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ABSTRACT

Significant product innovation often entails standardization of product characteristics and mass-production. This paper examines the market outcome and social-welfare property of product innovation involving mass-production. It is shown that the share of mass-producers has tendency to be larger than the social optimum. The equilibrium share of mass-produced products is determined by the indifference condition of the *marginal* customer, while the optimal share is based on the indifference condition of the *average* customer. Since the marginal customer's benefit of using local products is lower than the average customer's, consumers move to mass-produced products more than desired. However, if there is positive externality among consumers in using mass-produced products, the market may have multiple equilibrium and the conclusion of excessive share of mass-produced products in market equilibrium may be reversed.

Keywords: Product differentiation, Standardization, Mass-production, Social Welfare, Retail Markets, Personal Computers

JEL Classficiation: L81, L13, L50, O53, D43

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1. INTRODUCTION

Significant product innovation often entails standardization of product characteristics and mass-production. For example, Adam Smith's pin-making example of gains from division of labor cannot be achieved without standardization of pins and resulting mass-production. Imagine that a pin maker has to tailor its pin individually to very heterogeneous customers' demand. Each pin has a different shape. Then, it is difficult to gain substantially from specialization. In order to take full advantage of specialization, pins must be of the same shape and be produced in bulk. Thus, the introduction of a standardized pin is the key element of the success of innovation that Smith reported. Ford's T model may also be another example of this type of product innovation with mass-production.

Standardization of product characteristics and resulting mass-production are not confined to the market of physical products. In the retail business, waves of retail innovation have been accompanied by various "standardization" of services and mass-supply of the standardized product-service mix. A similar example is found in hotel services. In contrast with differentiated service of country inns, motels have standardized service and low-cost operation. It may be fair to say that product innovation of sizable importance is often accompanied by product standardization and mass-production.

Although product innovation involving mass-production is considered as a driving force of economic growth, critics often lament that such innovation drives richness of local diversity out of the market, and leads to banality. In some cases, the opposition is more than rhetorical, and makers of existing differentiated products often argued that the government should protect them since otherwise they will be driven out of the market and their customers will suffer.

The purpose of this paper is to analyze the market outcome and social-welfare property of product innovation involving mass-production, concentrating on substitution between existing products and mass-produced ones. Specifically, I examine whether product innovation with mass-production is excessive in the market, in the sense that the marginal loss of richness in diversity outweighs marginal gains from lower marginal cost.

The major finding of this paper is that the share of mass-producers has tendency to be larger than the social optimum, and that thus product innovation with mass-production is likely to be excessive. In this paper, mass-produced products are assumed to be competitively supplied, so that there is no efficiency loss on the side of mass-produced products. Inefficiency sneaks into the choice of consumers.

Consider a consumer contemplating whether to switch from the differentiated product supplied by their local supplier to the mass-produced product. They will switch if the benefit of using the mass-produced product net of the price and the switching cost is higher than that of the local product net of its price. The market equilibrium is determined by the movement of consumers. The equilibrium share of mass-produced products is determined by the indifference (or "no-arbitrage") condition of the *marginal* customer. However, the optimal share of mass-produced products is determined by overall social welfare maximization, in which the optimum allocation is based on the indifference condition of the *average* customer. Since the marginal customer's benefit of using local products is lower than the average customer's, consumers move to mass-produced products more than desired.

However, if there is positive externality among consumers in using mass-produced products, the conclusion of excessive share of mass-produced products in market equilibrium may be reversed. Suppose that imperfect knowledge of products is the major cause of high switching cost to mass-produced products, and thus the switching cost declines as more and more consumers use the products and more and more product information diffuse among them. Then, there is possibility of multiple stable market equilibria, which are rankable in social welfare. The market may be trapped in inferior equilibrium of insufficient share of mass-produced products. I will show that insufficient innovation with mass-production is more likely if local producers have similar demand and cost structures.

The organization of this paper is as follows. In Section 2, I present two examples of product innovation with mass-production (large discount stores in the retail market, and IBM PC AT-compatibles in the personal computer market), which are currently important political and economic issues in Japan. In Section 3, the retail market model with discount stores is presented, and market equilibrium is characterized in Section 4. It is shown that there is unique, stable market equilibrium if there is no externality or there is negative externality in consuming mass-produced products. Welfare properties of the market equilibrium are examined in Section 5, which contain major results of this paper. The market under positive externality in using mass-produced products is analyzed in Section 6. Concluding remarks are given in Section 7.

2. PRODUCT INNOVATION WITH MASS-PRODUCTION

I consider introduction of new products having the following two characteristics. First, they have standardized product characteristics suitable for mass-production, and are supplied competitively. Second, they are aimed at the global market, not for its local segment as in the case of differentiated products. Product characteristics of the standardized products are often the "greatest common divisor" of those of existing products, ensuring the cost of switching from existing products to the standard ones being not very much different among consumers.

Since mass-produced products are intended to be used by many consumers, there may be strong possibility of externality among consumers. To simplify analysis, I assume that only mass-produced products have possibility of externaltiy in consumption, although externality in using differentiated products have been extensively discussed in the literature of network externality.[1] The following are typical examples involving product innovation with mass-produced goods. However, they differ from each other in the direction of externality in using mass-produced products.

Example 1: Neighborhood and Discount Stores.

In many countries, there are many neighborhood stores serving a local market, offering high service, and having small sales volumes resulting high prices. They are located close to

[1]There is now a sizable literature of network externality among differentiated products. See, for example, Economides and White (1993).

their particular customers, and thus sell differentiated "locational-service" to consumers with physical products.[2] This "traditional structure of retailing" is often challenged by discount stores serving the global market, offering low (zero) service and having large sales volumes, resulting in low prices. Discount stores' service is standardized, and the price of their merchandise is substantially lower than the neighborhood stores' price, mostly due to standardization of their service. In some countries including Japan, whether the government should regulate discount stores becomes an important policy issue.[3]

In the case of discount stores, *negative* externality of congestion is often considered as far more important than possible positive externality.[4] Since discount stores depend on a large number of consumers buying from them, their presence causes heavy traffic of automobiles, and congestion. Congestion is the major concern of the government authority in many countries including the United States when it considers whether to allow the construction of large shopping centers.[5] Congestion adds to the overall cost of switching from neighborhood stores to discount stores. This case will be analyzed in Sections 3 and 4.

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[2]In addition, although it is not explicitly analyzed in this model, neighborhood stores often provide personalized service specially tailored to specific needs of each customer.

[3]The problem is particularly acute in Japan. Entry and operation regulation based on the Large Scale Retail Store Law becomes a sensitive political issue between the Japanese and U.S. governments. A similar regulation on large stores is found in France. In contrast, there is no such regulation in the United States. See Nishimura (1993) for a comparative study between Japan and United States, of and Nishimura and Tachibana (1994) for investigation of the determinants of the Japanese market structure.

[4]Small (1992) surveys congestion from the viewpoint of transportation economics. However, there may also be positive externality. For example, if there are many consumers buying from discount stores, they may be able to car-pool in shopping, and to cut the shopping cost. But their importance is usually considered as small.

[5]There are many examples of opposition to the construction on this environmental ground in the United States, of which the Tyson's Corner II in Virginia is one. Even the opposition of existing stores to such a project disguises itself as environmental concern.

Example 2: Personal Computers

In the Japanese personal computer market, NEC, Fujitu and other Japanese companies sold highly differentiated products using product-specific software at high price.[6] In 1992, Compaq, Dell and other companies (mostly selling imports from Taiwan) introduced standardized low-price IBM PC AT-compatibles with standardized software (based on standardized DOS /V) into the market.[7] However, as of the spring of 1994, the market share has changed little since the introduction of the PC-AT compatibles, although prices decline dramatically.[8] The PC AT-compatible machine makers have not yet shown their clear dominance in the Japanese market, although they are now the industry-standard in other

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[6]As of 1992, NEC's PC9800 series was strong in business use, having many software's tailored to specific needs. Fujitu sold the FM-Towns line, which was targeted to multi-media-oriented consumers. Toshiba manufactured mostly laptop and notebook computers, with its own DOS, which could run IBM DOS softwares in the English mode. IBM PC DOS-based AX computers were also manufactured by several companies including Mitsubishi and Matsushita, mostly targeted to business use. However, Toshiba DOS and AX DOS were incompatible in the Japanese mode, and they added their own hardware subsystem to DOS in order to display and print Chinese and Japanese characters.

Home use of personal computers was mostly Japanese word processing. Specially-tailored Wā puro (a Japanese abbreviation for Wā do-Purosessā, word processor) was produced by many manufacturers. Fijitu produced OASYS Wā puros, which had a special keyboard and a transformation system from alphabets to Japanese and Chinese characters. NEC, Toshiba, and other manufacturers of personal computers also sold their line of Wā puros. Some were good in graphics, capable of producing Chinese calligraphy, and some had spread-sheet ability. Although NEC was dominant in the market of personal computers with DOS, it was not so conspicuous in the larger market of personal computers including Wā pros.

