A(p_A^G, s_A; p_B^G)$. The first-order conditions remain the same, and so do all the results. This is because the first-order conditions for s_i^* do not involve the standardized prices. The customization benefit (tx) and cost ($c\left(x\right)$) only depend on the distance x but not on the standardized prices or the number of firms n. Similar logic applies to the case in which the customization decision is made after the pricing stage.

Rather than assuming price-taking consumers, suppose firms and their customers engage in Nash bargaining. Buying the standardized product becomes customers' disagreement outcome. The gains from a customization deal are tx. Suppose the firm's bargaining power is $\beta \in (0, 1)$. Then, $p_A^x = p_A^G + \beta tx$. All results continue to hold, and the model is simply a case in which $\beta \to 1$.

2.3 An Alternative Model: Large Client and Bargaining

2.3.1 Setup

In some cases of customization, large consumers can be first movers in the market, shopping among those firms that could potentially accommodate them, with price being negotiated in the process. We offer an alternative model to consider this scenario.

Assume that there is a single large client with demand $D > 0$ located at $x \in [0, 1)$. This large client can also be interpreted as a mass of clients each demanding one unit, and they act collectively. For tractability, we focus on this large client and assume no other consumers.[13] Assume that entrants do not know about the exact location of x before they enter. Since firms do not know the location of the clients, even spacing of firms still applies. After entry, the firms learn about the exact location of x.[14] Without loss of generality, suppose that $x \in \left[0, \frac{1}{2n}\right]$, where the firm at 0 is called firm A and that at $\frac{1}{n}$ firm B. When there is a locational advantage of a firm, i.e., $x < \frac{1}{2n}$, then this firm is generically called A. The large client can choose one of the firms to negotiate a deal on a customized product. If a deal is reached and executed, then the game ends, and if not, then firms will offer standardized products to the large client, as in the basic model. The rest of the model setup remains the same. Below is the game's timeline.

Stage 1: Potential entrants simultaneously decide whether to enter. To enter, an entrant has to pay an entry cost ϕ.

Stage 2: The large client chooses one firm to negotiate a deal on a customized product. The game ends if a deal is agreed (and then executed) by both parties. Otherwise, the game goes on to the next stage.

Stage 3: Firms simultaneously decide their prices for their standardized products, and the large client decides from whom to purchase a standardized product.

We use Nash's bargaining solution. We present the main arguments and results; the Appendix contains the detailed proofs and discussions.

[13] The model will lose significant tractability when we combine this large client with uniformly distributed small clients.

[14] That firms do not know x before they enter reflects the uncertainty of the consumer's actual preference that firms face. It is also made to justify the even spacing of firms, as the location choice of firms is not the focus of our analysis.

2.3.2 Analysis

In Stage 3, given prices p_i^G, $i \in \{A, B\}$, the large client's utility of purchasing from A and B are $D\left(v - tx - p_A^G\right)$ and $D\left[v - t\left(\frac{1}{n} - x\right) - p_B^G\right]$, respectively. This implies a price war between two firms in a Bertrand fashion. In equilibrium, the client purchases from A, $p_A^G = t\left(\frac{1}{n} - 2x\right)$, and firm A's profit is $\pi_A^G = Dt\left(\frac{1}{n} - 2x\right)$.

In Stage 2, whatever can be achieved by bargaining with firm B can be achieved by bargaining with firm A. In equilibrium, bargaining only occurs between the large client and firm A. In any customization deal, $c(x)$ has to be paid by firm A, and the large client can obtain a utility of $D\left(v - p_A^x\right)$. As the disagreement outcome is given by Stage 3's equilibrium outcome, Nash's bargaining solution is given by the p_A^x that gives each player half of the total gains from customization,[15] that is,

$$D\left(v - p_A^x\right) - D\left(v - tx - p_A^G\right) = \frac{1}{2}\left[Dv - D\left(v - tx - p_A^G\right) - c(x) - \pi_A^G\right] = \frac{1}{2}\left[Dtx - c(x)\right].$$

Thus, $p_A^x = \frac{c(x)}{2D} + \frac{t}{2}\left(\frac{2}{n} - 3x\right)$. Such a deal involving p_A^x will only be reached if and only if the total gains from customization are nonnegative, i.e., if and only if $c(x) \leq Dtx$.

Given n firms and realization of x, the large client either purchases a customized product or a standardized one, depending on whether $c(x) \leq Dtx$ holds. The realizations of the random variable x, however, can be interpreted as different (niche) markets or a market at different times. Thus, we exploit this nature to proxy the share of customized sales by the expected sales of customized products relative to the total expected sales. Without prior information of x and with even spacing, x is uniformly distributed on $\left[0, \frac{1}{2n}\right]$ with density $f(x) = 2n$. Let $\hat{x}$ be such that $c(\hat{x}) = Dt\hat{x}$ (note its similarity to (8)), and recall that c increases in x fast enough so that $\hat{x} < \frac{1}{2n}$. The share of customized sales r is

$$r = \frac{\int_0^{\hat{x}} p_A^x Df(x)\,dx}{\int_{\hat{x}}^{\frac{1}{2n}} p_A^G Df(x)\,dx + \int_0^{\hat{x}} p_A^x Df(x)\,dx} = \frac{\frac{1}{2Dt}\int_0^{\hat{x}} c(x)\,dx + \frac{\hat{x}}{n} - \frac{3\hat{x}^2}{4}}{\left(\frac{1}{2n} - \hat{x}\right)^2 + \frac{1}{2Dt}\int_0^{\hat{x}} c(x)\,dx + \frac{\hat{x}}{n} - \frac{3\hat{x}^2}{4}}.$$

Proposition 2. *(a) An exogenous increase in competition, i.e., an increase in the number of firms n, leads to a larger expected share of sales from customization, r. (b) Suppose that $c(x) = x^b$ for any $b > 1$. Then, an endogenous increase in competition induced by a larger market size D leads to a larger expected share of sales from customization, r.*

For result (b), the functional form assumption is a sufficient condition made for tractability. That $b > 1$ is consistent with c being strictly convex.

[15] Here, we assume equal bargaining power between the firm and the client. It is a straightforward exercise to extend this to a general bargaining power.

3 Empirical analysis

3.1 Data and Background

3.1.1 Data

Our empirical analysis draws on data from the Survey for Chinese Enterprises (SCE), which was carried out by the World Bank in cooperation with the Enterprise Survey Organization of China in early 2003. For balanced representation, the SCE covered 18 prefecture-level cities in five geographic regions of China: Benxi, Changchun, Dalian, and Harbin in the Northeastern region; Hangzhou, Jiangmen, Shenzhen, and Wenzhou in the Coastal region; Changsha, Nanchang, Wuhan, and Zhengzhou in the Central region; Chongqing, Guiyang, Kunming, and Nanning in the Southwestern region; and Lanzhou and Xi'an in the Northwestern region.

In each of these cities, the SCE randomly sampled 100 or 150 firms from nine manufacturing industries (garments and leather products, electronic equipment, electronic parts making, household electronics, auto and auto parts, food processing, chemical products and medicine, biotech products and Chinese medicine, and metallurgical products) and five service industries (transportation services, information technology, accounting and non-banking financial services, advertising and marketing, and business services). A total of 2,400 enterprises were surveyed.

