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The provision of convenience and variety by the market

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Consumers commonly face purchasing costs, for example, travel or wait time, that are fixed to quantity but increase with variety. This article investigates the impact of such costs on the demand and supply of variety. Purchasing costs limit demand for variety like prices limit demand for quantity. When demand for variety is low, manufacturers generally invest substantially in lowering purchasing costs, to attract consumers. In the monopolistic competition free-entry equilibrium, providing convenience increases the demand for variety, but its costs reduce supply. The desirability of nonprice competition in convenience and its implications for variety and market concentration are discussed.

1. Introduction

■ It is difficult to think of a more common obstacle to the consumption of variety than the costs and inconvenience of purchasing it. Yet the provision of the optimal amount of variety, a central topic in welfare economics (Spence, 1976; Dixit and Stiglitz, 1977; Mankiw and Whinston, 1986), international trade (Krugman, 1979), and industrial organization (Salop, 1979), has been studied almost exclusively in the context of limits on the supply side.[1] This ignores the possibility that market-provided quantities of variety depend on the demand side in important ways. In this article, I propose a model of demand for variety with purchasing costs, itself a generalization of love-of-variety models often used in trade and industrial organization, and study how manufacturers compete under such demand. This results in a simple general equilibrium model of convenience or marketing, which I use to evaluate the optimality of market-provided variety.

As a motivating, albeit stylized, example, consider the market for clothing. Consumers can choose from many manufacturers, each selling unique styles. When sellers are geographically

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[1] In a survey of the literature, Lancaster (1990) writes, “This is true of both the main classes of market variety models, representative consumer (neo-Chamberlinian) and location-analog or characteristics (neo-Hotelling) models, and of almost all other kinds.”

dispersed or have long service queues, a consumer logically buys fewer styles. In this example, the consumer is less limited in his/her consumption of variety by the fixed cost of production or entry than by the purchasing costs that are associated with buying variety. Purchasing costs like travel, idling in queues, or negotiation with sales agents are fixed to quantity but increase with variety. They therefore reduce the demand for variety.

Manufacturers see this. The consumer's purchasing or transaction costs are mostly not exogenously given, but endogenously set by producers of goods who consider performing the additional task of producing convenience. When clothing manufacturers observe that consumers have low demand for their variety because of fixed transaction costs, they might invest in setting up nearby outlets or online stores, hire service personnel so that consumers do not waste time, provide self-checkout systems, etc. In short, sellers can provide convenience in the sense of lowering the fixed cost of purchasing their style. Relevant for the amount of variety on the market is that doing so increases the fixed cost of doing business, lowering the amount of variety produced. It also makes firms' entry costs endogenous. This article addresses the question when firms provide convenience, and the broader question whether the market provides the best division of purchasing cost into a consumer cost of buying and a firm cost of selling.[2]

Although the substantive interest in the market provision of convenience is motivated by the suggestion above that it plays a central, yet overlooked, role in the demand and supply of variety, in a very practical sense, the article is also motivated by the difficult to ignore observation that it constitutes a very large economic sector. Figure 1 shows the distribution of the fraction of gross domestic produce (GDP) devoted to making products conveniently available. Across the 215 nations in the United Nations (UN) National Accounts database, this fraction is remarkably constant, with a mean of 23% of and a standard deviation of 7%. Although not all of these costs are made to offset consumers' fixed costs, the costs of providing convenience are nonetheless formidable. Spence (1976) also noted that marketing cost is frequently overlooked in the debate on variety, although its size often rivals that of production.[3] Even long before, a similar point was observed by Shaw (1912) in the *Quarterly Journal of Economics.* Still, the convenience sector is virtually unstudied in economic theory.[4]

I use a setup that is based on the familiar Dixit-Stiglitz framework, in which consumers have constant elasticity of substitution (CES) preferences. However, my model differs from this framework in that purchasing consumption goods is assumed to be costly. Next, I allow firms to lower the consumer's purchasing cost at an investment and study the free-entry equilibrium with firms competing in prices and the provision of convenience. The resulting analysis features endogenous entry costs on the supply side and endogenous transaction costs on the demand side and is informative of the investments that firms make in selling.

Accounting for purchasing costs and the provision of convenience changes demand, competition, and the role of firms, in fundamental and, for some purposes, more realistic ways. First, demand changes from homothetic Marshallian demand for quantity to a nonhomothetic demand system with demand for quantity and demand for variety. Second, erstwhile monopolist manufacturers become rivalrous when demand for variety is low because of substitution of their unique variety with other unique varieties from the set of unchosen alternatives. That is, consumer

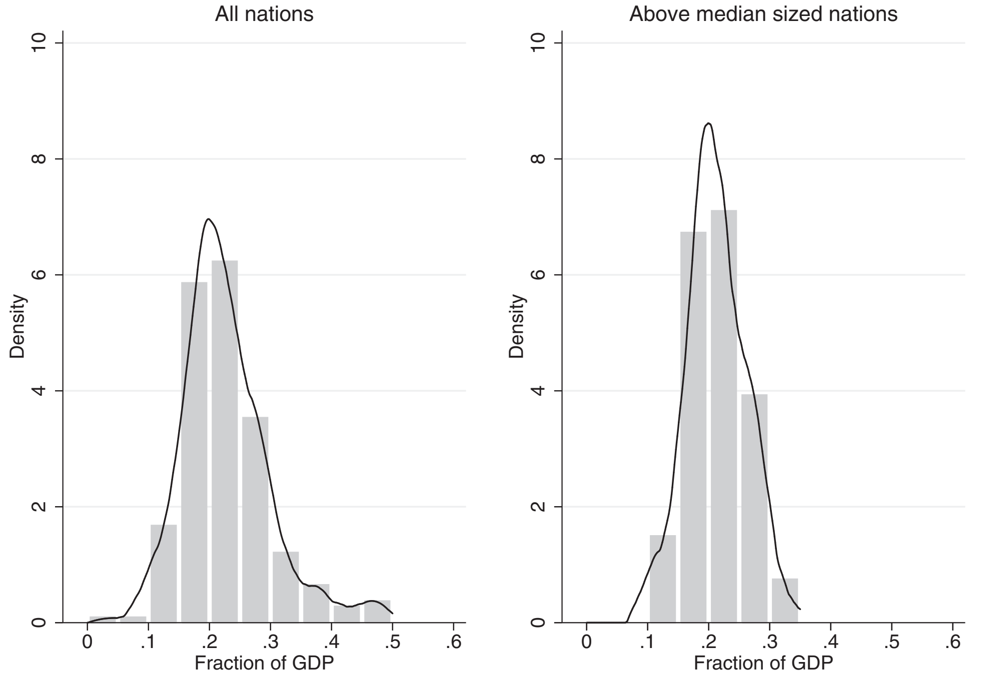
[2] I consider selling in the sense of distribution of products to consumers, that is, the provision of convenience. There is also a "persuasive" selling or marketing system intended to change the understanding or the perception of what is offered to the consumer (see, e.g., Galbraith, 1967). Although persuasion is important (see also McKloskey and Klamer, 1995; Kamenica and Gentzkow, 2011), this system is not studied here.

[3] This is true in a very literal sense. From the UN National Accounts database, the ratio of the cost of distribution (wholesaling and retailing) and manufacturing, for the largest 100 countries, has spiked distribution with a mode at 1 and a mean of 1.15.

[4] There is, however, an early empirical literature. In 1929, the United States conducted a census of distribution to determine its cost. Estimates were reported in Galbraith and Black (1935), Malenbaum (1941), and Stewart and Dewhurst (1939). Shaw (1990) summarizes these estimates and discusses how they fueled an ongoing debate about the height of the distribution bill.

FIGURE 1

THE COST OF SELLING AS A FRACTION OF GDP



Notes: The cost of selling in each country is constructed using the United Nations National Accounts Database by adding the cost of wholesaling and retailing (ISIC G-H) and the cost of communication and transportation (ISIC I) reported in those accounts. The histogram is constructed from the average fractions per country over the years 1991 – 2010. The total number of countries reporting these costs is $N = 215$. The right side panel reproduces this graph for countries with above-median GDP.

fixed costs cause firms to compete vigorously over customers independently of their degree of product differentiation. Third, constant-margin prices in the Dixit-Stiglitz model are replaced by equilibrium prices that reflect demand and supply for variety. Fourth, when it is more profitable for manufacturers to compete on purchasing or transaction costs than on prices, sellers invest in lowering the transaction costs of consumers and marketing emerges as economic activity. In equilibrium, investments in convenience do not take place in small markets and rise in market size. Finally, in regard to welfare, relative to the socially optimal level of convenience, manufacturers underinvest in making products available conveniently. Their incentive to lower transaction costs vanishes as soon as they have won a customer, even when they are highly efficient at lowering purchasing costs for the consumer further. Their actions are therefore generally not first best in producing convenience.