[7]DOS /V is revolutionary, since it enables IBM PC AT-compatible machines to display Japanese and Chinese characters not by adding hardware, but by devising special software. Since this is softeware-based, every IBM PC AT-compatible machine might be benefited.

[8]The share of NEC was actually increased rather than decreased. DOS /V machines got some share, but it was not considered as large as expected.

countries. A natural question is whether the Japanese consumers suffers from insufficient entry of PC AT-compatible machines.

In contrast with discount stores, the example of PC AT-compatibles with DOS /V is likely to involve *positive* externality of knowledge diffusion. Consumers must not only buy new software programs in order to switch from their specially-tailored system to the standardized one, but also *learn* to operate them.[9] Since learning often involves positive externality, the total cost of switching including learning cost is likely to decline as more and more consumers switch to standardized products. The case of positive externality will be discussed in Section 5.

It is not only of theoretical interest but also of practical importance to examine why the initial attempt of PC AT-compatibles was not as successful in Japan as in other countries. The difficulty of this kind in import penetration is found in other markets in Japan.[10] It is often argued that this difficulty is the sign that hidden trade barrier in the Japanese market. I will also take up this issue in Section 5.

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[9]There is also strong positive pecuniary externality. The cost of devising and producing new software programs, and ultimately their price, is likely to decline as more and more consumers switching and buying such software programs.

[10]A similar story is found in the Japanese market of VTR around 1985. At the one end of the market, there were domestic high-end products, which have many functions designed for a particular segment of consumers, reliable post-sales services, and high prices. At the other end, there were no-frills imports which had standardized functions, minimum post-sales service, and low prices (imports from, for example, Hong Kong, Korea, and Taiwan). The subsequent history of the market showed that although there was no import restriction, cheap standardized imports were almost driven out of the market, and the market is still dominated by domestic differentiated products.

3. A RETAIL MARKET WITH DISCOUNT STORES

The Setting: a Circular City with a Beltway

The model is based on the circular city model of Salop (1979) with one modification, in which there is a highway called the Beltway circulating around the city. Figure 1 depicts the city. The city has a circle road called the Neighborhood Road, the length of which is normalized as unity. Consumers are homogeneous, and distributed uniformly along the Neighborhood Road, the density of whom is L. The Neighborhood Road is too narrow to allow traffic of automobiles. Thus, consumers travel on foot on the Neighborhood Road.

In addition to the Neighborhood Road, there is a highway called the Beltway in the suburb of the city, which surrounds the city . No consumer lives along the beltway. There are access roads connecting each point of the Neighborhood Road to the Beltway. If consumers drive a car, they can travel on the Beltway using these access roads.

There are two types of retail stores: small neighborhood stores and large discount stores. I assume that they sell the same product but in different locations.

Demand

As in Salop (1979), I assume the individual demand for products is inelastic. Specifically, consumers buy one unit of the product.[11] The value of the product is v. In order to consume the product from a store, the consumer has to pay the store's price p and incur the cost of traveling to the store, T. Thus, the utility from buying from the store is $v - p - T$.

Starting Point: Product Differentiation with Neighborhood Stores

Starting point is the case that Salop analyzed, in which there are *only* neighborhood stores located on the Neighborhood Road. The model is well-known, and thus I explain it only

[11] Thus, I ignore the issue of creating new demand by the introduction of standardized products, and rather concentrate on substitution between differentiated and standardized products. In other words, I consider the issue of economic obsolescence due to product innovation with standardization. In addition, by assuming inelastic demand, I am concerned with inefficiency due to either insufficient or excessive entry, not with inefficiency due to (partial) monopoly.

briefly. Their marginal cost of sales (the cost of merchandise purchased for resale) is the same and equal to m. Beside the cost of merchandise, the neighborhood store has to incur a fixed cost of operation.

Neighborhood stores may have a different fixed cost. Let us put potential entrants in the neighborhood retail market in a ascending order with respect to their fixed cost. Let $f(n)$ be the fixed cost of the n-th store, so that we have $f(1) < f(2) < f(3) < f(4) \ldots\ldots < f(N)$, where N is the number of potential entrants. In order to make analysis simple, I hereafter treat n as real number, instead of integer. The distribution of the fixed cost is such that all consumers are served in equilibrium.

Following Salop, let us consider equilibrium of a two-stage game in which (1) neighborhood stores enter and locate themselves equidistantly from one another in the first stage, and (2) then they compete with each other by price in the second stage. Hereafter symmetric price equilibrium is considered in the second stage since the stores have the same marginal cost.

Suppose that n stores enter the market and located equi-distantly. If the consumer decides to buy the product from a neighborhood store located in the distance d from him, he has to walk to the store along the Neighborhood Road. In this case, his traveling cost is c per distance, so that the total traveling cost to the neighborhood store, T, is

$$T = cd. \tag{1}$$

Let p_i be the neighborhood store's price, while p be the other stores'. A consumer located at the distance $x \in (0,\ 1/n)$ from this store is indifferent between buying from this store and buying from this store's closest neighbor if $p_i + cx = p + c\{(1/n) - x\}$. Thus, the demand for the store's product is $D(p_i, p) = 2Lx = (L/c)\{p + (c/n) - p_i\}$, so that its profit excluding the fixed cost is $(p_i - m)(L/c)\{p + (c/n) - p_i\}$. Differentiating with respect to p_i and then setting $p_i = p$ yields $p = m + (c/n)$, which implies the profit excluding the fixed cost is cL/n^2. In the first stage, only stores having non-negative profit enter the market. Then, the zero profit condition of free entry implies $f(n) = cL/n^2$, which determines the equilibrium number of stores entering the market in the first stage.

If the fixed cost is the same for all neighborhood stores and equal to $\bar{f}$, then the number of neighborhood stores is equal to $(cL/\bar{f})^{1/2}$, so that the equilibrium price is $p = m + (c\bar{f}/L)^{1/2}$.

Product Innovation with Mass-production: Discount Stores

Let us now characterize discount stores. Discount stores are located on the Beltway. They are homogeneous among themselves, and their cost of merchandise for resale is substantially lower than that of neighborhood stores. It is assumed that all discount stores achieve minimum efficiency scale, and that the fixed cost of operation can be neglected. Their marginal cost (including the cost of merchandise for resale), m^*, is constant and equal to their average cost. The marginal cost of discount stores is smaller than the neighborhood stores' marginal cost ($m > m^*$).

Since the discount stores' product-service mix is new to all consumers, they must incur cost in switching their supplier from neighborhood stores to the discount stores. If the consumer wants to buy from a discount store, he has to use a car and to drive to the discount store. This involves a fixed cost c^*, which is the switching cost in this retail-market example. I assume that the switching cost is substantial so that $m^* + c^* > m$.[12] However, I assume that marginal traveling cost is negligible, that is, the cost of gasoline is small enough to be ignored.

Besides the cost of using a car, congestion may increase the consumer's travel cost (for example, increases the cost of waiting for empty space to park, which is added to the cost of using a car)[13]. I will consider both cases of no congestion and positive congestion.

The congestion cost g, if exists, depends on the share of discount stores in the total sales in this market, s^*, since congestion increases as the number of consumers buying from discount stores increases (so that s^* increases). Thus, the total travel cost to the discount store, T^*, is

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[12]It will be shown that otherwise no neighborhood store could ever be profitable in equilibrium, so that they would be eradicated from the market.

[13]Externality can be both technological and pecuniary. If the parking lot is privately-owned and the parking fee is collected, the fee is likely to be raised when the lot is congested. In this case, externality is pecuniary. If the parking is free of charge, then externality is technological.

$$T^* = c^* + g(s^*), \tag{2}$$

I assume that the congestion cost g is, if exists, twice differentiable, $g(0) = 0$, $g' > 0$ and $g'' > 0$, where ' (") hereafter denotes the first (second) derivative. Thus, the marginal congestion cost is assumed to be increasing.

Consumers' Choice with Discount and Neighborhood Stores

If discount stores are present, consumers have options to buy either from one of the neighborhood stores or from one of the discount stores. Consumers buy the product from the discount store if $v - p^* - T^* > v - p - T$, while they purchase from the neighborhood store if otherwise, so long as $v - p^* - T^* \geq 0$ and $v - p - T \geq 0$.

Two-Stage Game

I consider the following two-stage game involving both discount stores and neighborhood stores.

(1) The First Stage: Entry.

In the first stage, discount stores determine whether to enter the market and neighborhood stores decide whether to stay in the market. Here, I consider the "long-run equilibrium" in which relocation costs of neighborhood stores are ignored.[14]

On the one hand, since the marginal cost of traveling on the Beltway is zero, location of discount stores does not matter in this model. On the other hand, neighborhood stores always try to move away from one another on the ground of maximal differentiation (Economides 1989), but they cannot "move" further away from discount stores since consumers' travel cost to discount stores does not depend on location. In the end, neighborhood stores are located distantly from one another so that their market area does not touch one another's, and they come to compete only with discount stores. Then, the exact location of neighborhood stores also becomes irrelevant in this model.

