CentER for Economic Research

Discussion paper

[redacted]

Tilburg University

Center
for
Economic Research

No. 9562

MONOPOLISTIC COMPETITION WITH A MAIL ORDER BUSINESS

By Jan Bouckaert

June 1995

ISSN 0924-7815

Monopolistic Competition with a Mail Order Business

Jan Bouckaert *

March 1995

*Center for Economic Research, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, The Netherlands. I would like to thank Helmut Bester for his advice. I also benefited from helpful comments made by Eric van Damme, Dave Furth, Andreas Ortmann, Johan Stennek, and Frank Verboven.

Abstract

This paper studies a market in which firms can choose to sell either by a retail store or by a mail order business. For the consumer, purchases made at retail stores entail transportation costs that increase with distance. In contrast, a consumer served by mail order businesses pays a fixed cost, irrespective of his or her location. This paper considers monopoly, oligopoly, free entry, and the social optimum. In the free-entry case, at most one mail order business emerges in equilibrium. In the free-entry equilibrium with a mail order business, competition is more fierce, compared to the well-known Salop-model, without mail order business. Therefore, fewer firms are active in equilibrium. In contrast with the free-entry case, the monopolist and the social planner never open both stores and a mail order business at the same time.

Keywords : Monopoly, Free Entry, Mill Pricing, Mail Order.

JEL Classification No.: D21, D42, D43.

1 Introduction

This paper investigates the equilibrium structure of an industry in which firms sell a homogeneous good at mill prices by two alternative methods. The first method consists of opening a retail store, which consumers can visit by paying a linear transportation cost. In the spatial price terminology, this method is called 'uniform Free-On-Board (FOB) pricing.'[1] The other method involves setting up a 'mail order business,' where consumers are served by paying a fixed cost, irrespective their initial location. The mail order business serves its consumers by some exogenous technology, e.g. a postal service. Both selling policies have in common that *none* of the firms bears transportation costs. They differ, however, in their impact on consumers' decisions. When a consumer buys at a retail store, his total expenditure equals the price *at* retail plus his transportation cost *to* the retail store. In contrast, all consumers buying at the mail order business have the same total expenditure. The store's selling policy implies uniformity of the price only at the store. The mail order business's selling policy implies uniformity of the price – – not only at the mail order business, but also at the place of delivery; that is, the consumer's home location. The fixed transportation cost implies that a price change affects every consumer equally. Location, therefore, becomes completely irrelevant when selling occurs by a mail order business. Markets in which consumers are served by stores and/or mail order businesses include the following: books, clothing, computers,[2] flowerbulbs, photographic developing, records, banking and insurance products, etc... . This paper aims to investigate the conditions and properties of an industry with the above characteristics.

The analysis adds a mail order business to the standard circle model à la Salop (1979). I characterize the protected monopoly,[3] the oligopoly and free entry equilibrium, and the social optimum. It is never optimal for the monopolist to offer at the same time both selling policies, i.e. stores and a mail order business. With free entry, only one store or

[1] In discussing this spatial price policy, Phlips (1983) remarks : "In any event, the net producer price (after deduction of freight) is the same whatever the destination, since at any point of delivery the delivered price is equal to the factory price plus actual carriage costs" (p. 28).

[2] In 1991, 22% of all microcomputers in the US were sold through the mail (see McWilliams (1991)).

[3] i.e. a monopolist 'who does not face the threat of entry' (Bonanno (1987), p.39).

mail order business is allowed per firm. If the set-up cost is large relative to the marginal transportation cost, no mail order business appears. However, at most one mail order business emerges in equilibrium. The presence of a mail order business implies more competition, compared to the original Salop-model. As a result, a smaller number of firms is active in equilibrium. Finally, in the social optimum, it is never optimal to offer both selling policies at the same time.

The importance of mail order businesses varies between countries. In terms of per capita expenditures for 1991, it ranges from \$23 in Italy, to \$273 in the United States. As a percentage of the total turnover in the non-food retail trade in 1991, the mail order industry represented 5.1% in France, 4.7% in Sweden, and in the total retail trade, 4.7% in the Federal Republic of Germany.[4] These figures, however, take no account of the importance of the mail order business in a particular industry. They include industries where no mail order business exists. Excluding these industries will increase the mail order industry's share.

The subject of the paper clearly differs from Thisse and Vives (1988), in which firms make strategic choices in terms of *spatial price* policy. Thisse and Vives consider two price policies: uniform FOB pricing and discriminatory pricing. They find "a robust tendency for a firm to choose the discriminatory policy" (p. 134). In footnote 8, they remark: "let us emphasize the fact that what we call here uniform pricing is different from uniform delivered pricing as defined in postage stamp systems." This paper takes these two variants of uniform pricing as the available strategic choices for selling products.

A mail order business can serve the entire market without affecting the consumer's cost of being served. This differs from uniform zone pricing in at least two ways. First, uniform zone pricing implies that every consumer within a well-defined region is charged the same price. Actual transportation costs, however, are borne by the firm. By choosing such a pricing policy, the firm faces a minimization problem for its total transportation costs. Second, the larger the market that is being served, the larger the average transportation cost is. Therefore, and in contrast with the mail order business, location

[4]Source : *NRC Handelsblad*, June 30, 1993 and *European Mail Order Trade Association*, Key Figures 1991.

matters under uniform zone pricing.