This study is related to existing work in several ways. Like my article, the literature on international trade and increasing returns (e.g., Krugman, 1979, 1980), and international trade and consumer awareness (e.g., Arkolakis, 2010) argues that welfare rises through consumption of more variety. This article adds a dimension by, first, focusing on the cost of buying variety and a resulting demand side trade-off between quantity and variety. With demand for variety limited by high costs of purchase, it is no longer the case that offering more variety automatically leads to better outcomes. Second, firm investments associated with lowering transaction costs force some sellers to exit. Although paradoxical at first glance, this exit is beneficial even to variety-loving consumers, because it is limited to variety for which consumers had no demand and creates economies of scale. The setup costs saved from firm exit make the net cost of distribution to society low.

My work also draws from and is related to the literature on entry and endogenous types of variety (e.g., Kuksov, 2004; Bar-Isaac, Caruana, and Cuñat, 2012). It is also related to von Ungern-Sternberg (1988) who studies endogenous travel costs in a Hotelling model and finds that firms provide excessively low travel costs when their number remains fixed. Using a neo-Hotelling approach, he does not study the demand for variety. Independently from my study, Li (2013) derives a demand model that is similar to mine to propose Engel curves for variety. He studies welfare implications of variety growth in India given exogenous costs per variety. In contrast, my article focuses on when firms invest in convenience to lower the per-variety fixed costs. Finally, my analysis aims to contribute to the conduct-structure-performance literature on market concentration and firm strategy. As in Sutton (1991), my argument implies a lower bound of concentration even as markets grow large, but via the complementary mechanism of a bounded demand for variety.

The remainder of the article is structured as follows. Section 2 presents the demand model that takes into account fixed purchasing costs. Section 3 considers when sellers invest in convenience and whether they provide it in the socially desired amount. Section 4 evaluates how market size impacts convenience and market concentration. Section 5 concludes with suggestions for future research.

2. Demand for quantity and variety

■ Consider a one-period economy consisting of a continuum of differentiated manufacturers with mass N. Each manufacturer produces a single unique variety $\omega \in \overline{\Omega}$. There is a mass of M consumers. Each consumer has CES preferences for quantities $x(\omega)$ over a subset of varieties $\Omega \subseteq \overline{\Omega}$,

$$U(x, \Omega) = \left(\int_{\omega \in \Omega} x(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

In this formulation, σ is the elasticity of substitution between two varieties. Two varieties are closer substitutes when σ is larger. I consider markets for substitutes, $\sigma > 1$. Using a continuum of varieties, rather than a discrete set, is for analytical convenience.

A consumer is endowed with T units of time, a fraction of which are supplied to the market inelastically at a wage $w = 1$, which in turn is the numeraire. T has the interpretation of the total time endowment, but also as total consumer income (e.g., Becker, 1965), that is, income if the consumer allocated all of his time to paid work. There are consumer costs associated with purchasing variety ω. These costs, $\mu(\omega)$, are fixed with respect to quantity, $x(\omega)$. Manufacturers charge prices $p(\omega)$.

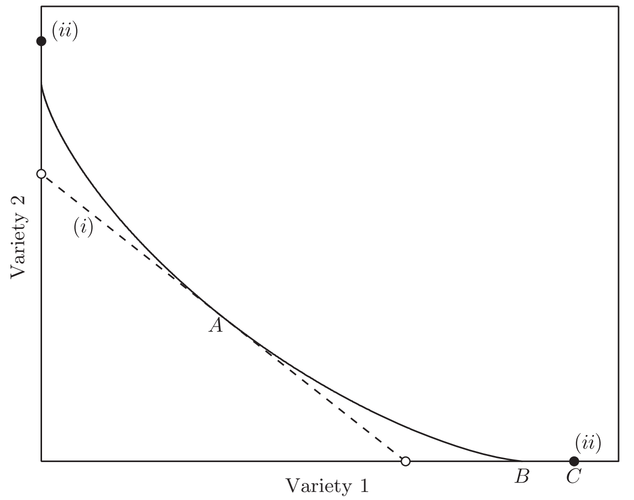
The fixed transaction costs enter the consumer problem via the consumer's resource constraint. This effectively causes a difference between total time available and total time available for earning income.[5] Accordingly, disposable income Y, available for buying consumption goods, is equal to

$$Y = T - \int_{\omega \in \Omega} \mu(\omega) \, d\omega. \tag{2}$$

[5] This implies that there is a willingness to trade income (money) for convenience (time). Studies report that consumers are willing to pay to avoid spending time shopping for books (Clay, Krishnan, and Wolff, 2001), fast food (Thomadsen, 2007), financial products (Hortaçu and Syverson, 2004), and groceries (Chintagunta, Chu, and Cebollada, 2012). Barger (1955) reports that the profit margin of distribution services has been high since the 1860s, that is, that consumers value convenience in money terms. This setup also captures the possible presence of monetary fixed costs, such as travel expenditures.

FIGURE 2

VARIETY REDUCTION AND TRANSACTION COSTS



Notes: The solid curve through A and B is the CES iso-preference curve. The budget set consists of all bundles of variety 1 and 2 on the line (i), excluding the open dots, combined with quantities for a single variety represented by the solid dots. Point A denotes the bundle where the indifference curve touches the income constraint indicated by (i). The consumer obtains the same utility from consuming only variety 1 at the quantity B along the indifference curve. The consumer prefers to limit variety, that is, $C \succ A$ when point C is to the right of B. This happens when the shift in the income constraint is large enough or when the iso-preference curve is closer to a straight line, that is, when μ or σ are high.

The limited availability of time creates a trade-off between variety and quantity. Figure 2 provides a stylized representation of this trade-off involving two varieties. A consumer can purchase all quantities in the budget set $(i) \cup (ii)$. If the consumer buys both varieties, then the utility maximizing bundle is A. If, however, the consumer buys less variety, and visits one less manufacturer, then the income constraint shifts out from (i) to (ii) because of the saving in transaction costs μ. The consumer can now buy variety 1 at quantity C, which is larger than B if the shift in income is large enough or the iso-preference curve is straight enough. Under these conditions, the consumer has a limited demand for variety, because A and B are on the same indifference curve and thus C is preferred over A.

□ **The consumer problem.** To formalize demand, assume the consumer has an information set consisting of variety-specific prices and transaction costs. The consumer maximizes utility with respect to varieties, $\Omega \subseteq \overline{\Omega}$, and quantities, $x(\omega)$,

$$\max_{\Omega,x} \left(\int_{\omega\in\Omega} x(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \text{ such that } T = \int_{\omega\in\Omega} (\mu(\omega) + p(\omega)x(\omega))\, d\omega. \tag{3}$$

First, Dixit and Stiglitz (1977) show that quantity demand given any purchase set Ω is of the constant elasticity form. This derivation does not need to be repeated here. Thus, given any purchase set Ω, quantity demand equals

$$x(\omega) = \begin{cases} A(\Omega)\, p(\omega)^{-\sigma} & \text{if } \omega \in \Omega \\ 0 & \text{if } \omega \notin \Omega \end{cases}. \tag{4}$$

Referring once more to Dixit and Stiglitz (1977), the demand shifter $A(\Omega)$ in equation (4) is $A = YP^{\sigma-1}$, where Y is disposable income, that is, $Y = T - \int_{\omega\in\Omega} \mu(\omega) d\omega$, and P is the ideal price index $P = (\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$, all defined over the set of varieties demanded. Note that adding variety to Ω decreases the demand shifter A, as it decreases both disposable income as well as the ideal price index.

Second, substitution of optimal quantities in the utility function yields a semiindirect utility function which is equal to disposable income divided by the Dixit-Stiglitz ideal price index

$$\upsilon(p, \mu, \Omega, T) = \left(T - \int_{\omega\in\Omega} \mu(\omega)\, d\omega\right)\left(\int_{\omega\in\Omega} p(\omega)^{1-\sigma}\, d\omega\right)^{\frac{1}{\sigma-1}}. \tag{5}$$

The dependence of utility on the purchase set, Ω, captures the essential trade-off: purchasing more varieties (a larger mass in Ω) leads to lower disposable income $Y = (T - \int_{\omega\in\Omega} \mu(\omega)d\omega)$ but also to a lower price per unit of utility $P = (\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$, that is, to a higher inverse of the ideal price index.