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[14] Thus, I am not concerned with dynamic strategic positioning of stores. This assumption is justified on the ground that the major concern of this paper is to characterize free entry equilibrium and its welfare property, as in Salop (1979).

Taking this in mind, I assume for simplicity that discount stores are placed equi-distantly from one another on the Beltway, and neighborhood stores are also located equi-distantly from one another.

(2) The Second Stage: Pricing.

In the second stage, competition takes place between neighborhood stores and discount stores. For given location, both neighborhood and discount stores determine their prices, taking other stores' price as given.[15] Since neighborhood stores' location is different, they have a partial monopoly over their customers. Thus, neighborhood stores are monopolistically competitive.

Discount stores compete with one another as well as neighborhood stores. Since the marginal cost of transportation along the Beltway is zero and that products they carry are homogeneous, competition among discount stores is the homogeneous-product Bertrand, making their price equal to their marginal cost, i.e., the perfectly competitive price.

4. MARKET EQUILIBRIUM

I hereafter examine symmetric equilibrium in which the price and quantity of neighborhood stores are the same among them in equilibrium. I first examine the second-stage (pricing) equilibrium for given numbers and location of neighborhood and discount stores. Then, I consider the first- stage (entry) equilibrium.

Pricing Equilibrium

Because of the Bertrand competition among discount stores, the equilibrium price of discount stores on the Beltway, p^*, is always equal to its marginal cost m^*, that is,

$$p^* = m^*. \tag{3}$$

[15] Thus, I analyze the Nash equilibrium.

Let us now consider neighborhood stores. Since neighborhood stores are located equi-distantly at the beginning of the second period, the potential customers of discount stores are those located between neighborhood stores.

A consumer located at the distance x from a store posting price p is indifferent between purchasing from this neighborhood store and purchasing from the discount store if

$$v - p - cx = v - p^* - T^* \quad \text{or} \quad x = (p^* + T^* - p)/c. \tag{4}$$

Since consumers located at the distance $d \in [0, x]$ of both sides of the neighborhood store posting price p will buy from the store, the neighborhood store faces demand such that

$$D(p, p^*) = 2Lx = (2L/c)\{p^* + T^* - p\} \tag{5}$$

Therefore, the store seeks to maximize the following profit Π, with respect to p

$$\Pi = (p - m)D(p, p^*) - f = (p - m)(2L/c)\{p^* + T^* - p\} - f, \tag{6}$$

where f is the fixed cost of operation of the neighborhood store. The f may differ among neighborhood stores, but this does not influence the pricing equilibrium. From the first-order condition, we have

$$p = (p^* + T^* + m)/2. \tag{7}$$

Because of (2), we have the equilibrium neighborhood price p for the given number of neighborhood stores and the given location, such that

$$p = (m^* + T^* + m)/2. \tag{8}$$

In sum, pricing equilibrium is a pair of prices p and p^* satisfying (2) and (7).

The equilibrium price does not depend on the number of neighborhood stores and their location, since they compete with discount stores but not with one another under the assumption of equi-distance allocation of neighborhood stores.

The equilibrium prices p and p^* determine the share of discount stores, s^*. Note that the number of neighborhood stores, n, is given. The total sales of neighborhood stores $nD(p, p^*)$ must be equal to demand for them Ls, where $s \equiv 1 - s^*$. Therefore, we have, from $nD(p, p^*) = L(1 - s^*)$,

$$m^* + c^* + g(s^*) = m + \frac{c(1-s^*)}{n}, \tag{9}$$

which determines the share of discount stores s^* as a function of n, m^*, c^*, m, and c.

Condition (8) has straightforward interpretation. Rearranging terms both sides in (8), we have

$$p^* + T^* = p + \textit{Marginal Customer's Travel Cost to Neighborhood Store}, \tag{10}$$

where $p^* = m^*$, $T^* = c^* + g(s^*)$, $p = (p^* + T^* + m)/2$, and

$$\textit{Marginal Customer's Travel Cost to Neighborhood Store} \equiv c\frac{1}{2}\frac{1-s^*}{n}. \tag{11}$$

The left-hand side of (9) is the marginal customer's (and in fact, all customers') private cost of buying from the discount store, which consists of the discount-store price p^*, and the sum T^* of the fixed cost of using a car c^* and the cost effect of externality $g(s^*)$. The right-hand side is the marginal customer's private cost of buying from the neighborhood store, which is the sum of the neighborhood-store price p and the marginal customer's travel cost to the neighborhood store.[16] Thus, if the left-hand side of (9) (and thus (8)) is smaller than the left-hand side, the marginal customer switches from the neighborhood store to the discount store, and thus s^* increases. The market is in equilibrium only when (9) and thus (8) are satisfied.

Adjustment to Free Entry Equilibrium

Let us now consider free entry equilibrium. I assume that (i) consumers always choose their supplier optimally and thus (9) (or equivalently (8)) is satisfied, but that (ii) entry and exit of small stores take time, so that n changes slowly. Because their marginal cost is a constant m^* and their fixed cost is neglected, the number of discount stores is irrelevant. I hereafter concentrate my attention on the number of neighborhood stores, n.

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[16] The share of neighborhood stores, s, is the total market area of neighborhood stores. Since there are n neighborhood stores, each neighborhood store's market area is s/n. Thus, the distance between the marginal customer and the store is equal to $(1/2)(s/n)$. Then, the trip cost is equal to $c(1/2)(s/n)$.

Neighborhood stores enter the market if they earn positive profits, and exit from it if not. Thus, the number of neighborhood stores, n, follows the following differential equation

$$\dot{n} = \delta[\pi(s^*) - f(n)], \tag{12}$$

where δ is the speed of adjustment and $\pi(s^*)$ is the neighborhood store's second-stage profit excluding the fixed cost such that

$$\pi(s^*) = (p - m)D(p, p^*) = \frac{\{m^* + c^* + g(s^*) - m\}^2 L}{2c}. \tag{13}$$

Here D is in (4), and p^* and p are determined by (2) and (7). Free entry equilibrium is the stationary point of this differential equation (11).

Unique, Stable Coexistence Equilibrium

Figure 2 and 3 depict the adjustment and the equilibrium under no externality and under negative externality, respectively. In these figures, $\dot{s}^* = 0$ is the pricing equilibrium condition (8). Pricing equilibrium is assumed to be instantaneously achieved, so that the market is always on the $\dot{s}^* = 0$ curve. This curve cuts the n-axis at $n = c/(m^* + c^* - m) > 0$, since we have $g(0) = 0$ when $s^* = 0$. The curve also cuts the s^*-axis at $n = 0$, because $n = 0$ when $s^* = 1$. In Figure 2 of no externality, the curve $\dot{s}^* = 0$ is a straight line, while it is a downward-sloping curve in Figure 3, representing the effect of negative externality g.

The curve $\dot{n} = 0$ shows the free entry equilibrium condition based on (11). Figure 2 shows the case of no externality. Here $\dot{n} = 0$ is a horizontal line at n is such that $f(n) = \pi^* = (m^* + c^* - m)^2L/(2c)$. On the region over the $\dot{n} = 0$ curve, n is decreasing because $\pi^* < f(n)$. Under the curve $\dot{n} = 0$, n is decreasing.

In Figure 3 under negative externality, the $\dot{n} = 0$ curve is upward-sloping. As the share of discount stores increases, the congestion cost increases. Neighborhood stores take advantage of it, which implies higher equilibrium price of them. This results in higher profits inducing more entry, and thus the number of neighborhood stores increases. As in Figure 2, n is increasing in the region over $\dot{n} = 0$, and decreasing under it. Therefore, as depicted in both figures, there exists unique, stable equilibrium in which both neighborhood stores and discount stores coexist. The equilibrium number of neighborhood stores is determined by (8) such that

$$n^e = \frac{c(1-s^{*e})}{m^*+c^*+g(s^{*e})-m}. \tag{14}$$

Let us now compare the equilibrium neighborhood-store price with discount stores and without them. If the fixed cost of neighborhood stores is the same and equal to $\bar{f}$, then the neighborhood stores' price is unambiguously lower when there are discount stores than when there is none. Free entry equilibrium condition $\dot{n} = 0$ implies that the equilibrium share of discount stores s^{*e} satisfies

$$m^* + c^* + g(s^{*e}) = m + \{2c\bar{f}/L\}^{1/2}.$$

(15)

Consequently, the neighborhood store's price p when discount stores exist is equal to

$$p = \frac{m^*+c^*+g(s^{*e})+m}{2} = m + \frac{1}{\sqrt{2}}\sqrt{\frac{c\bar{f}}{L}}. \tag{16}$$

which is lower than the neighborhood store's price when there is no discount store, which is $p = m + \sqrt{c\bar{f}/L}$.