The SCE contains two parts. The first is a general questionnaire directed at senior management that seeks information about the enterprise, such as degree of innovation, product certification, marketing, relations with suppliers and customers, access to markets and technology, relations with government, labor force, infrastructure, involvement in international trade, finance, and taxation, and information on the CEO and board of directors. The second questionnaire is directed at accountants and personnel managers and covers ownership, various financial measures, and labor and training. Most of the information in the first part of the SCE pertains to the survey year, 2002, whereas that in the second part pertains to the 2000-2002 period.

As service industries are largely localized and customized, we focus here on the manufacturing firms in the SCE. There are 1,566 manufacturing firms, but 55 of them did not report customized sales.

3.1.2 Background and Descriptive Analysis

Table 1 reports the total customized sales as a percentage of total sales in the entire sample, in each industry, and in each city. This is calculated as the weighted mean of each

Table 1: Customization Across Cities and Industries

	Custom-Share	Custom-Mean	Obs.
Entire Sample	0.413	0.406	1,511
Industry			
Garment & leather products	0.343	0.488	345
Electronic equipment	0.690	0.358	178
Electronic parts making	0.468	0.418	271
Household electronics	0.346	0.355	61
Auto & auto parts	0.226	0.450	348
Food processing	0.148	0.149	67
Chemical products & medicine	0.099	0.234	58
Biotech products & Chinese medicine	0.061	0.140	28
Metallurgical products (manuf.&tools)	0.650	0.408	155
City			
Benxi	0.428	0.391	62
Changchun	0.267	0.536	100
Changsha	0.248	0.346	100
Chongqing	0.139	0.305	100
Dalian	0.690	0.558	61
Guiyang	0.206	0.320	83
Harbin	0.095	0.513	99
Hangzhou	0.374	0.421	65
Jiangmen	0.307	0.398	66
Kunming	0.141	0.332	94
Lanzhou	0.590	0.381	96
Nanchang	0.237	0.531	97
Nanning	0.209	0.211	62
Shenzhen	0.783	0.519	62
Wenzhou	0.167	0.358	66
Wuhan	0.335	0.346	99
Xi’an	0.505	0.411	99
Zhengzhou	0.499	0.431	100

Source: Authors’ calculations with SCE data.

firm's such percentage with weights being each firm's sales and shown under the column Custom-Share. Table 1 also reports the unweighted mean under the column Custom-Mean. In the entire sample, 41.3% of total sales is custom-made. As mentioned in the introduction, Thailand and Malaysia have similar figures among their manufacturing firms.

There can be important difference in customization between developed countries and developing ones. Suppose that manufacturing firms in the US and China form a supply chain in which Chinese firms are largely upstream and American firms are largely downstream. In the US, as shown by Holmes and Stevens (2012), customization is an important part of consumer goods production. However, a standardized consumer good in the US may require upstream manufacturing firms in China to tailor their production to provide suitable parts for such a standardized good sold in the US. This is especially true where there is significant product proliferation in the consumer goods in the US. This then implies that customization could be much more profound and widespread in developing countries, if such countries are deeply involved in the supply chains.

While we do not have data to support the above conjecture, the MIT Smart Customization Group (SCG), an MIT-Industry collaboration, gives a similar perspective on the importance and role of customization in China. The SCG hosts a large-scale conference on customization every two years. The importance of customization in China's manufacturing can be shown by their choice of locations; both the first and the third conference took place in China, that is, in Hong Kong in 2001 and in Hong Kong and Hangzhou in 2005. Frank Piller, a faculty of SCG, summarizes the 2005 conference with the following description on China, "most often, China is however discussed in western countries as a manufacturing place for custom goods. While there is a large debate if logistic disadvantages would not favor local manufacturing of custom goods close to the markets, several western brands are sourcing the custom goods from China: Most custom sneakers and fashion shoes are produced in Guangzhou for the US and European market, Also, several large US brands like Nordstorm, Polo Ralph Lauren or Tommy Hilfinger are producing some of their custom garments in China. This trend may increase." Their 2005 conference includes visits to Chinese firms such as Youngor (customized shirt manufacturer), Hong Hua (customized fabric manufacturer), and Ai Ke Software (customized CAD systems).[16]

Table 1 shows that the percentage of customized sales differs significantly across industries and across cities. For example, Garment & Leather Products, Auto & Auto Parts, and Metallurgical Products industries exhibit a higher degree of customization, while much less customization has been found in the Food Processing and Biotech & Chinese Medicine industries. These results are consistent with our intuition; the products in the

[16]The data source is www.mcpc2005.com.

Table 2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Custom-made	1,511	0.406	0.419	0	1
Competition	1,507	0.273	0.337	0	1
Firm characteristics					
Firm Size	1,563	5.040	1.453	0	9.899
Firm Age	1,566	2.494	0.777	1.099	3.970
Private Ownership	1,566	0.796	0.389	0	1
Labor Productivity	1,332	3.503	1.574	-3.761	11.150
Skilled Labor	1,542	0.026	0.060	0	1
CEO characteristics					
CEO Education	1,553	15.359	2.511	0	19
CEO Tenure	1,548	6.240	4.580	1	33
Deputy CEO Previously	1,548	0.280	0.449	0	1
Government Cadre Previously	1,548	0.036	0.185	0	1
Party Member	1,524	0.648	0.478	0	1
Government-appointed	1,544	0.243	0.429	0	1
Instrumental variable					
Local Clients	1,542	0.331	0.362	0	1
Local Suppliers	1,541	0.373	0.349	0	1
Additional controls					
Clients' Duration Dummies					
<1 yr	1,549	0.039	0.193	0	1
1 to 2 yrs	1,549	0.073	0.260	0	1
2 to 3 yrs	1,549	0.125	0.331	0	1
3 to 4 yrs	1,549	0.126	0.332	0	1
>4 yrs	1,549	0.637	0.481	0	1
Custom-made Component	1444	0.068	0.221	0	1

Source: Authors' calculations with SCE data.

former three industries are quite differentiated (or, quite a large degree of product proliferation) whereas those in the latter two are rather homogeneous. Inland cities (like Nanning, Chongqing, Guiyang) also witness a lower degree of customization than do coastal cities (like Dalian, Shenzhen, Harbin), where firms there generally face more intense competition than do firms in inland cities. The case of Shenzhen is particularly interesting, as it is a well-known manufacturing base in China, and it has the highest percentage of customized sales, at 78.3%, among all cities in the sample. We also calculate the correlation coefficient between a city's customization share reported in Table 1 and a city's road distance to the nearest large sea ports, and this number is -0.43.[17] All these seem to suggest that there may be an important link between trade and customization due to the above-mentioned supply chain rationale.

In Table 2, we report summary statistics for an array of variables that will be used in our empirical analysis. The first two variables, *Custom-made* and *Competition*, are the main focus of the empirical analysis. As mentioned, *Custom-made* is measured by a firm's percentage of customized sales, where as *Competition* is measured as each firm's proportion

[17] For this calculation, we pick the largest six sea ports in China; Shanghai, Hong Kong, Ningbo, Qingdao, Tianjin, and Dalian. Shenzhen is also a very big port, but location is very near Hong Kong.

of its competitors' output that is produced locally. The large standard deviations of these variables across firms suggests that there are substantial variations from which to draw inferences.