The economics literature on spatial structure in the retail trade where fixed vs. linear transportation costs appear in a strategic context is rather scarce.[5] Heal (1980) studies a circle model in which consumers can buy either from the producer at the center or from a store on the circumference. Also the store, however, has to buy its products from the producer at the center. Due to increasing returns to scale in transportation costs, the outer store can develop a comparative advantage *vis-à-vis* the consumers. Lewis (1945) takes account of forms of retailing in which consumers do not visit the stores but order by telephone or by mail. He remarks that this kind of retailing is "convenient if the customer knows what he wants ..."(p.216). Henriet and Rochet (1991) discuss a circle model in which consumers can buy insurance either directly from the company (located at the center of the circle) or from one of its intermediaries (located on the circle). Buying from the direct writer implies a fixed cost for the consumer, regardless of his location. The alternative is to buy from the nearest intermediary. They investigate the influence of different vertical restraints on the equilibrium outcome.

One recent article in the economics literature on mail order businesses versus retail stores is Michael (1994). He uses the theory of transaction costs to explain marketing channels. His analysis focusses on differences in costs of physical distribution and of informing the consumers in mail order businesses and retail stores. Changes over time in these costs significantly affected the sales of mail order businesses. The empirical results also support the assertion that a higher density of population makes retailing relatively more advantageous.

In contrast with the economics literature, the marketing and retailing literature focusses on the mail order industry (see e.g. Darian (1987)). The central theme is on the relationship between demographic characteristics at the household level and (mail order) shopping behavior. This paper studies the impact of selling by a mail order business

[5]There is, however, a considerable body of literature on endogenous (spatial) pricing policies. Spiegel (1982) demonstrates that sellers prefer the 'meet the competition' policy to uniform delivered pricing and mill pricing. Furlong and Slotsve (1983) show that a monopolist can increase profits when the choice is available between mill and uniform delivered pricing. In a different context, Bester (1993) analyzes whether posted prices or negotiated pricing will emerge in a market with quality uncertainty.

on competition with retail stores. In the same line as the cited article by Thisse and Vives, the analysis stresses that "current business practices reflect a *strategic* positioning of firms in the market" (p. 122).

The paper is organized as follows. Section 2 presents the model. Section 3 analyzes the optimal structure for a monopolist. In order to focus on strategic interactions between firms, section 4 studies the oligopoly case. Section 5 considers the equilibrium market structure in a free-entry context. Section 6 addresses a welfare analysis. Finally, section 7 contains some concluding remarks.

2 The Model

Consider a market for a homogeneous product. Marginal cost of production is constant and without loss of generality normalized at zero. Each firm, indexed by $i = 1, ..., N$, can choose from a set of two strategies to market the product. The first is the traditional way of opening a single store. At this store, consumers are charged a uniform mill price $p_i \geq 0$. Each consumer located at distance z from the store, bears the linear transportation cost $tz \geq 0$. I use the Salop (1979) circle model, where firms are located equidistant from each other. The second strategy is to open a mail order business, where consumers can order the product (by mail) at a mill price $q_i \geq 0$ plus a non-negative fixed cost φ (e.g. the price of the stamp) for sending the product to the consumer's location. This fixed cost φ is assumed to be independent of one's location and not susceptible to (strategic) manipulation by any of the players.[6] One possible interpretation is that the mail order business is located at the center of the circle. The radius of the circle then represents the fixed cost φ.

There is a unit mass of consumers whose initial locations are uniformly distributed on a circle with density one. The consumers buy from that firm that offers the lowest full price, i.e. mill price plus fixed or linear transportation cost. Each consumer has the same reservation price r and buys at most one unit of the good.

[6] The model assumes that price discrimination based on the consumer's address is illegal. This seems reasonable if the analysis concentrates on competition within one country.

3 Monopoly

Consider a protected monopolist who can make use of both selling policies. The monopolist decides on the number of stores on the circle, whether to set up a mail order business and, for each of these selling policies, what prices to charge. There is an identical positive set-up cost F for every mail order business and each store on the circle. Assume that $r \geq t$ so that, with only one store on the circle, it is in the monopolist's interest to serve the whole market. In addition, assume that $r > \varphi$, so that a mail order business can operate for some positive set-up cost.