5. SOCIAL WELFARE

Command Optimum

Let us consider a planned economy, in which the social planner controls the number and location of neighborhood and discount stores, and the market area of each neighborhood store. Consumers in the market area of the neighborhood store are ordered to buy from the store on the Neighborhood Road, and those who are not in the area are ordered to buy from discount stores on the Beltway.

Policy

I consider a symmetric policy in which the social planner locates neighborhood stores equi-distantly on the Neighborhood Road and discount stores on the Beltway, and the market area around each neighborhood store is the same. Figure 4 depicts a possible policy. For each neighborhood store, the area of length x of each side is this neighborhood store's market area. Consumers who are located inside of this area are ordered to go to and buy from this store.

Consumers outside of all neighborhood-market areas are required to go to and buy from the discount store on the Beltway.

The social planner's control variables are thus (1) the number of neighborhood stores, n, and (2) the market area x of each neighborhood store. Since the marginal cost of discount stores is constant, the number of discount stores is irrelevant with respect to social welfare, so that I assume one discount store.

Note that the number of neighborhood stores, n, and the length of the neighborhood market area, x, uniquely determine the share of the discount store in the total sales, s^*, that is, $s^* = 1 - 2nx$. It turns out to be easier and more intuitive to use the market share of discount stores s^* as a control variable than to use the market area x. Thus, in the following, the social planner's control variables are the number of neighborhood stores, n, and the share of discount store in the total sales, s^*.

Objective Function

Next, consider the objective function of the social planner. Because the value of the product is v for all consumers and they buy only one unit of the product, the social planner's problem is to minimize the sum of consumers' travel costs (taking account of externality) and producers' production and fixed costs, with respect to its control variables (n, s^*).

Firstly, consider the total travel cost. Take a particular neighborhood store. The consumer located at the distance $d \in [0, x]$ in both sides buys from this store. Thus, we have the total travel cost of consumers buying from this store, taking account of the fact that the density of consumers is L and that $s^* = 1 - 2nx$, such that

$$n\left[2\left(\int_0^x ctdt\right)\right]_{x=\frac{1-s^*}{2n}} L = n2c\left[\frac{t^2}{2}\right]_{t=0}^{t=\frac{1-s^*}{2n}} L = \frac{c(1-s^*)^2}{4n}L. \tag{17}$$

The total travel cost (taking account of the effect of externality) to the discount store is T^*s^*L, since s^* is the share of consumers buying from discount stores. Note that $T^* = c^* + g(s^*)$ where c^* is the fixed cost of using a car and $g(s^*)$ is the effect of externality. Therefore, the total travel cost is

$$Total\ Travel\ Cost = L[\{c^* + g(s^*)\}s^* + \frac{c(1-s^*)^2}{4n}]. \tag{18}$$

Secondly, consider production and fixed costs. Since the marginal cost is a constant m and $1 - s^*$ is the total sales (production) of neighborhood stores, the total production cost of neighborhood stores is $m(1 - s^*)L$. Similarly, m^*s^*L is the total production cost of the discount store. Neighborhood stores incur the fixed cost of production. I have assumed that the fixed cost of the n-th firm is $f(n)$, and that n is treated as a real number for simplicity. Then, when n neighborhood stores operate, the total fixed cost of neighborhood stores is equal to $\int_{i=0}^{i=n} f(i)di$.

Since the fixed cost of discount stores is ignored, we have

$$Total\ Production\ and\ Fixed\ Cost = m(1 - s^*)L + m^*s^*L + \int_{i=0}^{i=n} f(i)di. \tag{19}$$

Thus, by rearranging terms, we have the total social cost TSC such that

$$TSC = (m^* + c^*)L + [\{m + \frac{c(1-s^*)}{4n}\} - (m^* + c^*)](1 - s^*)L + \int_{i=0}^{i=n} f(i)di + g(s^*)s^*L. \tag{20}$$

The first term in TSC is the social cost (excluding the effect of externality) when all consumers are served by the discount store. The second term is the difference in the social cost (excluding the effect of externality) of $(1 - s^*)L$ consumers between buying from neighborhood stores and the discount store. The third term is the total fixed cost, and the fourth term is the effect of externality.

The social planner minimizes TSC with respect to s^* and n. It is straightforward to show that TSC is strictly convex in s^* and n in the case of no externality ($g = 0$) and negative externality ($g > 0$, $g' > 0$ and $g'' > 0$).

Optimal Policy

Let n^o be the optimum number of neighborhood stores, s^{*o} the optimum share of the discount store. The first-order condition with respect to s^* yields

$$m^* + c^* + g(s^{*o}) + g'(s^{*o})s^{*o} = m + c\frac{(1-s^{*o})}{2n}. \tag{21}$$

Similarly, the first-order condition with respect to n is

$$f(n^o) = \frac{c(1-s^{*o})^2}{4n^{o2}}L. \tag{22}$$

Equations (20) and (21) simultaneously determine the optimum share of the neighborhood stores s^o and their optimum number, n^o.

Welfare Properties of the Laissez-faire Market Equilibrium

Let us now examine the welfare properties of the *laissez-faire* retail-market equilibrium, which is characterized by (8) and (11) with $\dot{n} = 0$, by comparing them to the command optimum determined by (20) and (21). In the subsequent analysis, s^{*e} and n^e are the equilibrium share of discount stores and the equilibrium number of neighborhood stores, while s^{*o} and n^o are the optimum ones.

On the one hand, market equilibrium condition (9) derived from (8) shows that market equilibrium is determined by *private* "no-arbitrage condition" of the *marginal customer.* That is, the marginal consumer's private cost of buying from a discount store must be equal to that from a neighborhood store. On the other hand, the social optimum requires that *social* "no-arbitrage condition" of the *average customer* must be achieved, because the social optimum conditions (20) and (21) can be rewritten as

$$p^* + \hat{T}^* = \hat{p} + \textit{Average Customer's Travel Cost to Neighborhood Store}, \tag{23}$$

where $p^* = m$, $\hat{T}^*$ is the social marginal travel cost such that $\hat{T}^* = c^* + g(s^*) + g'(s^*)s^*$, $\hat{p} = \{p^* + \hat{T}^* + m\}/2$, and

$$\textit{Average Customer's Travel Cost to Neighborhood Store} \equiv 2\int_{t=0}^{t=\frac{1-s^*}{2n}} ctdt \Bigg/ 2\int_{t=0}^{t=\frac{1-s^*}{2n}} dt = c\frac{1}{4}\frac{1-s^*}{n}. \tag{24}$$

Suppose first that the social planner imposes the socially optimum allocation, and orders neighborhood stores to charge p^o and discount stores to post p^{*o}. Then, assume that the social planner de-regulates the market, so that consumers can freely choose their supplier. Since (i) the marginal customer's travel cost to the neighborhood store is always larger than the average consumer's, and (ii) private agents ignore the externality effect $g'(s^{*o})s^{*o} > 0$ in their decision whereas the social cost of buying from a discount store includes it, we have $p^* + T^* + g(s^*) < p$ + *Marginal Customer's Travel Cost to Neighborhood Store*, where $T^* = c^* + g(s^*)$ and $p = (p^*$

$+ T^* + m)/2$. Then, the marginal customer of the neighborhood store switches from the neighborhood store to the discount store, thus increases the share of discount stores.

The above thought experiment also suggests that the market area of the neighborhood store in the market equilibrium is too small, and the share of the discount store is too large than the optimum. The following two propositions confirm this intuition.

PROPOSITION 1: NO EXTERNALITY

Under no externality, the individual market area of neighborhood stores is smaller in market equilibrium than in the optimum, i.e., $(1-s^{*e})/n^e < (1-s^o)/n^o$. Moreover, the share of discount stores is excessive in market equilibrium, i.e., $s^{*e} > s^{*o}$.

Proof. From (8) and (20), we have in the case of no externality ($g = 0$),

$$\frac{1-s^{*e}}{n^e} = \frac{m^*+c^*-m}{c} = \frac{1}{2}\frac{1-s^{*o}}{n^o}, \tag{25}$$

which implies the market area of the neighborhood store $(1 - s^*)/n$ is too small in market equilibrium. From (11), (20) and (21), we have

$$f(n^e) = \frac{\{m^*+c^*-m\}^2 L}{2c} = \frac{1}{2}f(n^o). \tag{26}$$

Since $f' > 0$, we have $n^e < n^o$ and consequently, $n^{e2}f(n^e) < n^{o2}f(n^o)$. Substituting (24) into (25), we have

$$1 - s^{*e} = \left(\frac{2f(n^e)n^{e^2}}{cL}\right)^{1/2} < \left(\frac{4f(n^o)n^{o^2}}{cL}\right)^{1/2} = 1 - s^{*o}. \tag{27}$$

From the above expression, we have $s^{*e} > s^{*o}$. •

The same proposition holds in the case of negative externality, so long as the distribution of the fixed cost among neighborhood stores is not very much dispersed. In the following propositions, $f_{\min}$ is the minimum fixed cost among neighborhood stores, while $f_{\max}$ is the maximum fixed cost.