3.2 Empirical approach

We test whether increased competition leads to a larger share of sales from customized products by estimating the following equation:

$$Custom\text{-}made_{fic} = \alpha + \beta \cdot Competition_{fic} + Z^{'}_{fic}\gamma + \upsilon_{fic}, \tag{9}$$

where f, i, and c index firm, industry, and city, respectively.

The measure of our dependent variable, $Custom\text{-}made_{fic}$, comes from the SCE's question about the percentage of a firm's sales made to clients' unique specifications (i.e., its sales of products that cannot be sold to other clients).[18]

We make two remarks on our measure.[19] First, it would have been ideal if all surveyed firms conceive that, if not for a particular customer, that product would not have been produced based on the survey's specific remark: "cannot sell to other clients." We, however, cannot entirely rule out the possibility that it may have been some long-term commitments between the firm and its clients that prevent its products, even standardized, from being sold to other clients. This problem, if serious but random, would contaminate our measure by making our dependent variable more noisy, biasing against us by making it harder to find any significant relationship between the dependent variable and our regressor of interest. Nevertheless, in our estimation, we include a variable indicating whether a firm has signed any contracts with its clients to partially control for the long-term commitments issue.[20]

Second, product customization involves a relatively new approach where customers are actively involved in the product design. Thomke and Hippel (2002), for instance, examine this relatively new approach to production. Syam, Krishnamurthy, and Hess (2008) provide an explicit model of the situation in which customers are uncertain about their own preferences. They show that if customers anticipate their regret on their customized products, firms would change their product strategies. The famous businessman, Richard

[18] The exact words in the World Bank survey are: "What percent of your sales are made to your clients' unique specification (i.e. you cannot sell to other clients)?"

[19] We are grateful to an anonymous referee for suggesting these two remarks.

[20] Alternatively, we have also estimated using a sub-sample of firms without signing any contracts with their clients (in which case the long-term commitments issue is less prominent) and find similar results (available upon request).

Branson (2012), in his new book, also shares his view on the fact that many customers do not know what they want. A great business is to help customers find out what they want. In theory, we incorporate neither the new type of product design involving the customers, nor customers being not certain about their own preferences. In our measure, however, we cannot rule out customization with active customer involvement, or uncertain preferences.

The regressor of interest, $Competition_{fic}$, concerns market competition. In the model, any rivals locating closer to the firm intensifies price competition and toughens competition. If a client walks away from a potential deal with a firm, how easy is it for her to find another firm to buy from? If there are plenty of rivals offering similar products located within a close distance, price competition should be intense. We capture such a notion of market competition by the percentage of competitors' output produced *within* the same city.[21] Consider two polar cases. If a firm reports that all their competitors produce in other cities, the firm's clients would find it challenging to find another nearby firm to buy from. In contrast, if a firm reports that all their competitors produce within the city, the firm's clients would find it relatively easier. Price competition would be more intense in the latter than in the former.

This proximity of rivals leading to increased competition argument can be made independent of the locations of the clients.[22] The reason is that location is one of the many attributes of the product offered by a firm. Holding constant the distribution of the product attributes among firms, the closer they are located, the more competition they face because their products are becoming more "similar" at least in the location attribute. Within our theoretical model, that also means that firms are located closer to each other, and therefore less differentiated in the eyes of the potential clients. Nonetheless, in all the regressions, we include industry dummies, which helps us control for the heterogeneity in transportation and hence the geographic distribution of product market across industries. Furthermore, we conduct a robustness check by focusing on a sub-sample of firms whose main market is located locally (i.e., the same city).

Our measure of competition circumvents two problems. First, the intensity of competition hinges on who a firm is competing with. The key questions concern: (a) how competent are the rivals; and (b) how available are competent rivals to the firm's potential clients. The number of firms and market concentration can at best only partially capture

[21]The exact words in the World Bank survey are, "considering all your competitors, what percentage (in terms of output) have located their plants: (1) In the same district as your plant; (2) Outside your district but in the same city area as your plant." Our measure is the sum of these two percentages.

[22]We thank an anonymous referee for mentioning clients' locations, which inspired us to think further on their relation to our competition measure.

the answers to these key questions. Demsetz (1995) argues that unless one is willing to impose a Cournot-type competitive environment, the number of firms in an industry can only poorly reflect the intensity of competition. Holmes and Schmitz (2010) show how the lifting of entry barriers can lead to an increase in market concentration, making increased competition positively, but not negatively, related to market concentration. While it is related to market concentration and the number of firms within an industry, our competition measure directly connects to the ease of a firm's potential clients in finding another nearby rivals.

Second, tackling firm heterogeneity necessitates a firm-level analysis, as opposed to an industry-level analysis. Measuring competition thus requires firm-level variation, a unique feature possible in our competition measure. Conducting estimation at the industry-level cannot avoid the implicit assumption that every firm within an industry faces the same level of competition, a strong and unrealistic assumption sensitive to how industries are categorized and the degree of firm asymmetry.

Our measure comes with its own shortcomings. Unlike the total number of firms in the same industry and city used in Holmes and Stevens (2002) and Henderson (2003), which can be measured objectively, our measure is subjective. Arguably, a firm's answer (with regard to customization) is based on its perception of the competition. As long as firms in the same industry and city potentially face different degrees of competition (e.g., large versus small firms), our subjective measure is able to capture this heterogeneity in responses. However, it may suffer from the problem of idiosyncratic observational error or misreporting. We detail our approach to tackle this measurement error problem later in this section. We also experiment with an objective measure (i.e., the total employment of other firms in the same industry within the same city) as a robustness check.

To deal with the possible heteroskedasticity, we cluster the standard errors at the industry-city level.

3.2.1 Omitted variables

It is plausible that $Competition_{fic}$ is correlated with the error term ε_{fic}, thus biasing the estimation of β. One prominent set of omitted variables includes industrial differences, such as differences in entry barriers (e.g., ϕ), customization technology (e.g., s_i), and taste (e.g., t). To address this concern, we include industry dummies in the estimation. We also include city dummies to account for any potential city differences. To further control for variations across industries within a city, we saturate the estimation model with industry-city dummies.

Another prominent set of omitted variables encompasses those related to firm capability. Picone, Ridley, and Zandbergen (2009) show that firms with a greater ability to differentiate their products are more likely to cluster strategically. To single out the effect of competition on customization, we control for a list of firm[23] and CEO characteristics commonly used in the literature.[24] To avoid the "bad control" problem, we employ the lagged values of these variables, as in the regression, wherever possible (Angrist and Pischke, 2009).

3.2.2 Instrumental variables

Being subjective makes our competition measure prone to measurement error. Theoretically, it is difficult to say whether and why firms in more competitive environments are more (or less) likely to misreport the degree of competition. The long list of controls in the regression analysis may allow us to control for certain systematic patterns in the measurement error across firms, although the existence of the white-noise type of measurement error may drive the estimated coefficient β towards zero against any significant findings. We resort to the instrumental variable approach to address this measurement error problem, which also further addresses concerns over omitted variables. We use two instruments.