Maximizing utility in equation (5) with respect to the purchase set Ω, the demand for variety can be represented as a sorting rule, a selection rule, and a stopping rule.

Lemma 1.

(i) Arrange varieties in weakly ascending order of the scalar index $\mu(\omega)p(\omega)^{\sigma-1}$ on a continuum $S \in \mathbb{R}_+$. Denote the variety in position s on S by ω_s .

$$s < s' \Rightarrow \mu(\omega_s)\, p(\omega_s)^{\sigma-1} \leq \mu(\omega_{s'})\, p(\omega_{s'})^{\sigma-1}.$$

(ii) Select variety ω_s if

$$\mu(\omega_s)\, p(\omega_s)^{\sigma-1} \leq \frac{A(s)}{\sigma - 1}, \tag{6}$$

where $A(s)$ is the demand shifter that belongs to the set $\{\omega_t | t \in [0, s]\}$.

(iii) Stop when all varieties are included or equation (6) binds, whichever comes first.

Proof. See the Appendix. □

Looking at the ordering on S, the consumer prioritizes varieties on a combination of low prices and transaction costs weighted by the substitution parameter σ. When varieties are less substitutable (σ is closer to 1), the consumer shortlists varieties with low transaction costs $\mu(\omega)$. When, on the other hand, varieties are close substitutes (σ is large), the top of the list contains varieties with low prices $p(\omega)$.

As more varieties are added, the left-hand side of the inequality (6) increases or stays constant by the sorting rule. At the same time, the demand shifter $A(s)$ on the right-hand side decreases from demand sharing over more varieties. When transaction costs μ are high, equation (6) binds before all varieties in $\overline{\Omega}$ are included in the purchase set. This defines a marginal variety in the list for which the cost of inclusion into the set is just compensated by the benefit of consuming more variety. The location of the marginal variety, D, in the sorted list S defines the consumer's demand for variety.

The effect of transaction costs on the demand for variety can further be highlighted by focusing on how the consumer allocates income to buying quantity versus variety.

Corollary 1. The consumer selects a variety if the associated transaction cost is small enough relative to total expenditure on that variety,

$$\frac{\mu(\omega)}{p(\omega)\, x(\omega) + \mu(\omega)} \leq \frac{1}{\sigma}. \tag{7}$$

Proof. See the Appendix. □

The numerator of the left-hand side in equation (7) is equal to the cost of obtaining a variety and the numerator is the total expenditure on that variety. Thus, the consumer includes a variety when its associated transaction costs are less than a fraction $\frac{1}{\sigma}$ of total expenditures. Equation (7) implies that when varieties are more differentiated, the consumer is willing to allocate a larger and larger share of resources to acquiring variety instead of quantity.

A simple but informative case emerges when varieties are symmetric. If the consumer wants a mass of D varieties, then disposable income is equal to $Y = T - \mu D$. Per-variety expenditure on quantity, px, is equal to income divided by variety demand, that is, $\frac{T-\mu D}{D}$. Substituting this expenditure in equation (7) and solving as an equality, gives an explicit expression for the variety demanded $D(\mu)$,

$$D(\mu) = \frac{T}{\sigma \mu}. \tag{8}$$

Equation (8) is a constant and unit elasticity demand function, $D(\mu)$, in the "price," μ, for additional variety. The demand for variety further decreases in the substitutability of varieties (larger σ) and increases in total time endowment and total income (larger T).

□ **Discussion.** The novel feature in the demand model derived above is the presence of consumers purchasing costs. The resulting demand system contains two prices, a cost per unit and a cost per variety. The consumer does not want a variety when its price is too high or when it is too inconvenient to purchase it.

The demand system is nonhomothetic. When total income T rises, demand expands in the direction of varieties that are more expensive (see also, e.g., Föllmi and Zweimüller, 2006) and more inconvenient.

When μ is travel cost, the model gives rise to spatial demand systems, for example, the selective demand for local varieties. Alternatively, when μ has the interpretation of the cost of collecting and processing information, the demand model can be used to rationalize the existence of awareness sets (e.g., Sovinsky-Goeree, 2008; Arkolakis, 2010).

Finally, there are several earlier studies that share with my demand model that some varieties may not be bought, for example, the literature on incomplete demand systems (see, e.g., von Haefen, 2010), and on demand with corner solutions (Kim, Allenby, and Rossi, 2002). However, in these studies, the consumer's rationing of variety is not from the consumer cost of variety but from the shape of the utility function. Independently, Howell and Allenby (2013) and Li (2013) recently developed empirical models of demand with fixed costs.

3. Supply

■ Next, I study the provision of variety under a simple version of the proposed demand system. Consider henceforth the special case of symmetric varieties and equal transaction costs per variety. This is limiting, but as Dixit and Stiglitz (1977) note, "even the symmetric case yields some interesting results," and adhering to this tradition facilitates a comparison to some earlier results.

A typical variety is produced by a single manufacturer who has a setup cost of F units of labor to acquire a technology that produces an additional unit at constant marginal costs of c units of labor.[6] Manufacturers additionally have a technology to lower transaction costs to consumers. For example, clothing manufacturers can open dedicated outlets to reduce the consumer's cost of obtaining that manufacturer's variety. The manufacturer's cost required to lower the consumer's transaction cost is fixed. For a similar assumption on marketing expenses, see Spence (1976) and Sutton (1991). In the remainder of the article, a manufacturer who invests G units of labor

[6] These are the only firms in the market. In particular, they displace a cottage industry of home producers. The conditions under which industrial firms displace local home producers are outlined in Murphy, Shleifer, and Vishny (1989). This eliminates the scenario where consumers engage in home production to avoid transaction costs.

lowers the consumer's transaction cost of obtaining its variety to $\mu(G)$. The marketing technology $\mu(G)$ can therefore be seen as a conversion of consumer fixed costs to manufacturer fixed costs. For simplicity, I assume that it obeys the Inada conditions: $\mu'_G < 0$, $\mu'_G(0) = -\infty$, $\mu'_G(\infty) = 0$, $\mu''_G > 0$, and $\mu(\infty) = 0$. Under these assumptions, investment lowers transaction costs, but more investment is needed to keep lowering them at a constant rate. I assume that consumers know the transaction costs $\mu(G)$.

Manufacturers can additionally communicate price through advertising. To be conservative about the prospects of nonprice competition, I assume that communication of prices is inexpensive relative to lowering transaction costs to consumers,[7] effectively costless.

In sum, manufacturers can invest in the amount of G to create convenience and reduce transaction costs for consumers. In addition, manufacturers can communicate prices to the market at no cost, and compete on prices to attract consumers. The analysis focuses on symmetric free-entry equilibria in a simultaneous move game. The conditions for equilibrium are as in Krugman (1979): (i) firms maximize profits given the actions of others, (ii) free entry drives down profits to 0, and (iii) total labor required equals total labor available.

□ **Competing on price and transaction costs.** Consider a fixed mass of N firms in the market. Because profits require that transactions take place, a profit maximizing manufacturer ensures that consumers include its variety in their purchase set. That is, given the actions of others, a manufacturer sets price and convenience subject to the purchase constraint (6). The manufacturer's maximization problem is

$$\max_{p,G} M\,(p-c)\,Ap^{-\sigma} - (F+G)\,, \text{ subject to } \mu\,(G)\,p^{\sigma-1} \le \frac{A}{\sigma-1} \text{ and } G \ge 0, \tag{9}$$

where A is a demand shifter that includes all competitive actions and is taken as a constant by a profit maximizing manufacturer. Note that equation (9) captures both the case where there are ample varieties on the market to cover demand at zero investment, $N \ge D$, and where there is a shortage of varieties on the market given demand, $N < D$. In the first case, $A = A(D)$. That is, a given manufacturer makes profits from selling to a mass M consumers who all buy D varieties, while the constraint expresses that its variety is one among D that the consumer buys. If, on the other hand, there is a shortage of variety supplied relative to demand, the shifter $A = A(N)$ expresses that the firm is one of N competing for demand.

Before stating the main result of the analysis, it facilitates the exposition to define a measure of the *relative demand for variety*, $r(G)$, that is, demand relative to a measure of (counterfactual) supply at monopoly prices. Dividing the demand for variety, $D = \frac{T}{\sigma\mu(G)}$ (equation (8)) by a measure of supply,[8] $\frac{MT}{\sigma(F+G)}\frac{\sigma-1}{\sigma}$, relative demand for variety is

$$r\,(G) = \frac{1}{M}\left(\frac{\sigma}{\sigma-1}\right)\left(\frac{F+G}{\mu\,(G)}\right). \tag{10}$$

Closer inspection makes immediately clear that the partial derivative of relative demand for variety with respect to investment in convenience is positive, $r'_G > 0$.