PROPOSITION 2: NEGATIVE EXTERNALITY

Under negative externality, if $f_{max} < 2f_{min}$, then the individual market area of neighborhood stores is smaller in market equilibrium than in the optimum, i.e., $(1-s^{*e})/n^e < (1-s^o)/n^o$. Moreover, under the same condition, the share of discount stores is excessive in market equilibrium, i.e., $s^{*e} > s^{*o}$.

Proof. From (8) and (11) with $\dot{n}=0$, we have $c(1-s^{*e})/n^e = \{2cf(n^e)/L\}^{1/2}$, or equivalently,

$$f(n^e) = \{c(1-s^{*e})^2L\}/(2n^{e2}). \tag{28}$$

Comparing (27) and (21), we have

$$\frac{1-s^{*e}}{n^e} = \left(\frac{1}{2}\frac{f(n^e)}{f(n^{o})}\right)^{1/2}\frac{1-s^{*o}}{n^o} < \left(\frac{1}{2}\frac{f_{max}}{f_{min}}\right)^{1/2}\frac{1-s^{*o}}{n^o} < \frac{1-s^{*o}}{n^o}, \tag{29}$$

which proves the first half of the proposition. Subtracting (8) from (20), we have

$$g(s^{*e}) - g(s^{*o}) = c\left(\frac{1-s^{*e}}{n^e} - \frac{1}{2}\frac{1-s^{*0}}{n^o}\right) + g'(s^{*o})s^{*o}, \tag{30}$$

By definition, $g'(s^{*o})s^{*o} > 0$. Moreover,

$$\frac{1-s^{*e}}{n^e} - \frac{1}{2}\frac{1-s^{*0}}{n^o} = \frac{1}{\sqrt{2}}\left(\left(\frac{f(n^e)}{f(n^{o})}\right)^{1/2} - \left(\frac{1}{2}\right)^{1/2}\right)\frac{1-s^{*0}}{n^o} > \frac{1}{\sqrt{2}}\left(\left(\frac{f_{min}}{f_{max}}\right)^{1/2} - \left(\frac{1}{2}\right)^{1/2}\right)\frac{1-s^{*0}}{n^o} > 0$$

since $f_{max} < 2f_{min}$. Therefore we have $g(s^{*e}) - g(s^{*o}) > 0$, which implies $s^{*e} > s^{*o}$, since we have $g' > 0$ under negative externality. •

These propositions show that the market share of discount stores offering standardized product-service mix is too large from the viewpoint of social welfare. Thus, *innovation with mass-production is excessive in the laissez-faire market equilibrium under no externality and negative externality.* In other words, consumers who might be better-served by neighborhood stores are obliged to buy from discount stores, since no neighborhood store is located in their vicinity.

Congestion Tax on Discount Stores, Sales Subsidy on Neighborhood Stores, and Registration Fee on Neighborhood Stores

The optimal allocation can be achieved by a combination of "congestion tax" on discount stores, "sales subsidy" on neighborhood stores, and "registration fee" on neighborhood stores. Suppose that the government imposes the sales tax t solely on discount stores, and gives sales subsidy w to neighborhood stores. However, the government requires that neighborhood stores must register and pay registration fee of r. Then, the social optimum is achieved by a triplet (t, w, r) such that

$$t = g'(s^{*o})s^{*o}, \tag{31}$$

$$w = \frac{3}{2}\frac{c(1-s^{*o})}{n^o} \tag{32}$$

and

$$r = \frac{\{t + w + m^* + c^* + g(s^{*o}) - m\}^2 L}{c} - f(n^o). \tag{33}$$

It is interesting to note that consumption taxes introduced in Japan in 1989 treat large stores and small stores differently (Ito 1992). The consumption taxes are in fact value-added taxes. However, under the current system, small businesses that have annual sales under thirty million yen are exempt from paying consumption taxes to the authority, and companies whose annual sales are under five hundred million yen may use a simplified formula for calculating value added (a fixed rate of value-added: twenty percent for retailers and ten percent for wholesalers may be presumed, without record keeping).[17] Thus, we now have the wedge in consumption taxes between large discount stores and small neighborhood stores. However, Japan does not have a system of registering stores, and there are no registration fees.

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[17]These features are often described as unfair loopholes in the tax code.

6. MARKET EQUILIBRIUM WITH POSITIVE EXTERNALITY

Personal Computer and Positive Externality of Knowledge Diffusion

The circular city model can also be considered as a stylized model of product differentiation in the market of personal computers in Example 2 of Section 2, in which the product-characteristics space is assumed to be one-dimensional for analytic simplicity. Standardized products are products which are different from all the existing differentiated products, mass-produced with sizable reduction in cost and supplied competitively. These characteristics are shared by PC AT-compatible products in Example 2. Thus, it is possible to re-interpret the model of previous sections as the model of personal computers. However, as explained in Section 2, the direction of externality among consumers are different in the case of personal computers. We have positive externality of knowledge diffusion, instead of negative externality.

If positive externality due to knowledge diffusion dominates, then the net effect of externality is reduction in the overall switching cost and thus g is negative. It is likely that the cost is reduced as the share of consumers using PC-AT compatibles increases, but that the magnitude of marginal cost-reduction is also declined. Since $-g$ is the absolute value of cost reduction in the case of positive externality, the above discussion suggests that we have $g(0) = 0$, $g(s^*) < 0$ for $s^* > 0$, $-g' > 0$ and $-g'' < 0$, or equivalently, $g' < 0$ and $g'' > 0$.

Multiple Stable Equilibria under Positive Externality

The pricing equilibrium condition in the case of knowledge-diffusion externality is still (8) and the differential equation (11) characterizes the adjustment. Figure 5 depicts equilibrium, and adjustment to it. (Here I make an additional assumption that the positive externality is not large so that $m^* + c^* - m > -g'$ is satisfied.)[18]

The curve $\dot{s}^* = 0$ is the same as before. However, the curve $\dot{n} = 0$ is now downward-sloping instead of upward-sloping. An increase in the share of mass-produced products results

[18] If this is not satisfied, then $\dot{s}^* = 0$ curve may have upward-sloping region near $s^* = 0$. Then, $s^* = 0$ is unstable, and the market moves from $s^* = 0$ to the highest point of the $\dot{s}^* = 0$ curve.

in the reduction of switching cost $c^* + g(s^*)$. Therefore, the price of local differentiated products declines in order to meet competition from mass-produced products. Then, the profit of local producers declines, so that the number of them decreases.

There may be multiple stable equilibria in which both mass-produced products and local differentiated products coexist, as exemplified in Figure 5. In this figure, E_1 and E_3 are stable equilibria, and E_2 is an unstable one. However, this is not the only possibility. There may be no stable coexistence equilibria, or the number of stable equilibria may be more than two, depending on the shape of f and g.

Let us now consider the social welfare property of the market equilibrium. The total social cost TSL is still strictly convex if $g''(s^*)s^* + 2g'(s^*) > 0$. This condition is a natural one implying that the elasticity of the marginal cost reduction $-g'(s^*)$ to an increase in the share of mass-produced products s^* is sufficiently small (less than 2). Equations (20) and (21) still characterize the optimum in this case.

Market equilibrium under positive externality may involve too large share of mass-produced products or too small share, depending on particular equilibrium. Positive externality implies too small share, while the wedge between private incentive and social gain to switch explained in the previous sections leads to too large share. Thus, the overall effect is ambiguous. Moreover, if there are multiple stable equilibria, they can be ranked with respect to social welfare. The market may be trapped in inferior equilibrium.[19]

Difficulty in Penetration: No Stable Coexistence Equilibrium under Homogeneous Fixed Cost

In Section 2, I have described the Japanese personal computer market in which mass-produced IBM PC AT-compatibles found it difficult to penetrate. Let us now examine factors that may contribute to the difficulty.

[19] This is another manifestation of the effect of positive externality among consumers, which have been extensively discussed in the literature. See Tirole (1988).

If producers of differentiated products have homogeneous fixed cost, stable equilibrium is at the two corners: one in which only local differentiated products exist, and the other in which only mass-produced products exist. Figure 6 depicts this case. In the case that producers of local differentiated products have the same fixed cost, the $\dot{n} = 0$ curve becomes vertical. Since a decrease in s^* implies an increase in the switching cost, the differentiated-product producers take advantage of it by raising their price, which increases their profit. The opposite is true on the right-hand side. Thus, n is increasing on the left-hand side of this vertical line, and decreasing on the right-hand side. Consequently, the coexistence equilibrium E is unstable equilibrium, and both $s^* = 0$ and $s^* = 1$ are stable equilibria.