We show in Section 2.2.3 that increasing the number of consumers indirectly leads to a larger share of sales from customized products through toughening competition (see equation (6)). To see the intuition, consider the classic Hotelling model with two firms locating at the end of a Hotelling interval. The location of the marginal client reflects their pricing strategies, which in turn hinge on how close the two firms are (or how differentiate they are) but not how many clients they are competing for. If taking into account the fixed entry cost, a larger group of clients makes an additional firm believe that it is profitable to enter the market. The degree of differentiation among the three firms would change. Price competition becomes tougher not directly because of the increase in the client base,

[23]The variables related to firm characteristics include *Firm Size* (measured by the logarithm of 2001 total employment), *Firm Age* (measured by the logarithm of years of establishment), *Private Ownership* (measured by the share of equity owned by private parties in 1999), *Labor Productivity* (measured by the logarithm of output per worker in 2001), *Skilled Labor* (measured by the share of workers in 2001 who dealt with advanced technology), and *Client Contract* (a dummy variable indicating whether a firm has signed any contracts with its clients).

[24]The variables concerning CEO characteristics are his or her human capital, including *CEO Education* (years of schooling), *CEO Tenure* (years of being CEO), and *Deputy CEO Previously* (a dummy variable indicating whether the CEO was the firm's deputy CEO before he or she became its CEO), and political capital, including *Government Cadre Previously* (a dummy variable indicating whether the CEO was a government official before he or she became CEO), *Party Member* (a dummy variable indicating whether the CEO is a member of the Chinese Communist Party), and *Government-appointed* (a dummy variable indicating whether the CEO was appointed by the government).

but because it makes it more likely for any firm's clients to buy from a closer substitute. Such a natural exclusion restriction makes the number of consumers a good instrumental variable for the competition measure.[25] One question in the SCE asks respondents about the percentage of the firm's clients (in terms of sales) that are located in the same city as the firm. We construct our first instrument, *Local Clients*, accordingly.[26]

We exploit the intuition that any forces that drive more firms into an industry are natural candidates for instrumental variables. Although not shown explicitly in the model, if the entry cost ϕ reduces, it weakly increases the number of firms entering the market. Controlling for industry-city dummies and firm-level characteristics, what additional measures would constitute a reduction of such an entry cost? Krugman and Venables (1995) and Venables (1996) provide a hint. They show that the clustering of manufacturers is positively correlated with that of their suppliers due to the vertical linkage. Nearby suppliers facilitates the setup of business networks and distribution channels, making entry cheaper.[27] Accordingly, we construct our second instrument, *Local Suppliers*, which is the percentage of a firm's suppliers (in terms of sales) that are located in the same city as the firm.[28]

3.3 Empirical results

Columns 5 and 6 of Table 3 show that both instruments are positively and statistically significantly correlated with the key explanatory variable (*Competition*). The Kleibergen-Paap rk Lm statistic further confirms that the instruments are relevant, and the Kleibergen-Paap Wald rk F statistic rules out the concern over weak instruments.

Column 1 also shows that *Competition* (being instrumented) has a positive and statistically significant association with the degree of customization.

We include firm and CEO characteristics in Column 2. Although we believe that the

[25]Consistent with the rationale of this instrumental variable, Krugman (1991) shows that the clustering of manufacturers is positively correlated with that of consumers due to the demand-supply linkage.

[26]The exact words in the World Bank survey are, "Measured by sales, where are the purchasers of the products in your main business line located: (1) In the same district as your plant; (2) Outside your district but in the same city area as your plant." Our measure is the sum of these two percentages.

[27]We do not intend to rule out the possibility that more nearby suppliers lower the marginal cost of production. But our model has shown that the crucial result that competition leads to customization does not hinge on assuming a positive marginal cost of production. Therefore, lowering the marginal cost down to zero does not alter our central theoretical prediction. One can also envision that adding a positive marginal cost in a standard Hotelling model does not alter the fact that differentiation drives a wedge between the marginal cost and the price the firms charge.

[28]The exact words in the World Bank survey are, "Measured by expenditures, where are your plant's suppliers located? Please give the percentage between the following 4 locations: (1) In the same district as your plant; (2) Outside your district but in the same city area as your plant." Our measure is the sum of these two percentages.

Table 3: Customization and Competition: Instrumental Variable Estimation

	1	2	3	4	5	6
	IV 2nd stage		OLS		IV 1st stage	
Dep. Var.	Custom-made				Competition	
Competition	0.202*	0.227*	0.121***	0.129***		
	[0.118]	[0.118]	[0.032]	[0.034]		
Firm characteristics						
Firm Size		0.001		-0.003		-0.020***
		[0.012]		[0.012]		[0.007]
Firm Age		-0.003		0.002		-0.021
		[0.019]		[0.020]		[0.016]
Private Ownership		0.028		0.032		0.013
		[0.032]		[0.034]		[0.025]
Labor Productivity		0.007		0.006		-0.005
		[0.008]		[0.008]		[0.006]
Skilled Labor		-0.118		-0.149		-0.021
		[0.200]		[0.215]		[0.206]
Client Contract		0.046		0.05		0.047
		[0.056]		[0.058]		[0.031]
CEO characteristics						
CEO Education		0.003		0.002		-0.003
		[0.006]		[0.006]		[0.004]
CEO Tenure		0.003		0.004		0.003
		[0.003]		[0.003]		[0.002]
Deputy CEO Previously		0.041		0.044		0.023
		[0.026]		[0.026]		[0.018]
Government Cadre Previously		0.041		0.067		0.074
		[0.063]		[0.068]		[0.054]
Party Member		-0.05		-0.051		-0.013
		[0.031]		[0.032]		[0.020]
Government-appointed		0.024		0.019		-0.019
		[0.029]		[0.030]		[0.024]
Instruments						
Local Clients					0.375***	0.354***
					[0.034]	[0.035]
Local Suppliers					0.122***	0.123***
					[0.029]	[0.033]
Industry-city dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,437	1,338	1,437	1,338	1,437	1,338
R-squared					0.202	0.22
Kleibergen-Paap rk LM statistic	99.51***	86.09***				
Kleibergen-Paap rk Wald F statistic	35.16	33.74				
Hansen's J statistic	2.454	1.453				
p-value of Hansen J statistic	0.117	0.228				
Mean[standard deviation]						
Custom-made	0.406	0.405			0.406	0.405
	[0.417]	[0.416]			[0.417]	[0.416]
Competition	0.273	0.274			0.273	0.274
	[0.335]	[0.334]			[0.335]	[0.334]
Corresponding estimate of Competition	0.900***	1.039*	0.552***	0.598***		
by fractional logit	[0.306]	[0.570]	[0.129]	[0.192]		

White-robust standard errors clustered at the industry-city level are reported in brackets. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively. A constant term is included in all regressions, but the results are not reported to save space. Columns 5 and 6 are the first-stage results of the corresponding estimation in columns 1 and 2, respectively. Columns 3 and 4 are the OLS results of the corresponding estimation in columns 1 and 2, respectively. The bottom row presents estimate using fractional logit; standard errors are boostrapped.

small-sized nature of the firms in our data renders it difficult for an individual firm's characteristics to influence the location choice of its clients and suppliers, the additional control of firm and CEO characteristics can help us validate our argument and improve estimation efficiency. As can be seen in Column 2, the estimated coefficient of *Competition* remains positive and statistically significant.