Now consider the main proposition of the article,

[7] It is reasonable to assume that the cost of advertising is low relative to providing convenience. According to the national accounts of the United Nations Database, in 2007, the total bill of wholesaling and retailing in the United States was \$B2,110 (United Nations, 2014). The cost of advertising in the same year was estimated to be around \$B158 (Sass, 2012).

[8] In particular, this is the mass of firms that can recoup their fixed cost $F + G$ when they charge monopoly prices and consumers buy D varieties. In these conditions, total market income is $M(T - D\mu(G))$, which simplifies to $MT\frac{\sigma-1}{\sigma}$. Total variable profits are income times margin $\frac{1}{\sigma}$. The mass of firms that can recoup their fixed costs is total variable profits divided by per-firm fixed costs $F + G$. This is equal to $\frac{MT}{\sigma(F+G)}\frac{\sigma-1}{\sigma}$.

Proposition 1.

(i) When transaction costs are low, $\mu(0) < \frac{F}{M}(\frac{\sigma}{\sigma-1})$, equilibrium prices are equal to monopoly prices,

$$p = c\frac{\sigma}{\sigma - 1}, \tag{11}$$

no firm invests,

$$G = 0, \tag{12}$$

and the supply of variety is

$$N = \frac{MT}{\sigma F + M\mu(0)}. \tag{13}$$

(ii) When transaction costs are high, $\mu(0) \geq \frac{F}{M}(\frac{\sigma}{\sigma-1})$, equilibrium prices are

$$p(G) = c\frac{\sigma}{\sigma - r(G)}, \tag{14}$$

equilibrium investments follow from the productivity condition

$$\mu'_G = -\frac{1}{(1 - r(G))M}, \tag{15}$$

and the supply of variety is equal to the demand for it

$$N = \frac{T}{\sigma\mu(G)}. \tag{16}$$

Proof. See the Appendix. □

When consumer transaction costs are low relative to manufacturer setup costs, $\mu(0) < \frac{F}{M}(\frac{\sigma}{\sigma-1})$, it is easily checked that the demand for variety, D, exceeds free-entry supply, N, at monopoly prices and zero investment. In this situation, a manufacturer has no incentive to lower consumer transaction costs μ because every consumer is already a customer and offering additional convenience has no effects on the quantity sold. With only the intensive consumer margin to consider, manufacturers charge the monopoly price. Therefore, when consumers have low transaction costs, manufacturers remain passive sellers. The free-entry supply of variety is equal to $\frac{MT}{\sigma F + M\mu(0)}$, and it drops in transaction costs from $\frac{MT}{\sigma F}$ when $\mu(0) = 0$,[9] toward $\frac{MT}{\sigma F}(\frac{\sigma-1}{\sigma})$ as transaction costs $\mu(0)$ rise toward $\frac{F}{M}(\frac{\sigma}{\sigma-1})$.

When transaction costs rise further, $\mu(0) \geq \frac{F}{M}(\frac{\sigma}{\sigma-1})$, the demand for variety, D, is less than or equal to free-entry supply, N, at monopoly prices. The proposition states that price and investment in convenience now depend on the relative demand for variety $r(G)$.

With respect to prices, first, the Appendix shows that $r(G) < 1$, when $\mu(0) > \frac{F}{M}(\frac{\sigma}{\sigma-1})$, and therefore equilibrium prices, equation (14), are below monopoly prices when transaction costs are high enough. The intuition for why firms cut price is as follows. Manufacturers maximize profits subject to the constraint that consumers buy their variety, that is, $\mu(G)p^{\sigma-1} \leq \frac{A(D)}{\sigma-1}$, where the right-hand side is a constant to any given manufacturer depending only on market aggregates. The proof shows that this condition binds when transaction costs are high. The manufacturer problem can now be interpreted as finding the most profitable way to meet the consumer's purchase constraint, whereby investing less in convenience requires setting a lower price. Because profits are locally unaffected at the monopoly price, manufacturers are always willing to cut price and

[9] This is equal to the case of Dixit and Stiglitz (1977).

save on investing in convenience along the consumers' purchase constraint.This reduction in monopoly power ultimately comes from the high cost of transactions.

Second, because relative demand for variety rises in investment, $r'_G > 0$, equilibrium prices rise in consumer convenience. It is easy to see why. The equilibrium supply of variety being equal to demand for variety rising from lower transaction costs, prices need to rise to accommodate more entry. Thus this predicts that prices, convenience, and variety supplied move together (for a related discussion in the context of a demand-based explanation for cities see, e.g., Stahl, 1983).

Third, when the relative demand for variety $r(G)$ is low, the margin erosion from competition to meet the purchase constraint, that is, competition over customers, is large and can lead to near marginal-cost pricing despite varieties being differentiated. For instance, when the transaction costs μ are high or setup costs $F + G$ low, equilibrium prices drop simply because there is an abundance of entry at high prices relative to demand and manufacturers compete each other out of the market over the extensive consumer margin that exists at high prices.

Next, I discuss the productivity condition on investment in convenience, that is equation (15). Even without making more specific assumptions about the technology $\mu(G)$, equation (15) has a number of clear implications. First, interpret μ'_G as the marginal rate at which consumer transaction costs $\mu(G)$ are transferred to firm fixed costs G. This marginal rate starts at $-\infty$ and increases monotonically to 0 as more investment takes place. The proposition then makes the simple point that equilibrium investment is negatively related to the relative demand for variety. For instance, when the demand for variety is only slightly less than free-entry supply at monopoly prices, $r(G)$ is slightly less than 1. In this case, the equilibrium condition (15) states that investment is low because it takes place at the point where μ'_G is still strongly negative. When, on the other hand, relative demand for variety, $r(G)$, is low, investment takes place until a less productive level has been reached, that is, firms invest more in providing convenience. As an example, take chains of fast-food restaurants or coffee shops who provide convenience by investing heavily in store density. According to the theory, they do so because in these industries competing chains sell substitutable products (high σ) and typically have low setup costs (low F), whereas consumers face high transaction costs in the form of travel (high μ), all of which lower the relative demand for variety.

A second observation about convenience considers productivity more directly. Note that $r(G) \leq 1$ when $\mu(0) \geq \frac{F}{M}(\frac{\sigma}{\sigma-1})$, and that $r(G) > 0$, that is, that the relative demand for variety is larger than 0 in equilibrium. Using these bounds, equation (15) then implies that $\mu'_G < -\frac{1}{M}$. This means that optimal investment is less than the level where an additional dollar invested by firms leads to a dollar less transaction cost across all M consumers.

Third and last, in the context of the equilibrium level of convenience, convexity of $\mu(G)$ and the condition $\mu'_G < -\frac{1}{M}$ imply that $\mu(G) < \mu(0) - \frac{G}{M}$.[10] This means it is better to invest G and offer consumers a low transaction cost of $\mu(G)$ than it is to offer consumers a monetary subsidy $\frac{G}{M}$ to visit the store at a transaction cost of $\mu(0)$. Indeed, a two-part tariff consisting of a price p and a subsidy $-\frac{G}{M}$ would lead to a higher consumer cost of variety, all else equal. An obvious interpretation is that centralized distribution benefits from scale economies which would be left unused when giving consumers a cost-equivalent monetary incentive to visit the store.

With respect to the entry, the equilibrium supply of variety is equal to the demand for it, as captured by equation (16). Supply of variety in excess of demand is competed out of the market. That is, if supply is above demand, then manufacturers are no longer selling to all consumers and have an extensive consumer margin. Using the classic Bertrand argument, each manufacturer can now capture this margin by undercutting its rivals slightly on price or transaction costs. The collective effect of this undercutting on the free-entry supply is that $N = D$, when transaction costs are high. Note that entry and the supply of variety does not depend on market size M directly. This is because consumer demand for variety $\frac{T}{\sigma\mu(G)}$ does not depend on market size directly. Entry

[10] Convexity of μ implies that $\frac{\mu(0)-\mu(G)}{0-G} < \mu'_G$. Together with $\mu'_G < -\frac{1}{M}$, this results in $\frac{\mu(0)-\mu(G)}{0-G} < -\frac{1}{M}$.

may depend on market size through investment, and I will investigate this possibility in a later section.[11]

Finally, it may be interesting to mention, without formal proof, the case where $\mu'_G = 0$ for all levels of G. It is clear that in this case $G = 0$. When transaction costs are low, the equilibrium price is as in Proposition 1. When transaction costs are high, as before, the free-entry supply of variety cannot exceed consumer demand for it. Manufacturers set the price such that the free-entry supply is equal to the demand for variety at zero investment. In other words, prices are given by equation (14) at $G = 0$. Thus, when transaction costs are high and investment has no effect, $G = 0$, and prices become $p = c\frac{\sigma}{\sigma - r(0)}$. The free-entry supply of variety at these prices is exactly equal to demand D, that is, $N = \frac{T}{\sigma\mu(0)}$, and this supply does not depend on market size.