Suppose that in seeing the possible challenge of mass-produced products, local differentiated-product producers cut their price so that the equilibrium price is (20) with $s^* = 0$. Then, since $s^* = 0$ is stable equilibrium, it is likely that a small disturbance does not change the equilibrium outcome of no penetration of mass-produced products. This implies that if producers of local differentiated products are rather homogeneous in their fixed cost, the penetration of mass-produced products is very hard to be materialized. Unless there is a large disturbance that make the market to jump into the right-hand side of $\dot{n} = 0$, the market is very hard for mass-produced products to penetrate, even though the social welfare will be improved by the penetration. Moreover, the market share of mass-produced products, which is zero, is clearly too small from the viewpoint of the social welfare.

One of the major characteristics of the Japanese market is that (1) relatively homogeneous firms compete with one another, and (2) timely price-cut decision in face of outside threat to enter. For example, in the Japanese personal computer market, NEC responded quickly to the challenge of PC AT-compatibles, by introducing new lines of high performance machines with lower price, and others followed suit. Figure 6 shows that penetration of mass-produced products is difficult in this case.

Although initial attempt of PC AT-compatibles was not so successful, their future picture is not so break in the Japanese personal computer market. There seems momentum building up for PC AT compatibles, since manufacturers of local differentiated products other than NEC begin to produce PC AT compatibles themselves. Thus, there is possibility that in the future that the market may exceed the critical point of $\dot{n}=0$. Even NEC, which is one of the successful PC AT-compatible producer in the United States, is said to be preparing the change.

7. CONCLUDING REMARKS

This paper has examined product innovation involving standardization of product characteristics and mass-production. I have shown that, when there is no or negative externality in consumption of mass-produced products, the share of mass-produced products is likely to be excessive from the viewpoint of social welfare, although mass-produced products are supplied competitively. Thus, the result of this paper clarifies the argument against mass-production, that it goes excessive in eradicating richness of local diversity and in leading toward monotone banality. This also gives an argument to protect small producers of local differentiated products against large producers of standardized products.

As demonstrated in Spence (1976), the number of products (firms) may be socially too large or too small under imperfect competition, depending on specific characteristics of the market. This paper identifies market characteristics which give an unambiguous answer of the question of too much or too little entry. The entry of perfectly competitive firms producing mass-produced goods into an imperfectly competitive market under local product differentiation is bound to be excessive.

There are several caveats on this result. First, the above proposition is obtained in the case where there is a sizable switching cost from differentiated products to mass-produced products. If the switching cost is negligible, it is apparent that the social welfare optimum involves no local differentiated products.

Second, as has been shown in Section 6, the result may be reversed if there is strong positive externality. In this case, the market have multiple stable equilibria which can be ranked according to their level of social welfare.

Third, the assumption of perfectly competitive price of mass-produced products may not be realistic in several cases. The products may be patented, and thus may be monopolized. Or they may be licensed. Non-competitive behavior of mass-produced products changes the cost and benefit of using mass-produced products, and ultimately alters the choice of consumers.

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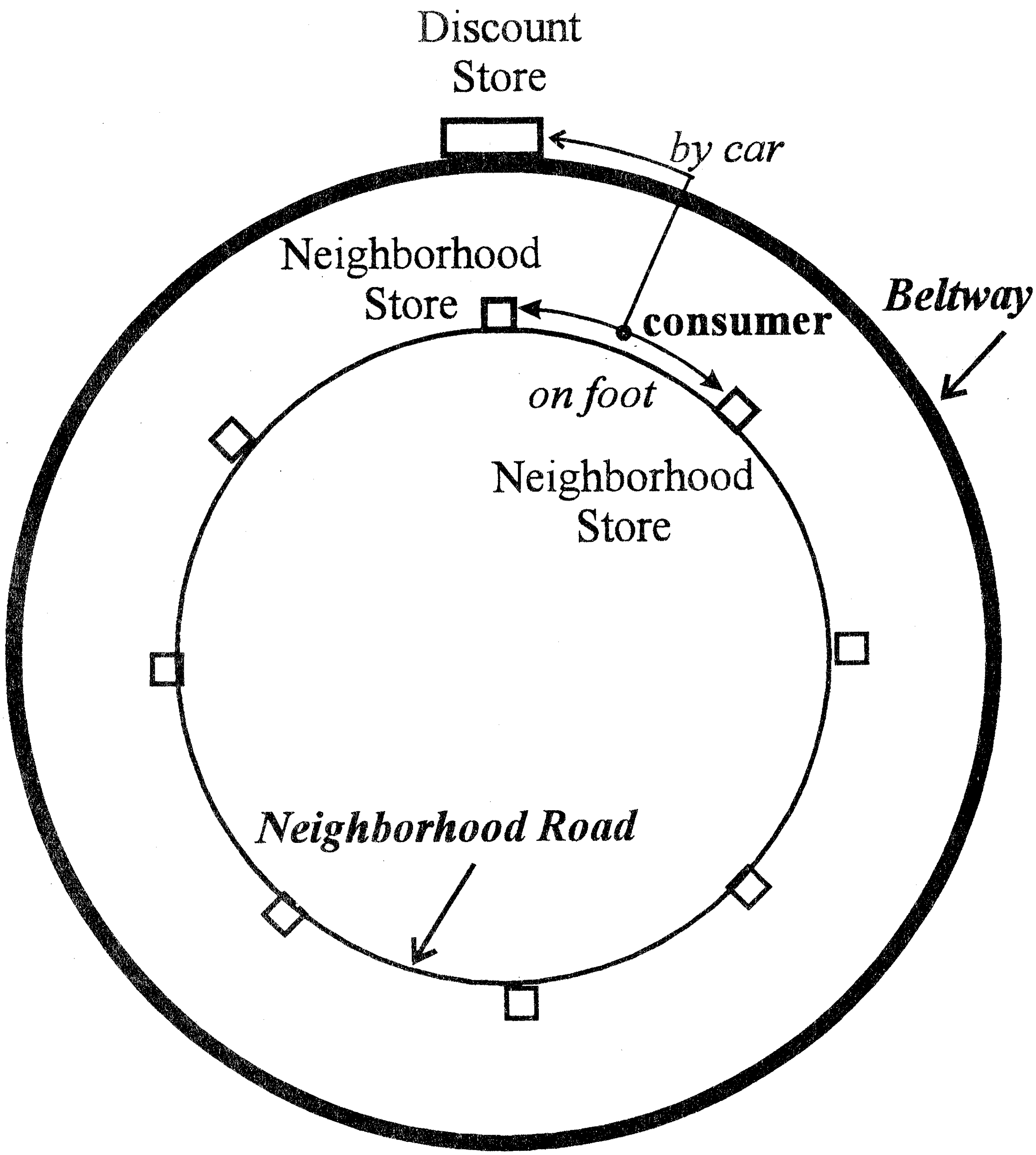