In terms of economic significance, Column 2 suggests that a one standard deviation increase in *Competition* is associated with an $0.227 \times 0.334 = 7.58\%$ increase in the percentage of custom-made products/services, or 18.72% and 18.23% relative to the mean and standard deviation, respectively, of *Custom-made*.

The corresponding OLS estimations are reported in Columns 3 and 4. The estimated coefficients of *Competition* are always positive and statistically significant, and their size remains relatively stable across the two specifications. Given the relevance of the control variables, these results suggest that omitted variables are unlikely to severely bias our findings.

Since our dependent variable *Custom-made* is a ratio, whenever possible, we also report the estimated coefficient of *Competition* for the column's corresponding fractional logit estimation. If a column uses instruments, we follow Wooldridge (2012) in implementing the corresponding instrumental variable fractional logit estimation. The results, as reported in the bottom row, are consistent with our linear estimates.

3.3.1 Validity checks on the instruments

The validity of GMM estimation relies on the exclusion restriction, which means that the two instruments can affect the outcome variable (*Custom-made*) only through the endogenous variable (*Competition*). While our model suggests that their exclusion restriction would hold, the possibility that they may fail to hold in our empirical implementation matters. With the inclusion of industry and city dummies, the possible correlation between the instrumental variables and the error term υ_{fic} in equation (9) stems largely from firm-level characteristics. Given the small-sized nature of the sample firms, it is difficult to see how an individual firm could influence the location decisions of its clients and suppliers. A consistent pattern comes from the Hansen J statistic, which fails to be significant. The additional inclusion of firm and CEO characteristics also does not affect our estimated coefficient of *Competition* in the GMM regression much.

Perhaps being close to suppliers and clients directly reduces the cost of customization, making firms more likely to customize their product. This concern would violate the instruments' exclusion restriction. To address this concern, we include several variables in the regression to control for the oft-mentioned channels through which our instrumental variables may affect the outcome variable rather than through market competition. On the supplier side, one potential concern is that the clustering of suppliers might lead to increased availability of customized components, which in turn positively affects firms' incentives to produce customized goods. It is also possible that a firm's ability to customize its products relies on the speed of receiving its supplies, which is related to the degree of local suppliers. The SCE contains two questions (one asking each firm whether its two major components are uniquely supplied to it, and the other asking each firm how many times a year it gets a delivery of its two main inputs), which allows us to construct two control variables (denoted *Custom-made Components* and *Delivery Speed*, respectively) to address these two concerns.

On the client side, three potential concerns are that the number of years that a firm has done business with its clients, the percentage of its products used in its clients' production process, and the clients' ability to inspect the quality of good on sight may affect both its location and customization strategies. To address these concerns, from the SCE data, we construct five dummies (denoted *Client Duration Dummies*) to account for five different business durations with clients (i.e., less than one year, one to two years, two to three years, three to four years, and more than four years), a variable *Product Warranty* (measured by the percentage of a firm's products having warranties) to account for the product quality, and a variable *Production Process* (measured by the percentage of a firm's output used in its clients' production process) to account for the degree of vertical linkage.

As shown in Column 1 of Table 4, controlling for all these additional sets of variables has little impact on our estimation results.[29]

We conduct another test based on a unique business feature of China. Some firms in the data are engaged in business with the government (i.e., 301 of the 1,509 firms).[30] In China, however, personal connections (*guanxi*), rather than market competitiveness, are critical in determining whether a firm could engage in business with the government. We can therefore exploit the intuition that a firm should respond to increased competition by being more customized only if it faces market competition. If competition is an important driver of customization, those firms who sell to the government should *not* have their customization scope correlated significantly with market competition. Accordingly, we divide the entire sample according to whether or not a firm has business with the government, and we check whether the estimate of β for the former sub-sample is smaller or

[29]The economic significance are similar to that of Column 2 of Table 3. A one standard deviation increase in *Competition* is associated with a 7.01% increase in the percentage of custom-made products/services, or 17.3% and 16.85% relative to the mean and standard deviation, respectively, of *Custom-made*.

[30]The exact words in the World Bank survey are: "What is the share of sales to the government?" 301 firms answered a positive share.

even insignificant.

The estimation results are reported in Columns 2 and 3 of Table 4.[31] As expected, the sub-sample of firms that do business with the government have an insignificant β. Consistent with our intuition, the estimated coefficient of *Competition* for the sub-sample of firms with government business dealings loses its statistical significance and becomes negative, whereas it remains positive and statistically significant for those not selling to the government.[32]

The corresponding estimates using instrumental variable fractional logit as in Wooldridge (2012) do not show inconsistent pattern. These results suggest that increased competition is significantly associated with a larger share of custom-made sales.

3.4 Robustness

Imperfect IV estimation. Despite the inclusion of a long list of control variables and several validity checks, we can never rule out the possibility that our instruments and the error term are correlated. Instead of arguing the exogeneity of the instruments, we build upon recent developments in the imperfect instrumental variable literature to conduct further robustness checks. Specifically, Nevo and Rosen (2012) show that in the case of the instrument (W) being correlated with the error term but to a lesser degree than the regressor of interest (X), $V(\lambda) \equiv \sigma_x W - \lambda \sigma_z X$ is uncorrelated with the error term and thus becomes a valid instrument. While σ_x (the standard deviation of X) and σ_z can be readily calculated, $\lambda \equiv \rho_{W\varepsilon}/\rho_{Xu} \in [0, 1]$ can never be figured out. In the benchmark, we pick $\lambda = 0.85$ (the details of selection are given in the Appendix) but experiment with $\lambda = 0.75$, 0.80, 0.90, and 0.95. As shown in Columns 1 to 5 of Table 5, the two-step GMM estimation using these newly constructed instruments consistently produces positive and statistically significant estimates.

Outliers. Performing an initial screening based on Cook's distance > 1 to eliminate gross outliers and then performing Huber iterations followed by bi-weight iterations (Li, 1985), we find that the process does not drop any observations. We therefore hold the view that outliers cannot be a major concern.

Alternative competition measure. We use the log of the total amount of employment for

[31] The OLS estimation results, which are available upon request, exhibits a similar pattern.

[32] The economic significance of Column 2 of Table 4 is: a one standard deviation increase in *Competition* is associated with a 9.52% decrease in the percentage of custom-made products/services, or 28.33% and 25.12% relative to the mean and standard deviation, respectively, of *Custom-made*. The economic significance of Column 3 of Table 4 is: a one standard deviation increase in *Competition* is associated with a 8.7% increase in the percentage of custom-made products/services, or 20.62% and 20.57% relative to the mean and standard deviation, respectively, of *Custom-made*.