Summarizing this subsection, compared to a world where sellers do nothing to reduce the transaction costs of consumers, competition over customers leads manufacturers to provide higher levels of convenience and price at below monopoly prices when transactions costs are high. The provision of convenience enables consumers to buy more variety. This comes at the expense of higher prices than when convenience is absent.

□ **Welfare.** Tracing back to Braithswaite (1928) and Kaldor (1950), competition over customers between firms has been viewed as wasteful duplication of marketing costs. In addition, marketing costs have been interpreted as a cause for inflated prices (see, e.g., Galbraith, 1967). The context of this article, that is, costly transactions and love of variety, places these two critiques in a different light. First, having more sellers than consumers have demand for implies wasteful duplication of fixed entry costs F. This waste can be eliminated by investments in convenience, which raise demand for variety to meet a supply reduced by the cost of selling. Second, high prices in a marketing equilibrium are not automatically a "bad" because they support more entry and assortment. Whether welfare is improved or reduced from demand management is therefore not clear *a priori*.

I study welfare from the perspective of a social planner who sets the level of entry and convenience without taking into account the constraint that manufacturer profits need to be nonnegative. This admits the possibility that firms post losses in equilibrium. To include these in the welfare analysis, consumers own the profits and losses of the firms. Consider the following result.

Proposition 2. The planner's first-best solution is for manufacturers to invest in convenience up to the point where $\mu'_G = -\frac{1}{M}$. The number of firms in the market is $N = \frac{T}{\sigma\mu(G) + \sigma\frac{F+G}{M}}$.

Proof. See the Appendix. □

Thus, the planner prefers the level of investment associated with $\mu'_G = -\frac{1}{M}$. This level minimizes the total purchasing cost of a variety $M\mu(G) + G$ to society, consisting of a demand side purchasing cost $M\mu(G)$ plus a supply side investment in convenience G. Comparing this with equation (15), the planner-preferred investment is more than manufacturers invest competitively. The explanation for the underproduction of convenience in the market is that firms do not benefit from setting convenience beyond the minimum that is needed to satisfy the consumer's purchase constraint (6), that is, that is needed to create a customer.[12] However, a social planner would like more convenience if the supply-reducing effect of investments G is small relative to the supply-enhancing effects of having lower transaction costs $\mu(G)$.

[11] For completeness, note that the equilibrium is continuous at $\mu(0) = \frac{F}{M}(\frac{\sigma}{\sigma-1})$. It is easily checked that at this transaction cost, $r(G) = 1$, $G = 0$, and $p = c\frac{\sigma}{\sigma-1}$, are a solution to the equilibrium conditions (14) and (15) by realizing that the latter becomes $\mu'_G = -\infty$, which is only true at $G = 0$.

[12] This also explains the difference with von Ungern-Sternberg (1988) who, in a different setting, finds firms overinvest.

Given the level of investment in convenience, the social planner prefers less entry than consumer's demand, that is, $N < \frac{T}{\sigma\mu(G)}$. Note that if $\mu(G) = 0$ for all levels of investment G, the social planner would set $G = 0$, and $N = \frac{MT}{\sigma F}$. This is equal to the planner's actions in Dixit and Stiglitz (1977).

Finally, compare Propositions 1 and 2. Whereas investment by the market is unambiguously too low, the amount of variety in the market can still be equal to the level preferred by the planner. A simple example can demonstrate this. In particular, consider $\mu = \frac{1}{G}$ and $F = 0$, which lead to simple solutions and obey the productivity assumptions of convenience. Using Proposition 2, the first-best solution is to set $G = \sqrt{M}$ and $N = \frac{1}{2}\frac{T\sqrt{M}}{\sigma}$. Investment rises in market size. Entry rises in market size, M, and the consumer endowment T, but falls in the elasticity of substitution. The social planner limits entry to half the demand for variety $D = \frac{T\sqrt{M}}{\sigma}$ at the planner's preferred investment.

When we compare this to Proposition 1, solving $\mu'_G = -\frac{1}{M(1-r)}$, the market makes each manufacturer invest $G = \sqrt{\frac{\sigma-1}{2\sigma-1}M}$ when transaction costs are high. [13] This is less than the social optimum and increasingly so when varieties are less substitutable, that is, when σ approaches 1. The number of firms in the market is equal to the demand for variety, $N = \sqrt{\frac{\sigma-1}{2\sigma-1}}\frac{T\sqrt{M}}{\sigma}$. Comparing the two levels of entry, it is easy to verify that relative to the social optimum of variety, the market provides too much variety when $\sigma > \frac{3}{2}$, and too little when the opposite holds. This means that when varieties are good substitutes, the market provides more than the social planner wants, but when varieties are poor substitutes, not enough. The explanation is that the relative demand for variety, $r(G) = \frac{1}{M}(\frac{\sigma}{\sigma-1})G^2 = \frac{\sigma}{2\sigma-1}$, gets closer to 1 as varieties become less substitutable. Thus, according to Proposition 1, each individual manufacturer scales back investment more and more. This leads to fewer varieties demanded, and therefore produced, in equilibrium relative to the level preferred by the planner.

4. Market size, convenience, and concentration

■ Before concluding, the final section discusses the role of market size on the provision of convenience and market concentration.

First, and somewhat trivially, by simply rewriting the condition for investment in convenience of Proposition 1 to $M \geq \frac{F}{\mu(0)}(\frac{\sigma}{\sigma-1})$, it is clear that, at a given transaction cost $\mu(0)$, investment in convenience only takes place if markets are large enough. However, conditional on passing the investment threshold, it is not *a priori* clear how market size influences the equilibrium. The final proposition focuses on the comparative statics of market size.

Proposition 3. Manufacturers provide convenience when market size M increases beyond $\frac{F}{\mu(0)}(\frac{\sigma}{\sigma-1})$. When market size increases further,

(i) investments in convenience G increase,
(ii) prices may either increase or decrease depending on the elasticity of substitution σ and the shape of the technology $\mu(G)$,
(iii) more firms enter, and
(iv) the revenue size of firms increases.

Proof. See the Appendix. □

[13] In particular, $r = \frac{1}{M}\frac{\sigma}{\sigma-1}G^2$, and the derivative of $\mu(G)$ is $\mu'_G = -\frac{1}{G^2}$. Thus, the equilibrium condition, $\mu'_G = -\frac{1}{M(1-r)}$, becomes

$$-\frac{1}{G^2} = -\frac{1}{M\left(1 - \frac{1}{M}\frac{\sigma}{\sigma-1}G^2\right)},$$

from which it is simple to solve the result.

As market size increases, manufacturers can make better use of economies of scale and are willing to invest more in convenience G to serve the market. With more investment and selling effort in larger markets, the demand for variety $D = \frac{T}{\sigma\mu(G)}$ will be higher in larger markets because it is offered at a lower transaction cost to consumers.

No direct result can be given for prices without making more assumptions about $\mu(G)$. First, referring to equation (14), prices can rise or fall in market size, M, because of the opposing direct effect of lower relative demand for variety, r, on prices (which is negative) and the indirect effect of higher investment on prices (which is positive). The Appendix develops the exact condition that prices rise if

$$\frac{\sigma}{\sigma-1} + \frac{r}{1-r}\left(1 - \frac{\mu\mu''_G}{\mu'_G\mu'_G}\right) > 0. \tag{17}$$

Inspecting this condition, prices are guaranteed to rise in market size when $\frac{\mu\mu''_G}{\mu'_G\mu'_G} \leq 1$. This is the case when μ''_G is small enough, for example, when the effects of G on μ are close enough to constant returns to scale or when μ'_G is large in absolute value. In this case, investment raises the demand for variety fast enough that prices increase.