FIGURE 1
A CIRCULAR CITY
WITH A BELTWAY

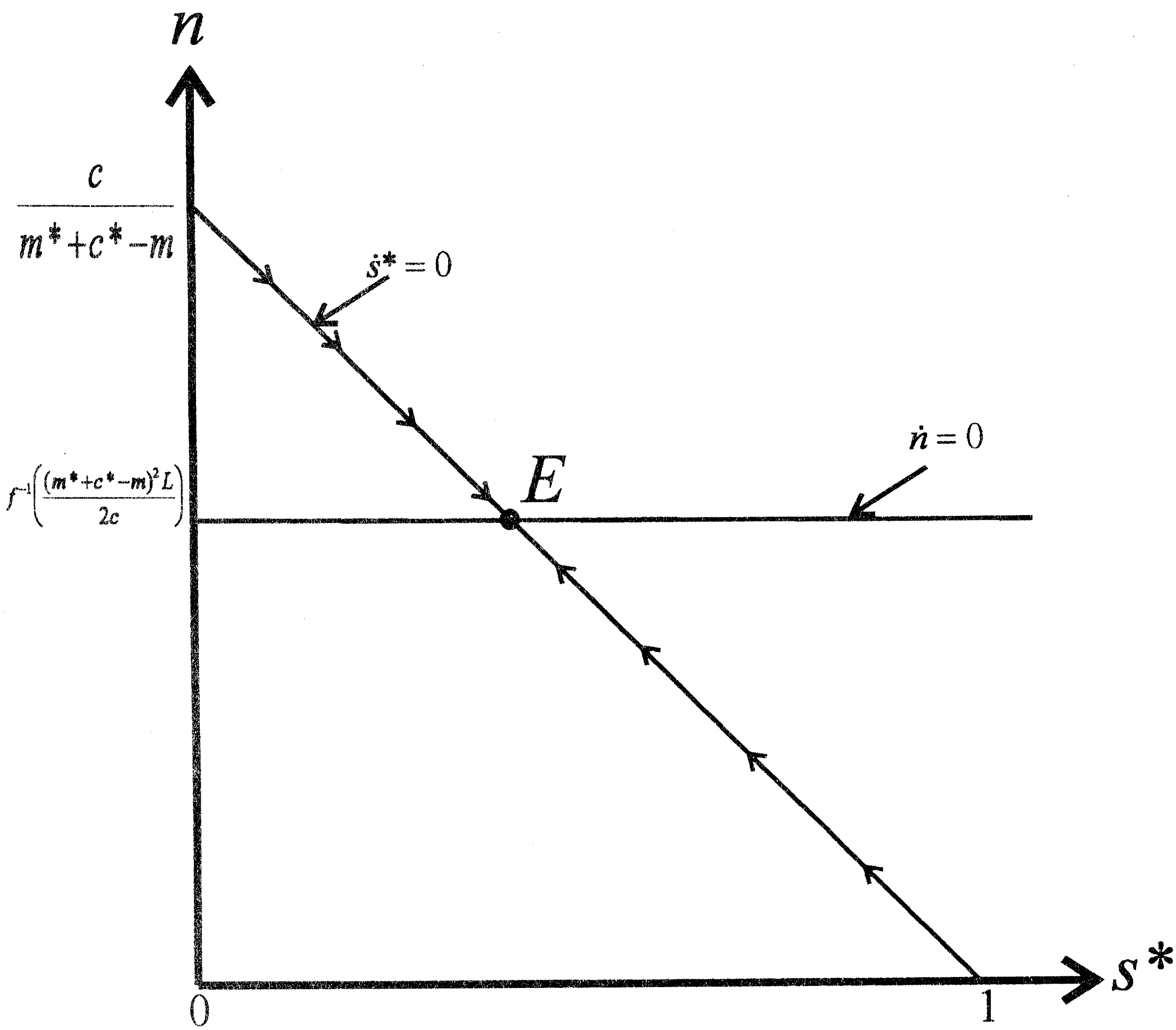

FIGURE 2
UNIQUE STABLE EQUILIBRIUM
UNDER NO EXTERNALITY

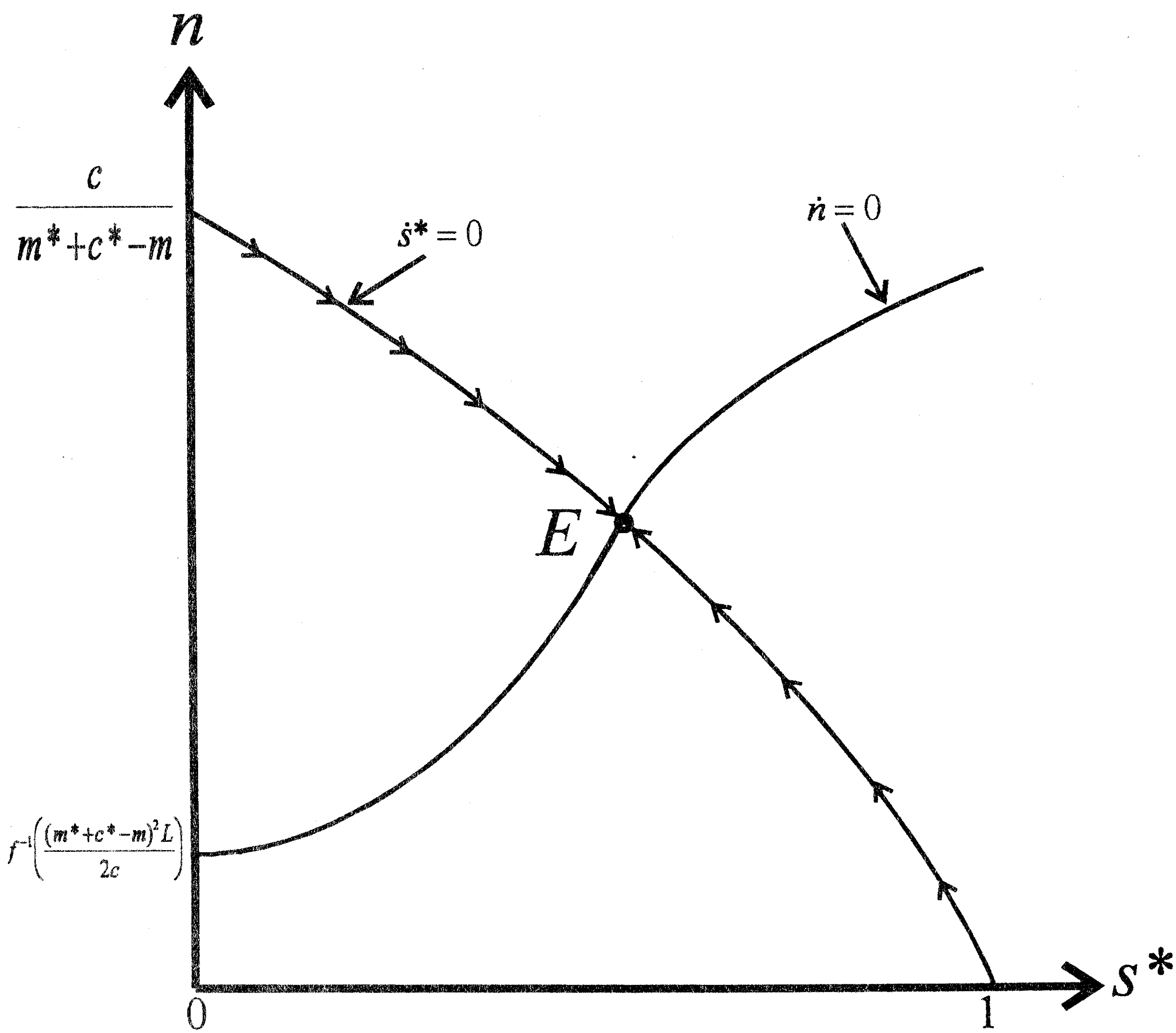

FIGURE 3
UNIQUE STABLE EQUILIBRIUM
UNDER NEGATIVE EXTERNALITY

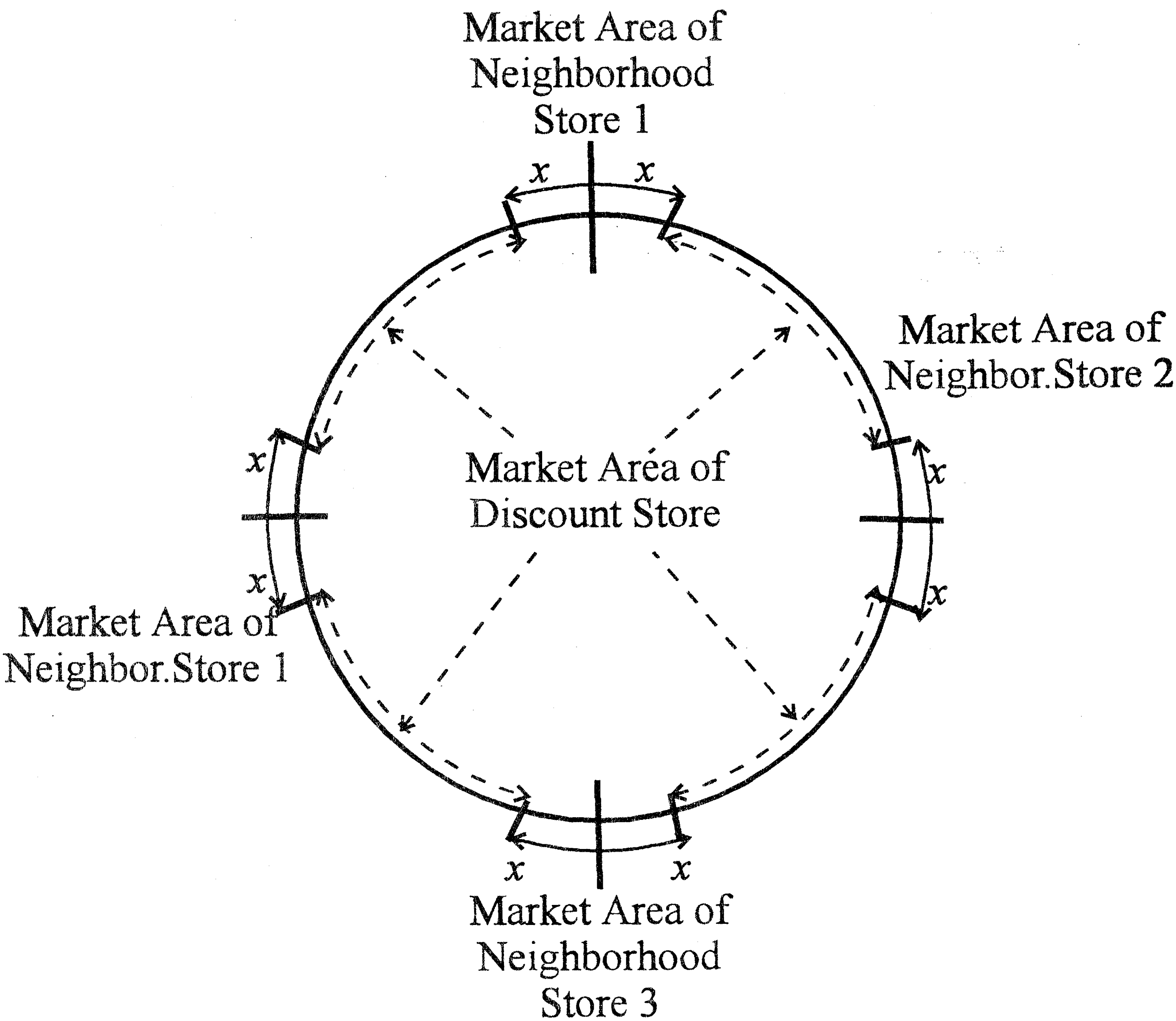