Table 4: Instrument Checks: (Dep. var.: Custom-made)

	1	2	3
Sample	Full	Government sales?	
		Yes	No
Competition	0.215*	-0.311	0.256**
	[0.126]	[0.299]	[0.130]
Custom-made Components	0.113		
	[0.075]		
Delivery Speed	0		
	[0.000]		
Production Process	0.073*		
	[0.038]		
Product Warranty	0.161*		
	[0.095]		
Client Duration Dummies	Yes		
Firm characteristics	Yes	Yes	Yes
CEO characteristics	Yes	Yes	Yes
Industry-city dummies	Yes	Yes	Yes
Observations	1,116	267	1,045
Kleibergen-Paap rk LM statistic	73.4***	9.637***	69.89***
Kleibergen-Paap rk Wald F statistic	32.14	14.69	28.52
Hansen's J statistic	1.432	0.251	0.343
p-value of Hansen J statistic	0.231	0.616	0.558
Mean[standard deviation]			
Custom-made	0.406	0.336	0.422
	[0.416]	[0.379]	[0.423]
Competition	0.263	0.241	0.283
	[0.326]	[0.306]	[0.340]
Corresponding estimate of Competition	0.998**	-0.763	1.254***
by fractional logits	[0.436]	[-0.810]	[0.459]

White-robust standard errors clustered at the industry-city level are reported in brackets. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively. A constant term is included in all regressions, but the results are not reported to save space. The bottom row presents estimate using fractional logit; standard errors are boostrapped.

Table 5: Robustness: (Dep. var.: Custom-made)

	1	2	3	4	5	6	7	8
λ for the imperfect IV estimation	0.85	0.75	0.8	0.9	0.95	N/A	N/A	N/A
Sample	All						Local sales	Local firms
Competition	0.119*	0.122*	0.120*	0.118**	0.117**		0.661***	0.230*
	[0.061]	[0.071]	[0.066]	[0.057]	[0.054]		[0.242]	[0.118]
Log Total Employment						0.048***		
						[0.012]		
Observations	1,338	1,338	1,338	1,338	1,338	1,338	440	1,311
R-squared						0.1055		
Corresponding estimate of Competition							2.910**	1.066*
by fractional logits							[1.170]	[0.474]

White-robust standard errors clustered at the industry-city level are reported in brackets, except column 6, in which bootstrap standard errors are reported. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively. Firm characteristics, CEO characteristics, industry-city dummies, and a constant term are included in all regressions, except in column 6, in which industry and city dummies are included instead of industry-city dummies. Except in column 6, all regressions are instrumental variable estimation. The bottom row presents estimate using fractional logit; standard errors are boostrapped.

other firms in the same industry within the same city as an alternative measure. Controlling for the industry and city dummies and the firm's own employment size, the larger this measure is relative to other firms within the same industry-city, the more manpower is employed by nearby rivals. While our main measure is one that gauges rivals' outputs (sales), this measure gauges rivals' inputs. It, however, does not capture all inputs (e.g., machinery). It nevertheless is reported by other firms, in contrast to the main measure, which is self-reported. Column 6 of Table 5 shows this alternative has a positive and statistically significant estimated coefficient.

Local market. To address the concern that our market competition measure may capture the degree of local competition poorly (due to the geographic proximity of the market), we focus on a sub-sample of firms where the majority of sales are made locally (i.e., in the same city). As shown in Column 7 of Table 5, our findings are robust to this sub-sample. The corresponding instrumental variable fractional logit estimation does not generate inconsistent pattern.

Reverse causality. Even if we obtain a consistent and unbiased estimate of β, it is still possible that the positive impact of competition on customization simply reflects the sorting of firms across locations, i.e., firms with a higher degree of customization locate in more competitive areas.

Given the cross-sectional nature of our data, it is difficult for us to rule out this "dynamic" concern completely. We further exploit the data by comparing firms that recently moved to the surveyed city with those that have been there for a long time. If the estimated coefficients of β are similar across these two samples, then such a reverse causality is unlikely to be a major concern in our analysis. One question in the SCE asks whether the firm recently relocated from another city. As only a fraction of the firms answered in the affirmative, it is not sensible to divide the full sample into two based on firms' answer to this question and to compare the two estimated coefficients of β. Instead, we compare the estimated coefficient of β for the subset of firms answering "no" to this question with that for the whole sample.

Column 8 of Table 5 shows the estimation on the sub-sample that excludes firms that recently relocated from another city to the survey city. The estimated coefficient of *Competition* remains positive and statistically significant, and its magnitude is in the neighborhood of that of the estimated coefficient for the full sample. The corresponding instrumental variable fractional logit estimation does not generate inconsistent pattern. Reverse causality, therefore, does not seem to be strong enough in driving our results.

4 Conclusion

Relative to standardized products, customized products tend to be less subject to price competition. We formalize this idea in a model that predicts that increased competition leads to a larger share of sales for customized products.

We present empirical evidence on this prediction using a World Bank survey on Chinese firms. This data set provides rare and unique firm-level measures of the extent of customization and the competition intensity they face. Compared with the previous evidence on customization, this data set provides a *direct* measure of customization for firms across *all industries*. Our results suggest that relative to firms of similar caliber within the same industry located in the same city, those firms that face more intense competition have a significantly higher share of sales from their customized products.

Having shown the rationale and relevance of customization, there remain quite a few interesting questions to be probed. For example, the relative importance of customization to other strategies when facing increased competition remains to be seen. Also, the propensity to customize when facing increased competition may depend on the nature of the industry, as hinted by the wide variation in the share of customized sales across industries shown in Table 1. If for a particular industry, firms are more likely to customize, then increased competition will have a smaller negative effect on the performance (profits, survival rates, etc.) of the firms in this industry. Moreover, consumers or downstream buyers may benefit from such increased competition because more customized products are provided to them. Therefore, such difference in propensity to customize across industries may be an important reference for discretionary and differential competition/liberalization policy, e.g., trade liberalization or privatization.

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Appendix

Robustness of Proposition 1

The main results as stated in Proposition 1 are actually robust to various extensions of the basic model. Here, we show three different cases. For clarity, we conduct the analysis by varying one assumption at a time and keeping the rest of the setup the same as in the basic model. We set $D = 1$ for ease of presentation.

Marginal cost of production We consider incorporating variable cost in the form of *a constant marginal cost* $a+\delta \geq 0$, where $a \geq 0$ is the marginal cost of producing standardized products, and $\delta \geq 0$ allows for the possibility that customized products are more costly to produce. First, suppose $\delta = 0$. As the pricing of customized products is still $p_A^x = p_A^G + tx$, the profit function viewed at Stage 3 (3) should be rewritten as

$$\pi_A(p_A^G; p_B^G) = \left(\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}\right)\left(p_A^G - a\right) + \int_0^{s_A} txdx.$$

The profit-maximizing solution entails $\widehat{p}_A^G\left(p_B^G\right) = \frac{1}{2}\left(p_B^G + \frac{t}{n} + a\right)$ and $\widehat{p}_B^G\left(p_A^G\right) = \frac{1}{2}\left(p_A^G + \frac{t}{n} + a\right)$. The equilibrium price pair is thus $\left(\frac{t}{n} + a, \frac{t}{n} + a\right)$.