Second, when producing convenience is subject to strongly decreasing marginal returns, prices may fall in large markets. Likewise, if additional investment becomes totally ineffective, that is, μ'_G approaches 0 at some G, the condition in equation (17) is violated. Prices now fall in M from the negative effect of market size on relative demand for variety.

Finally, if the condition in equation (17) holds in equality, then prices are independent of market size. This happens to be the case in the market equilibrium of the previous section, that is, with $\mu = \frac{1}{G}$ and $F = 0$. [14] Indeed, with $r = \frac{\sigma}{2\sigma-1}$, market prices in this example are $p = c\frac{\sigma}{\sigma-r} = c\frac{2\sigma-1}{2\sigma-2}$, and do not depend on market size.

Next, regarding entry in Proposition 3, the free-entry supply of variety grows in market size, because it is equal to demand, which in turn is higher at higher levels of convenience. So consumers in large markets benefit from more convenience and more variety than consumers in smaller markets.

With respect to the last part of the proposition on firm size, even though more firms enter in large markets, their revenue is also larger. Hence, the growth in the number of firms is less than market growth.

These comparative statics offer an explanation for endogenous market concentration. Figure 3 shows the Herfindahl index, $\int_0^N (\frac{1}{N})^2 d\omega = \frac{1}{N}$, as a function of market size. Figure 3 shows that concentration falls in market size when $\frac{M}{F} < \frac{\sigma}{\mu(0)(\sigma-1)}$. According to Proposition 1, it does so because more and more firms enter.

Further, when the market size continues to increase, $\frac{M}{F} \geq \frac{\sigma}{\mu(0)(\sigma-1)}$, in an equilibrium with convenience and price competition, manufacturers invest more and raise the demand for variety when market size rises. More entry takes place and concentration falls. However, entry falls slower than before, cushioned by the countervailing impact of entry costs $F + G$ rising in larger markets. This is shown with the solid line in Figure 3.

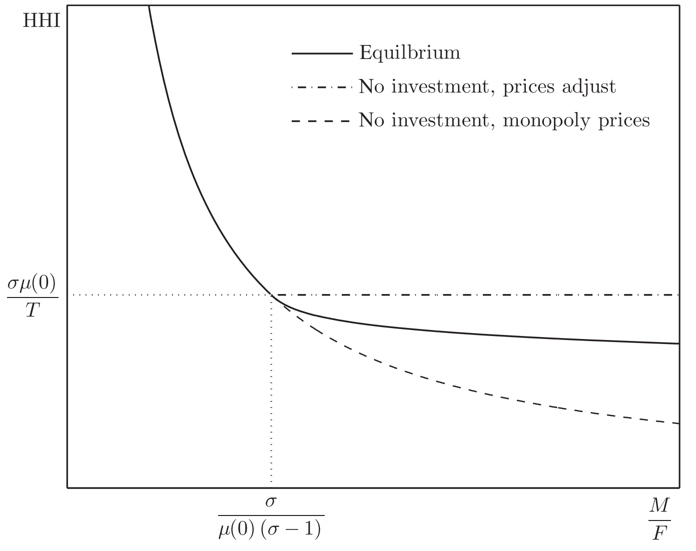
If manufacturers do not invest in convenience, for instance because $\mu'_G = 0$, and the market grows, they still compete away a growing supply using price, because supply equals demand for variety (see equation (16)). Concentration then stays constant in the region where $\frac{M}{F} > \frac{\sigma}{\mu(0)(\sigma-1)}$ because demand for variety, $D = \frac{T}{\mu(0)\sigma}$, does not change in market size, M. This scenario is drawn with the dash-dotted line in Figure 3.

The graph also shows the concentration when, as in Dixit and Stiglitz (1977), manufacturers charge monopoly prices and no investment is made. In large markets, $\frac{M}{F} > \frac{\sigma}{\mu(0)(\sigma-1)}$, this leads to more entry $N = \frac{MT}{\sigma F}\frac{\sigma-1}{\sigma}$ than demanded and consumers would buy a only fraction of varieties. This case is not an equilibrium and is shown just for reference.

[14] In particular, with $\mu = \frac{1}{G}$, $\frac{\mu\mu''_G}{\mu'_G\mu'_G} = 2$. Recall that $r = \frac{\sigma}{2\sigma-1}$. With these values, condition (17) holds in equality.

FIGURE 3

CONCENTRATION AND MARKET SIZE



Notes: The horizontal axis displays market size relative to setup costs. The vertical axis displays concentration (Herfindahl index). In equilibrium, there is no investment when markets are too small relative to setup costs, $\frac{M}{F} \leq \frac{\sigma}{\mu(0)(\sigma-1)}$. As the market size becomes larger than $\frac{\sigma}{\mu(0)(\sigma-1)}$, the concentration index is constant when firms compete only on price and do not invest (dash-dotted line). When they additionally invest in convenience, concentration falls but does so slowly, cushioned by rising investment in convenience (solid line). For reference, the hatched line shows concentration when no investment takes place, firms charge monopoly prices, and demand is equally spread across all firms.

Figure 3 invites a comparison with Sutton's (1991)) theory of endogenous sunk cost. That theory, too, focuses on concentration as a function of $\frac{M}{F}$ and endogenous investment. In Sutton (1991), as markets grow larger, manufacturer escalation in advertising competition limits entry. The costs of this advertising causes even large markets to remain concentrated. My theory offers a complementary explanation for endogenous market concentration. The insight added to Sutton (1991) is that entry in a market with high transaction cost is bounded by the demand for variety.

5. Conclusion

■ Consumer purchasing costs merit economic analysis because their presence fundamentally impacts demand, entry, and the nature of firms. This article presents a simple general equilibrium model to capture the idea that, complementary to the classic argument in welfare economics and trade, it is not only the fixed costs of firms that limit welfare but the sum of these costs together with the fixed costs of consumers. Incurring more entry costs may thus not be harmful to consumers if it offsets the cost of purchasing. This opens a debate about how to best arrange these costs in a cost of buying and a cost of selling, to which I hope to have made a modest contribution.

Coase (1937) proposed that the role of the firm is to bypass the market for the activities it can replace at a lower cost. This clearly admits the possibility that firms should produce transactions. The importance of demand management is not foreign to business scholars. Indeed, in a widely read and classic book, Drucker (1973) stated that an important role of a business firm is to "create a customer." This captures the essence of my article. Making products is obviously important economic activity. However, making products available is too, and relatively little is known about the effects of this activity.

Future research can hopefully address that manufacturers alone do not produce enough convenience and do not serve markets with low transaction costs at all. This suggests a role for multiproduct retailers who are motivated to lower transaction costs further in competition over customers.

Future research can also focus on the role of firm heterogeneity. The present analysis is silent about how investment in distribution and marketing interacts with, for instance, differences in productivity. In particular, related to important research on international trade and firm selection (e.g., Melitz, 2003), it will be valuable to study whether investment in marketing affects the survival of more productive firms over less productive ones.

Appendix

This appendix contains the proofs of the results in the paper.

Proof of Lemma 1. The proof is constructed in two steps. First, I show that utility always, that is, without any sorting of varieties, rises when equation (6) holds. Second, I show that unless the set consists of the varieties with the lowest $\mu(\omega)p(\omega)^{\sigma-1}$, it is possible to increase utility by changing the set.

(i) Arrange varieties in arbitrary order by ω_s, that is, not necessarily sorted on $\mu(\omega)p(\omega)^{\sigma-1}$, on a continuum $S \in \mathbb{R}_+$. Denote the variety in position s by ω_s. The utility for the purchase set $\{\omega_s,\ s \in [0, D]\}$ with mass D is $U = (\int_0^D x(\omega_s)^{\frac{\sigma-1}{\sigma}} ds)^{\frac{\sigma}{\sigma-1}}$. Substitute the demand for quantity $x(\omega_s) = A(D)p(\omega_s)^{-\sigma}$, with $A(D)$ being the demand shifter belonging to the purchase set. Recall that

$$A(D) = \left(T - \int_0^D \mu(\omega_s)\, ds\right)\left(\int_0^D p(\omega_s)^{1-\sigma}\, ds\right)^{-1}. \tag{A1}$$

Then, utility at optimal quantities is equal to

$$\begin{aligned} \upsilon(D, p, \mu, L) &= \left(\int_0^D \left(A(D)\, p(\omega_s)^{-\sigma}\right)^{\frac{\sigma-1}{\sigma}} ds\right)^{\frac{\sigma}{\sigma-1}} \\ &= \left(T - \int_0^D \mu(\omega_s)\, ds\right)\left(\int_0^D p(\omega_s)^{1-\sigma}\, ds\right)^{\frac{1}{\sigma-1}}. \end{aligned} \tag{A2}$$