FIGURE 4
COMMAND OPTIMUM:
MARKET AREA OF
NEIGHBORHOOD STORES

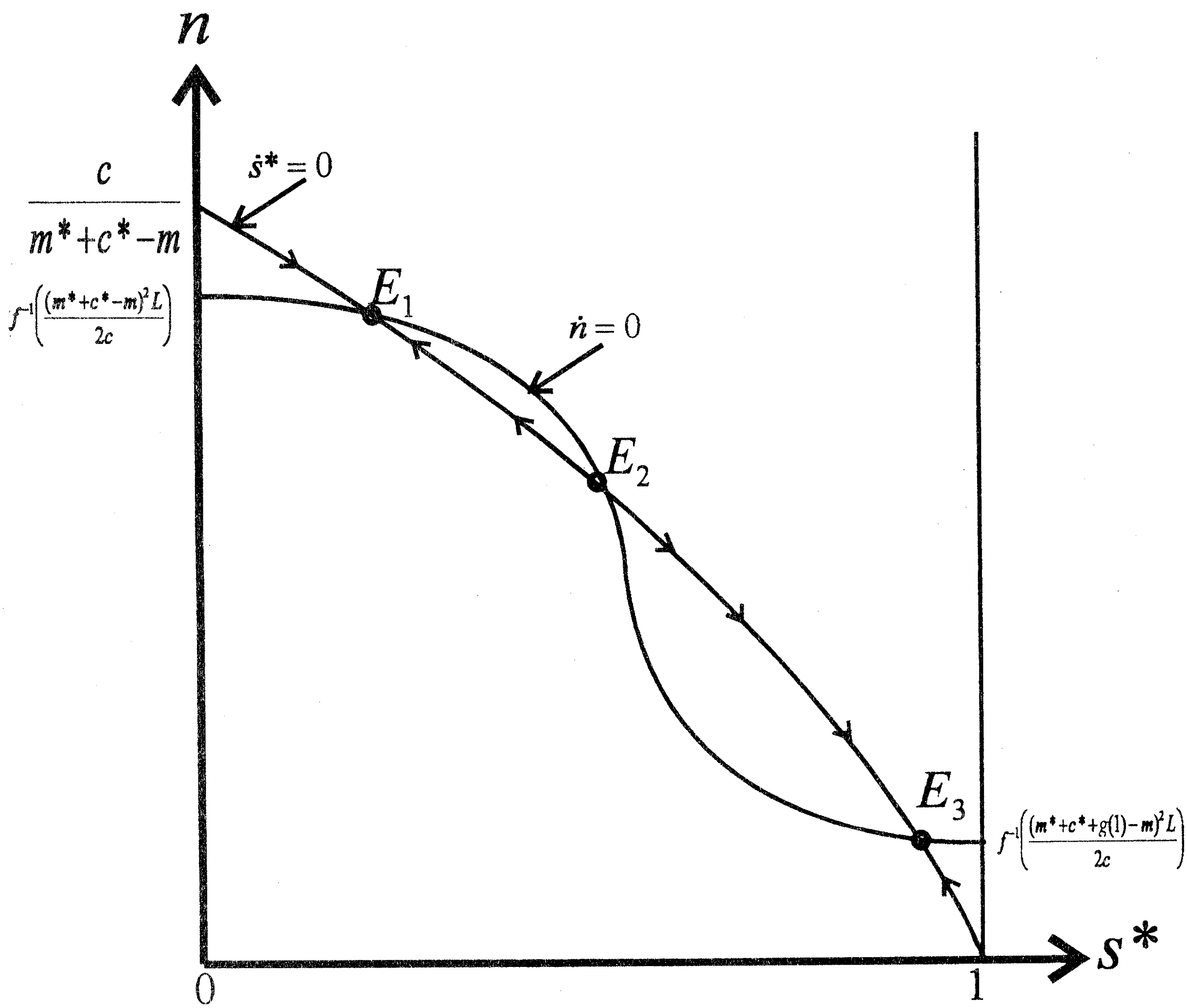

FIGURE 5
MULTIPLE STABLE EQUILIBRIA
UNDER POSITIVE EXTERNALITY

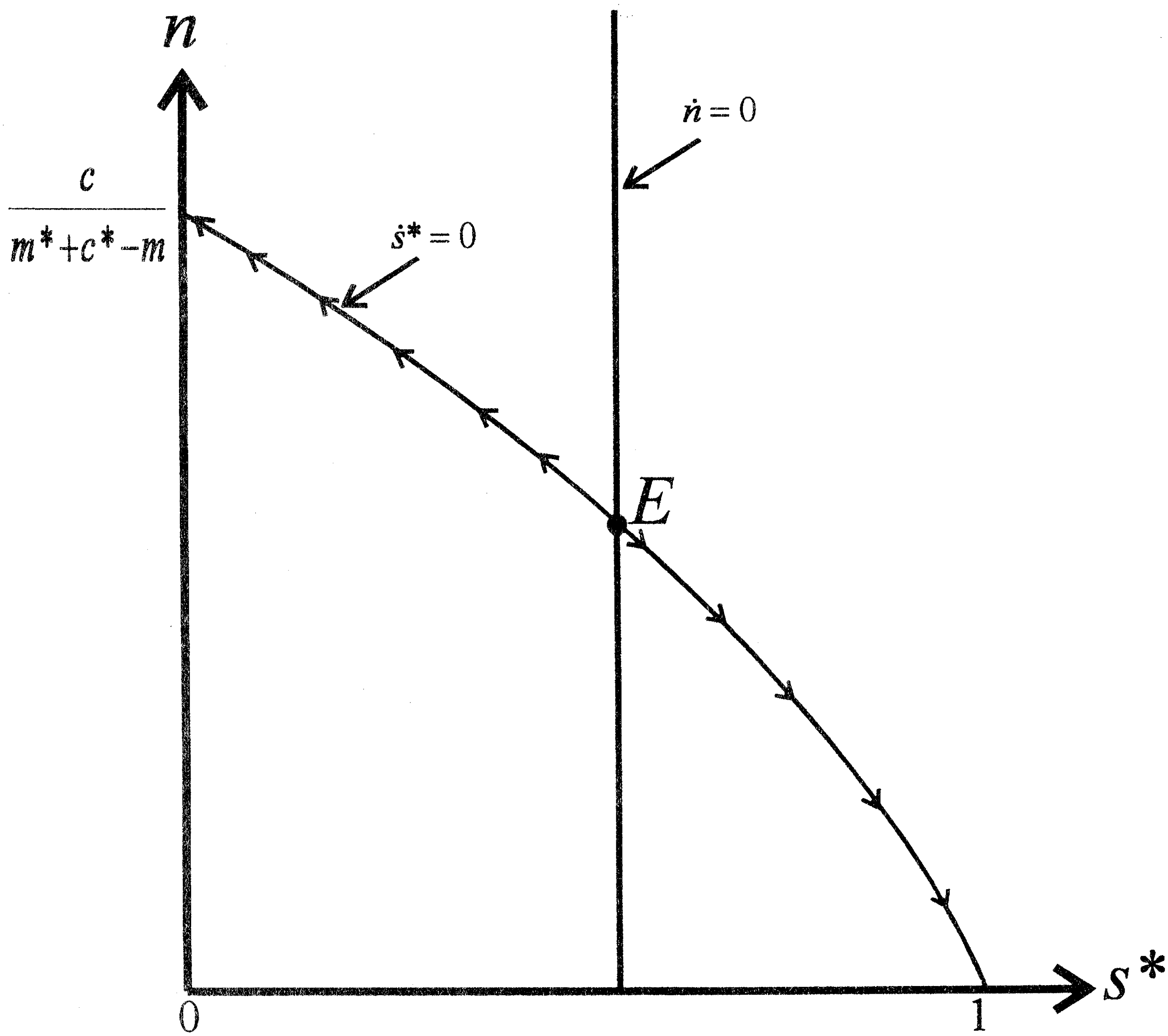

FIGURE 6
DIFFICULTY IN PENETRATION: HOMOGENEOUS FIXED COST