Now, consider $\delta > 0$. That is, customized products are more costly to produce. Again, in equilibrium, $p_A^x = p_A^G + tx$ still holds. However, firm A offers a customized product to x if and only if $p_A^x - a - \delta \geq p_A^G - a$, which is equivalent to $x \geq \delta/t$. That is, only the standardized products are offered to consumers who are located relatively close to the firms if customized products are more costly to produce. The profit function viewed at Stage 3 is

$$\begin{aligned}\pi_A(p_A^G; p_B^G) &= \left[\tilde{x} - \left(s_A - \frac{\delta}{t}\right)\right]\left(p_A^G - a\right) + \int_{\frac{\delta}{t}}^{s_A}\left(p_A^x - a - \delta\right)dx \\ &= \left(\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}\right)\left(p_A^G - a\right) + \frac{ts_A^2}{2} + \frac{\delta^2}{2t} - \delta s_A.\end{aligned}$$

Hence, the pricing under $\delta > 0$ is the same as the case where $\delta = 0$. The profit function viewed at Stage 2 is

$$\begin{aligned}\pi_i\left(s_i\right) &= p_i^G\left[\tilde{x} - \left(s_i - \frac{\delta}{t}\right)\right] + \int_{\frac{\delta}{t}}^{s_i}\left(p_i^G + tx\right)dx - a\tilde{x} - \delta\left(s_i - \frac{\delta}{t}\right) - C\left(s_i\right) \qquad (10) \\ &= \frac{t}{2n^2} + \frac{ts_i^2}{2} + \frac{\delta^2}{2t} - \delta s_i - C\left(s_i\right).\end{aligned}$$

The condition that determines s_i^* becomes $ts_i^* - \delta = c(s_i^*)$. That is, $\delta > 0$ reduces the marginal benefit of customization at the product s_i^* compared with the case of $\delta = 0$, and this reduces the scope of customization s_i^*.[33] Nonetheless, the determination of s_i^* is still unaffected by n. The share of customized sales is the second term divided by the first two terms in (10):

$$r = \frac{\int_{\frac{\delta}{t}}^{s_i} \left(\frac{t}{n} + a + tx\right) dx}{\left(\frac{t}{n} + a\right)\left[\frac{1}{2n} - \left(s_i - \frac{\delta}{t}\right)\right] + \int_{\frac{\delta}{t}}^{s_i} \left(\frac{t}{n} + a + tx\right) dx} = \frac{2n\left(s_i - \frac{\delta}{t}\right)\left(t^2 + atn\right) + t^2n^2s_i^2 - \delta^2n^2}{t^2 + atn + t^2n^2s_i^2 - \delta^2n^2}.$$

Given that $s_i^* < \frac{1}{2n}$ continues to hold as the s_i^* here is less than that in the basic model, it is then straightforward to verify that Proposition 1 holds.

Timeline It is reasonable that the entry stage comes first and that consumers choose between standardized products and customized products only when both types of products are presented to them with prices announced. However, we ask *whether the results are robust to the changes in timing of customization*.

First, suppose customization is determined at the same time as all the prices. Note the analysis in Section 2.2.1 is unchanged, for that analyzes how prices are determined given customization scope s_i. The question now is how s_i's are determined given these prices. For firm A, this is simply subtracting $C(s_A)$ from (3), i.e., the previous Stage 3 profits, and firm A chooses p_A^G and s_A simultaneously to maximize:

$$\begin{aligned}\pi_A(p_A^G, s_A; p_B^G) &= (\tilde{x} - s_A)\, p_A^G + \int_0^{s_A} p_A^x dx - C(s_A) \\ &= \left[\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}\right] p_A^G + \int_0^{s_A} tx dx - C(s_A). \end{aligned} \tag{11}$$

The first-order conditions of this problem for p_A^G and s_A remain the same as in the basic model, and so do all the results. The key here is that in both the basic model and this variant the first-order conditions for customization scopes do not involve the prices of the standardized products and vice versa.

Now, suppose instead that s_A and the prices p_A^x are determined given prices of standardized products. In this case, profits are only realized after the customization decisions are made since that is when the consumers are presented with all the options. The equilibrium price of a customized good is again $p_x = p_A^G + tx$, and the profit function (11) applies again even though we should replace $\pi_A(p_A^G, s_A; p_B^G)$ with $\pi_A(s_A; p_A^G, p_B^G)$. The fact

[33] Note that to ensure a positive s_i^* satisfying $ts_i^* - \delta = c(s_i^*)$ still entails a maximal profit, δ could not be too large.

that the first-order conditions for customization scopes do not involve the prices of the standardized products and vice versa again ensures that all results are the same as in the basic model.

Bargaining on customization In the basic model we have assumed that consumers are price-takers. *What if consumers do not take prices as given and instead bargain with the firms*? Say, when it comes to customization, the firms need to acquire some information from the consumers and hence consumers may naturally possess some bargaining power. Suppose that firms and consumers bargain when the firms would like to offer a customized product and that Nash's bargaining solution applies. Such a solution, as is well-known, can be approximately implemented by some sort of bargaining game with alternating offers.

As the disagreement outcome here is that the consumers simply purchase a standardized product, the total gains from a customization deal are tx. Suppose the firm's bargaining power is $\beta \in (0,1)$. Then, $p_A^x = p_A^G + \beta tx$. Hence, the profit function viewed at Stage 3 is

$$\pi_A(p_A^G; p_B^G, s_A) = \left[\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t} - s_A\right] p_A^G + \int_0^{s_A} \left(p_A^G + \beta tx\right) dx = \left[\frac{1}{2n} - \frac{p_A^G - p_B^G}{2t}\right] p_A^G + \beta \int_0^{s_A} txdx.$$

Hence, pricing of standardized products are unaffected. The profit function viewed at Stage 2 is

$$\pi_i\left(s_i\right) = \frac{t}{2n^2} + \frac{\beta t s_i^2}{2} - C\left(s_i\right),$$

which implies that the optimal s_i^* satisfies $\beta t s_i^* = c\left(s_i\right)$. Again, the determination of s_i^* is independent of n, and hence Proposition 1 holds. The basic model is simply a case in which $\beta \to 1$ (consumers have zero bargaining power). With a $\beta < 1$, customization scope s_i^* is smaller than that in the basic model, as firms' smaller bargaining power reduces their incentives to customize. In fact, from (8) one sees that β's role is isomorphic to that of market size D. Therefore, a larger β implies a larger s_i^*, a larger n, and the share of customized sales increases.

Proof of Proposition 2

Here, we provide a complete derivation leading to Proposition 2.

Equilibrium given n and realization of x

In Stage 3, given prices p_i^G, $i \in \{A, B\}$, the large client's utility of purchasing from A and B are $D\left(v - tx - p_A^G\right)$ and $D\left[v - t\left(\frac{1}{n} - x\right) - p_B^G\right]$, respectively. This implies a price war between two firms in a Bertrand fashion. With zero marginal cost, the lowest price B can charge is 0. The equilibrium limit pricing by firm A implies that

$$p_A^G = t\left(\frac{1}{n} - 2x\right), \qquad \pi_A^G = Dt\left(\frac{1}{n} - 2x\right),$$

where π_A^G is firm A's profit.