This semiindirect utility function depends on the set size D, prices p, transaction costs μ, and total time resource T. Now derive the incremental utility from adding variety to the set $[0, D)$. I use the fundamental theorem of calculus, that is, that the derivative of $\int_a^b g(h)dh$ with respect to its limit b is $g(b)$. The derivative of indirect utility with respect to variety at D is

$$\begin{aligned} \frac{\partial \upsilon}{\partial D} &= -\mu(\omega_D)\left(\int_0^D p(\omega_s)^{1-\sigma}\, ds\right)^{\frac{1}{\sigma-1}} + \\ &\quad \frac{1}{\sigma-1}\left(L - \int_0^D \mu(\omega_s)\, ds\right)\left(\int_0^D p(\omega_s)^{1-\sigma}\, ds\right)^{\frac{1}{\sigma-1}-1} p(\omega_D)^{1-\sigma} \\ &= P^{-1}\left(-\mu(\omega_D) + \frac{1}{\sigma-1} A(D)\, p(\omega_D)^{1-\sigma}\right), \end{aligned} \tag{A3}$$

with $P = (\int_0^D p(\omega_s)^{1-\sigma} ds)^{\frac{1}{1-\sigma}}$ equal to the Dixit-Stiglitz price index. The right-hand side of equation (A3) is larger than 0 when

$$\mu(\omega_D)\, p(\omega_D)^{\sigma-1} < \frac{A(D)}{\sigma-1}. \tag{A4}$$

This result holds for any ordering on ω. It says that, given an arbitrary set consisting of a mass D varieties, utility rises from including (excluding) the marginal variety that obeys (the opposite of) condition (A4).

(ii) To complete the proof, it is shown that the optimal set always consists of the varieties with the lowest values on $\mu(\omega)p(\omega)^{\sigma-1}$. Define the marginal variety ω_D, if it exists, as the variety that makes equation (A4) bind

$$\mu(\omega_D)\, p(\omega_D)^{\sigma-1} = \frac{A(D)}{\sigma-1}. \tag{A5}$$

If the marginal variety ω_D does not exist, for example, when $\mu(\omega_s) = 0$, $\forall s$, then the consumer buys all varieties. Suppose it exists. The claim is that the utility maximizing set consists of all varieties with $\mu(\omega_s)p(\omega_s)^{\sigma-1}$ lower than $\mu(\omega_D)p(\omega_D)^{\sigma-1}$. Suppose not, that is, that the utility maximizing set is such that there exists a variety with low prices and/or transaction costs $\mu(\omega_s)p(\omega_s)^{\sigma-1} < \mu(\omega_D)p(\omega_D)^{\sigma-1}$ that is not a member of the set. Given that equation (A5) holds in equality for D, the left-hand side is strictly less than the right-hand side for s, that is, $\mu(\omega_s)p(\omega_s)^{\sigma-1} < \frac{A(D)}{\sigma-1}$. Equation (A3) then implies that utility rises from selecting ω_s, a contradiction. A similar contradiction can be constructed for expensive varieties inside the set.

Proof of Corollary 1. Substitute demand for quantity, equation (4),

$$x(\omega_s) = A(s)\, p(\omega_s)^{-\sigma},$$

into demand for variety, equation (6),

$$\mu(\omega_s)\, p(\omega_s)^{\sigma-1} \leq \frac{A(s)}{\sigma - 1},$$

to obtain

$$\mu(\omega_s)\, p(\omega_s)^{\sigma-1} \leq \frac{x(\omega_s)\, p(\omega_s)^{\sigma}}{\sigma - 1}.$$

Rearranging terms gives the result.

Proof of Proposition 1.

(i) **Profit maximization.** Consumers will buy a given manufacturer's variety as long as equation (6) holds, that is, $\mu(G)p^{\sigma-1} \leq \frac{A}{\sigma-1}$, and will drop the variety otherwise. Given the actions of others, the manufacturer problem is,

$$\max_{p,G} M(p-c)\, Ap^{-\sigma} - (F+G), \text{ subject to } (\sigma-1)\,\mu(G) - Ap^{1-\sigma} \leq 0 \text{ and } G \geq 0$$

for a fixed A (which is an aggregate function of competitive prices and investments). The associated (modified) Lagrangian is

$$\mathcal{L} = M(p-c)\, Ap^{-\sigma} - (F+G) - \lambda h(p, G),$$

with the purchase constraint $h(p, G) = (\sigma - 1)\mu(G) - Ap^{1-\sigma}$.
The Karush-Kuhn-Tucker (KKT) conditions are (i) stationarity $\frac{\partial\mathcal{L}}{\partial G} \leq 0$, $G\frac{\partial\mathcal{L}}{\partial G} = 0$, $\frac{\partial\mathcal{L}}{\partial p} = 0$, (ii) primal feasibility $h(p, G) \leq 0$, (iii) dual feasibility $\lambda \geq 0$, and (iv) complementary slackness $\lambda h(p, G) = 0$.
The partial derivative for G is

$$\frac{\partial\mathcal{L}}{\partial G} = -1 - \lambda(\sigma-1)\,\mu'_G, \tag{A6}$$

and for p is

$$\frac{\partial\mathcal{L}}{\partial p} = Ap^{-\sigma}\left(M\sigma\frac{c}{p} - (M+\lambda)(\sigma-1)\right). \tag{A7}$$

(a) Suppose that the purchase constraint does not bind. In this case, complementary slackness requires that $\lambda = 0$. Now, equation (A6) implies that $\frac{\partial\mathcal{L}}{\partial G} < 0$. From the KKT condition that $G\frac{\partial\mathcal{L}}{\partial G} = 0$, this implies, too, that $G = 0$. The condition that $\frac{\partial\mathcal{L}}{\partial p} = 0$ with $\lambda = 0$ solves price, $p = c\frac{\sigma}{\sigma-1}$.

(b) If the purchase constraint binds, then $h(p, G) = 0$. Recall, $\mu'_G(0) = -\infty$. Given the effectiveness of allocating at low levels, it cannot be optimal to set $G = 0$ when maximizing profits with respect to p and G along the purchase constraint. Hence, we do not need to consider this possibility further. With $G > 0$, the KKT conditions state that the first-order condition $\frac{\partial\mathcal{L}}{\partial G} = 0$ needs to hold. Using equation (A6) the first-order condition for G solves λ as

$$\lambda = -\frac{1}{(\sigma-1)\,\mu'_G},$$

which is positive. Using equation (A7), the first-order condition for price solves

$$p = c\left(\frac{\sigma}{\sigma-1}\right)\left(\frac{M}{M+\lambda}\right). \tag{A8}$$

With a positive λ, it is clear from (A8) that $p < c(\frac{\sigma}{\sigma-1})$. In particular, substituting λ,

$$p = c\frac{\sigma}{\left(\sigma - 1 - (M\mu'_G)^{-1}\right)}. \tag{A9}$$

Together with the purchase constraint $h(p, G) = (\sigma-1)\mu(G) - Ap^{1-\sigma} = 0$, this gives two equations and two unknowns, which solve p and G in terms of the demand shifter A and therefore the collective competitive actions.
As a simple illustration, if all competitive manufacturers have a common strategy $[p_c, G_c]$, and the mass of manufacturers happens to be fixed at demand, then $A = A(D)$ and the binding purchase constraint $h(p, G) = (\sigma-1)\mu(G) - A(D)p^{1-\sigma} = 0$ simplifies to

$$p^{\sigma-1}\mu(G) = p_c^{\sigma-1}\mu(G_c), \tag{A10}$$

and combining equations (A9) and (A10) gives profit maximizing behavior, given the common actions of others.

(ii) **Zero-profit condition.** Firm size is determined by the zero-profit condition. We have $\pi = (p - c)Mx(p) - (F + G) = 0$, and that the total quantity per firm is

$$Mx\left(p\right) = \frac{F + G}{p - c}. \tag{A11}$$

(iii) **Labor market clearing.** The total number of firms in the market is equal to labor available in the market $M(T - N\mu(G))$ divided by the labor needed to set up one firm $F + G + cMx$. Using the expression for the scale of firms (A11), the labor needed to set up one firm is

$$F + G + c\frac{F + G}{p - c} = (F + G)\left(\frac{p}{p - c}\right).$$

The number of firms in the market is therefore

$$N = \frac{M\left(T - N\mu\left(G\right)\right)}{\left(F + G\right)}\left(\frac{p - c}{p}\right). \tag{A12}$$

(a) When the purchase constraint does not bind, $G = 0$ and $p = c\frac{\sigma}{\sigma - 1}$. Now equation (A12) solves

$$N = \frac{MT}{\sigma F + M\mu\left(0\right)}. \tag{A13}$$

(b) When the purchase constraint binds, given symmetry, it must bind for all manufacturers. So each manufacturer faces consumers who buy all varieties in the market but who wouldn't buy any more. This means that the mass of manufacturers in the market is equal to demand for variety, $N = D$. For the labor market to clear, equation (A12) needs to hold. Substituting $N = D$,

$$D = \frac{M\left(T - D\mu\left(G\right)\right)}{\left(F + G\right)}\left(\frac{p - c}{p}\right).$$

Next, substitute $D = \frac{T}{\sigma\mu(G)}$ and rearrange to obtain equation (14) in the proposition

$$p = \frac{\sigma}{\sigma - r\left(G\right)}c. \tag{A14}$$

Note that this must imply that $r(G) < 1$ in equilibrium because $\lambda > 0$ and equations (A8) and (A14) must hold at the same time. Finally, equations (A9) and (A14) give two equations and two unknowns from which we can solve

$$\mu'_G = -\frac{1}{M\left(1 - r\left(G\right)\right)},$$

which is equal to (15).

To complete the proof, the purchase constraint does not bind when consumers buy each manufacturer's variety at zero investment, that is, when $h(p, 0) < 0$ at the free-entry supply. This implies $(\sigma - 1)\mu(0) - A(N)p^{1-\sigma} < 0$. Substituting $A(N) = \frac{T - N\mu(0)}{Np^{1-\sigma}}$,

$$(\sigma - 1)\,\mu\left(0\right) - \frac{T - N\mu\left(0\right)}{Np^{1-\sigma}}p^{1-\sigma} < 0,$$

or equivalently $N\sigma\mu(0) - T < 0$. Substitute for N the free-entry supply of variety at zero investment (A13). This gives that the purchase constraint does not bind when $\mu(0) < \frac{F}{M}\frac{\sigma}{\sigma-1}$.

Proof of Proposition 2. Consumers have income from labor and owning the firms. Aggregated across M consumers and N firms, income is

$$MY = M\left(T - \mu\left(G\right)N\right) + N\left(p - c\right)Mx - N\left(F + G\right),$$

where the individual quantity bought per variety $x = \frac{Y}{pN}$. This equation holds only when demand for variety is high enough to buy all varieties supplied. We need to check later that this holds because the first-best solution cannot feature costly variety, which the consumer does not want. Solving for total disposable income,

$$MY = \frac{p}{c}\left(M\left(T - \mu\left(G\right)N\right) - N\left(F + G\right)\right),$$

which is proportional to prices because consumers own the firms and their profits. Total surplus is

$$MU = MN^{\frac{\sigma}{\sigma-1}}x = N^{\frac{1}{\sigma-1}}\frac{MY}{p} = \frac{1}{c}N^{\frac{1}{\sigma-1}}\left(MT - N\left(M\mu\left(G\right) + F + G\right)\right),$$

which is maximized with respect to entry N and investment G. The first-order condition for N is

$$\frac{1}{\sigma-1} N^{\frac{1}{\sigma-1}-1} \left(MT - N\left(M\mu(G) + F + G\right)\right) - N^{\frac{1}{\sigma-1}} \left(M\mu(G) + F + G\right) = 0,$$

which leads to

$$N = \frac{T}{\sigma\mu(G) + \sigma\frac{F+G}{M}},$$

which is less than demand at G. It is therefore checked that consumers buy all varieties. Further, the first-order condition for convenience is

$$\mu'_G = -\frac{1}{M}.$$

Proof of Proposition 3.

(i) Recall that the equilibrium conditions for G and p, when $\mu(0) \geq \frac{F}{M}\frac{\sigma}{\sigma-1}$, are $\mu'_G = -\frac{1}{(1-r(G))M}$, and $p = c\frac{\sigma}{\sigma-r(G)}$. Define

$$\begin{bmatrix} f_G \\ f_p \end{bmatrix} = \begin{bmatrix} \mu'_G + \frac{1}{(1-r(G))M} \\ p - c\frac{\sigma}{\sigma-r(G)} \end{bmatrix}.$$

The comparative statics with respect to M are equal to

$$\begin{bmatrix} \frac{dG}{dM} \\ \frac{dp}{dM} \end{bmatrix} = -\begin{bmatrix} \frac{\partial f_G}{\partial G} & \frac{\partial f_G}{\partial p} \\ \frac{\partial f_p}{\partial G} & \frac{\partial f_p}{\partial p} \end{bmatrix}^{-1} \begin{bmatrix} \frac{\partial f_G}{\partial M} \\ \frac{\partial f_p}{\partial M} \end{bmatrix}, \tag{A15}$$

with the partial derivatives of f_G equal to $\frac{\partial f_G}{\partial G} = \mu''_G + \frac{1}{\mu}\frac{(\frac{\sigma}{\sigma-1}+\frac{r}{1-r})}{(1-r)^2M^2}$, $\frac{\partial f_G}{\partial p} = 0$, and $\frac{\partial f_G}{\partial M} = -\frac{1}{(1-r)^2M^2}$. Further, the partial derivatives of f_p are $\frac{\partial f_p}{\partial G} = -\frac{c}{M\mu}\frac{\sigma}{(\sigma-r)^2}(\frac{\sigma}{\sigma-1} + \frac{r}{1-r})$, $\frac{\partial f_p}{\partial p} = 1$, and finally, $\frac{\partial f_p}{\partial M} = c\frac{\sigma}{(\sigma-r)^2}\frac{r}{M}$. Substituting these partial derivatives in equation (A15) and rearranging gives the comparative statics,

$$\frac{dG}{dM} = \mu\left(\frac{\mu\mu''_G}{\mu'_G\mu'_G} + \frac{\sigma}{\sigma-1} + \frac{r}{1-r}\right)^{-1} \text{ and } \frac{dp}{dM} = \frac{c}{M}\frac{\sigma}{(\sigma-r)^2}\frac{\left((1-r)\frac{\sigma}{\sigma-1} + r\left(1 - \frac{\mu\mu''_G}{\mu'_G\mu'_G}\right)\right)}{\left(\frac{\mu\mu''_G}{\mu'_G\mu'_G} + \frac{\sigma}{\sigma-1} + \frac{r}{1-r}\right)}.$$

First, all three terms of the inverse in $\frac{dG}{dM}$ are positive, and thus $\frac{dG}{dM}$ is positive. Second, the sign of $\frac{dp}{dM}$ is positive iff

$$\frac{\sigma}{\sigma-1} + \frac{r}{1-r}\left(1 - \frac{\mu\mu''_G}{\mu'_G\mu'_G}\right) > 0.$$

(ii) In equilibrium, $N = D = \frac{T}{\sigma\mu(G)}$. From this, using $G'_M > 0$ (see i) with the property $\mu'_G < 0$, the chain rule directly implies that $N'_M > 0$.

(iii) The revenue of a firm is equal to disposable income $MT\frac{\sigma-1}{\sigma}$ divided by the mass of firms $\frac{T}{\sigma\mu(G)}$, which equals $M(\sigma-1)\mu(G)$. Using total differentiation with respect to M, $(\sigma-1)\mu + M(\sigma-1)\mu'_G\frac{dG}{dM}$, the sign of the derivative is equal to the sign of $\mu + M\mu'_G\frac{dG}{dM}$. Substitute $\mu'_G = -\frac{1}{M(1-r)}$ and $\frac{dG}{dM}$ developed above to obtain that the sign of the derivative of revenue with respect to market size M is the sign of

$$\mu - \frac{1}{(1-r)}G'_M = \mu - \frac{1}{(1-r)}\mu\left(\frac{\mu}{\mu'_G}\frac{\mu''_G}{\mu'_G} + \frac{\sigma}{(\sigma-1)} + \frac{r}{(1-r)}\right)^{-1}.$$

Multiply by $(\frac{\mu}{\mu'_G}\frac{\mu''_G}{\mu'_G} + \frac{\sigma}{(\sigma-1)} + \frac{r}{(1-r)})$ and divide by μ. The sign of the derivative is equal to the sign of $\frac{\mu}{\mu'_G}\frac{\mu''_G}{\mu'_G} + \frac{\sigma}{(\sigma-1)} - 1$, which is positive.

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