In Stage 2, whatever can be achieved by bargaining with firm B can be achieved by bargaining with firm A. Thus, in equilibrium, bargaining only occurs between the large client and firm A. In any customization deal, $c(x)$ has to be paid by firm A, and the large client can obtain a utility of $D\left(v - p_A^x\right)$. As the disagreement outcome is given by Stage 3's equilibrium outcome, Nash's bargaining solution is given by the p_A^x that gives each player half of the total gains from customization, that is,

$$D\left(v - p_A^x\right) - D\left(v - tx - p_A^G\right) = \frac{1}{2}\left[Dv - D\left(v - tx - p_A^G\right) - c(x) - \pi_A^G\right] = \frac{1}{2}\left[Dtx - c(x)\right].$$

Thus,

$$p_A^x = \frac{c(x)}{2D} + \frac{t}{2}\left(\frac{2}{n} - 3x\right).$$

Such a deal involving p_A^x will only be reached if and only if the total gain from customization is nonnegative, i.e., if and only if $c(x) \leq Dtx$. In other words, when the cost of customization is too big either due to a costly technology $c(.)$ or due to a large x, then it is not worthwhile to reach a customization deal.

Share of sales of customized product

Given n firms and realization of x, the large client either purchase a customized product or a standardized one, but not both. However, the realizations of the random variable x can be interpreted as different (niche) markets or a market at different times. Thus, we exploit this nature to proxy the share of customized sales by the expected sales of customized product relative to the total sales. Without prior information of x and with even spacing, x is uniformly distributed on $\left[0, \frac{1}{2n}\right]$ with density $f(x) = 2n$. Let $\hat{x}$ be such that $c(\hat{x}) = Dt\hat{x}$. Recall that $c(\cdot)$ is strictly increasing and strictly convex, and that $c(0) = 0$. Similar to the analysis in the basic model, $\hat{x} \in \left(0, \frac{1}{2n}\right)$ is unique because $c'(0) < Dt$ and that c increases fast enough to ensure that $c(\frac{1}{2n}) > \frac{Dt}{2n}$. Note that the share of customized sales r increases if and only if the ratio of customized sales to standardized sales, which is called $\tilde{r}$, increases. Observe that

$$\tilde{r} = \frac{\int_0^{\hat{x}} p_A^x Df(x)\,dx}{\int_{\hat{x}}^{\frac{1}{2n}} p_A^G Df(x)\,dx} = \frac{\int_0^{\hat{x}} p_A^x dx}{\int_{\hat{x}}^{\frac{1}{2n}} p_A^G dx} = \frac{\frac{1}{2Dt}\int_0^{\hat{x}} c(x)\,dx + \frac{\hat{x}}{n} - \frac{3\hat{x}^2}{4}}{\left(\frac{1}{2n} - \hat{x}\right)^2}.$$

First, consider an exogenous increase in n. Then, since parameters are not changed, $\hat{x}$ is unaffected by this increase in n.

$$\frac{\partial \tilde{r}}{\partial n} = -\frac{2\left[Dt\hat{x}(2+n\hat{x}) + 2n\int_0^{\hat{x}} c(x)\,dx\right]}{Dt(2n\hat{x}-1)^3} > 0.$$

Thus, an increase in competition increases $\tilde{r}$. Now, consider an increase in n resulted from an increase in the market size D. First observe that $\frac{d\tilde{r}}{dD} = \frac{\partial\tilde{r}}{\partial n}\frac{dn}{dD} + \frac{\partial\tilde{r}}{\partial\hat{x}}\frac{d\hat{x}}{dD} + \frac{\partial\tilde{r}}{\partial D}$. Since $\frac{\partial\tilde{r}}{\partial n}\frac{dn}{dD} > 0$, it suffices to show that $\frac{\partial\tilde{r}}{\partial\hat{x}}\frac{d\hat{x}}{dD} + \frac{\partial\tilde{r}}{\partial D} \geq 0$. Observe that $\frac{d\hat{x}}{dD} = \frac{t\hat{x}}{c'(\hat{x}) - Dt}$. Thus,

$$\begin{aligned}&\frac{\partial\tilde{r}}{\partial\hat{x}}\frac{d\hat{x}}{dD} + \frac{\partial\tilde{r}}{\partial D}\\ = \;& 2n \times \frac{\left\{Dt\hat{x}\left[Dt(2+n\hat{x}) + n(1-2n\hat{x})c(\hat{x})\right] + n\int_0^{\hat{x}} c(x)\,dx\left[Dt(1+2n\hat{x}) + (2n\hat{x}-1)c'(\hat{x})\right]\right\}}{D^2t(2n\hat{x}-1)^3(Dt - c'(\hat{x}))}.\end{aligned}$$

The strict convexity of c implies that $c'(\hat{x}) > Dt$. Thus, $\frac{\partial\tilde{r}}{\partial\hat{x}}\frac{d\hat{x}}{dD} + \frac{\partial\tilde{r}}{\partial D} > 0$ if and only if

$$Dt\hat{x}\left[Dt(2+n\hat{x}) + n(1-2n\hat{x})c(\hat{x})\right] + n\int_0^{\hat{x}} c(x)\,dx\left[Dt(1+2n\hat{x}) + (2n\hat{x}-1)c'(\hat{x})\right] > 0.$$

If $c(x) = x^b$ with $b > 1$, then with $c(\hat{x}) = \hat{x}^b = Dt\hat{x}$, the above becomes

$$2(b+1) + n(b+1)(1-2n\hat{x})\hat{x} + 2n\hat{x} + 2(b+1)n^2\hat{x}^2 > 0,$$

which is true.

Selection of the benchmark value of λ

We can write the error term as $\upsilon_{fic} \equiv \omega_{fic} + \tilde{\upsilon}_{fic}$, where ω_{fic} is our omitted variable that is potentially correlated with our regressor of interest ($Competition_{fic}$; relabelled as X_{fic} for convenience) and our instrumental variables (*Local Clients*$_{fic}$ and *Local Suppliers*$_{fic}$; relabelled as W_{fic}), while $\tilde{\upsilon}_{fic}$ is uncorrelated with X_{fic} and W_{fic}. The OLS estimator of equation (9) takes the following form:

$$\beta_{OLS} = \beta + \psi_{X\omega}\theta_{Y\omega}, \tag{12}$$

where β is the true value; $\psi_{X\omega}$ is the regression coefficient of X on ω; and $\theta_{Y\omega}$ is the regression coefficient of our outcome variable (*Custom-made*$_{fic}$; relabelled as Y_{fic}) on ω.

Suppose there is no true relationship between *Custom-made* and *Competition* such that $\beta = 0$. Then $\beta_{OLS} = \psi_{X\omega}\theta_{Y\omega}$. In other words, the positive findings in the OLS regressions reported in Columns 3 and 4 of Table 3 are all due to the omitted variable ω. Given $\beta_{OLS} = 0.121$ Column 3, we have $\psi_{X\omega}\theta_{Y\omega} = 0.121$.

Doing the same set of regressions for W and making the same assumption that the estimated coefficients of the instruments purely reflect the effects of the omitted variable ω, we have $\chi_{W\omega}\theta_{Y\omega} = 0.104$. Given that $\lambda \equiv \rho_{W\varepsilon}/\rho_{Xu} = \chi_{W\omega}/\psi_{X\omega}$, we have $\lambda = 0.104/0.121 = 0.8595$. Thus, we round to 0.85 in the benchmark. However, in principle, we can never figure out the true λ as by definition, omitted variables are something we do not have handy. We therefore experiment with different values of λ too.