Lemma 1: *If the monopolist can only open stores on the circle, his profit equals* $max(0, r - \sqrt{2tF})$, *and* $\sqrt{0.5t/F}$ *is the optimal number of stores.*

Proof: Store i's marginal consumer, located at $\hat{x}$, is defined by the equation $p_i + t\hat{x} = r$. This implies that the monopolist's profit function is $2n_c\hat{x}(r - t\hat{x}) - n_cF$, with n_c the number of stores on the circle. Maximize this with respect to x, and the function is increasing as long as $r \geq 2t\hat{x}$. From the assumptions of symmetry and $r \geq t$, $0.5 \leq \hat{x}$ at $r = 2t\hat{x}$. Therefore, with $n_c \geq 1$ stores, the monopolist finds it optimal to serve the whole market, such that $\hat{x} = 0.5/n_c$, and the profit function becomes $r - 0.5t/n_c - n_cF$. Maximizing with respect to n_c yields an optimal number of $n_c^* = \sqrt{0.5t/F}$. After substitution, the profit equals $r - \sqrt{2tF}$. If this profit is larger than zero, the monopolist opens a number of $\sqrt{0.5t/F}$ stores on the circle. Otherwise, the monopolist stays out of the market. □

Lemma 2: *Assume that the monopolist cannot open stores on the circle. If* $r - \varphi \geq F$, *the monopolist opens one (and only one) mail order business. Otherwise, he opens no mail order business at all.*

Proof: If the monopolist opens $n_m \geq 1$ mail order businesses, his profit equals $(r - \varphi) - n_mF$. Therefore, opening more than one store would only reduce profits. If $r - \varphi - F \geq 0$, the monopolist opens only one mail order business. If F is such that profits are negative, the monopolist opens no mail order business at all. □

Proposition 1 contains the main result of this section. In contrast with lemma 1 and

2, I allow the monopolist to sell by stores and mail order businesses. The proposition assumes that both ways of selling are profitable.

Proposition 1: *(a) The monopolist opens a single mail order store if* $\varphi + F \leq \sqrt{2tF}$*; (b) he opens* $\sqrt{0.5t/F}$ *stores on the circle if* $\varphi + F > \sqrt{2tF}$*; (c) he never operates both types of business.*

Proof: If the monopolist can offer both types of selling policies, he chooses p_i, q_i, n_c, n_m and $\hat{x}$ so as to maximize

$$\pi(p_i, q_i, n_c, n_m, \hat{x}) = 2n_c\hat{x}p_i + min(1, n_m)(1 - 2n_c\hat{x})q_i - (n_c + n_m)F$$

subject to $0 \leq \hat{x} \leq 0.5/n_c$ and $n_c, n_m \geq 0$. The variable p_i (q_i) denotes the price at a store on the circle (at a mail order business). The number of stores, n_c and n_m, are interpreted similarly. From the profit function, it is clear that at most one mail order business will be opened, if any. The consumer who is indifferent between buying at a store on the circle and at the mail order business is characterized by $q_i + \varphi = p_i + t\hat{x} = r$. Substitute this into the profit function, and differentiation with respect to $\hat{x}$ shows that the function is monotonically non-decreasing as long as $\varphi \geq 2t\hat{x}$. Since $0 \leq \hat{x} \leq 0.5/n_c$, $\hat{x} = min(0.5/n_c, 0.5\varphi/t)$. If $\varphi/t \leq 1/n_c$, the profit function becomes

$$\tilde{\pi}(n_c, n_m) = 2n_c\frac{\varphi}{2t}(r - t\frac{\varphi}{2t}) + min(1, n_m)(1 - 2n_c\frac{\varphi}{2t})(r - \varphi) - (n_c + n_m)F.$$

If, in equilibrium, the monopolist uses both selling policies, $(1 - 2n_c\varphi/2t)(r - \varphi) > n_m F$. After some rearranging, the function becomes

$$\tilde{\pi}(n_c, n_m) = r - \varphi - n_m F + n_c(\frac{\varphi^2}{2t} - F).$$

$\tilde{\pi}(n_c, n_m)$ is non-decreasing in n_c as long as $\varphi \geq \sqrt{2tF}$. In this case, n_c can be increased up to the point where $\varphi/t = 1/n_c$. Every mail order business, therefore, cannot attract a positive market share. Since profits are decreasing in n_m, no mail order business is opened. In the other case, in which $\varphi < \sqrt{2tF}$, $\tilde{\pi}(n_c, n_m)$ is strictly decreasing in n_c and no stores on the circle are opened. The optimal number of one mail order business results if profits are nonnegative.

If $1/n_c < \varphi/t$, the profit function becomes (after rearranging)

$$\tilde{\pi}(n_c, n_m) = r - \frac{t}{2n_c} - (n_c + n_m)F$$

Since $\partial\tilde{\pi}(n_c, n_m)/\partial n_m < 0$, the optimal number of mail order stores equals zero. Differentiate with respect to n_c, and the optimal number n_c of stores on the circle equals $\sqrt{0.5t/F}$. If the resulting profit $r - \sqrt{2tF}$ is nonnegative, the monopolist opens a number of $\sqrt{0.5t/F}$ stores on the circle (see Lemma 1). The monopolist now makes the optimal choice by comparing both profits. If $r - \varphi - F > r - \sqrt{2tF}$, if and only if $\varphi + F > \sqrt{2tF}$, the monopolist prefers to open one and only one mail order business (see lemma 2). Otherwise, he only opens the optimal number of stores on the circle. □

In other words, the monopolist either opens retail stores *or* one mail order business. The intuition is as follows. Suppose opening a single mail order business is profitable. In addition, suppose the opening of one or more retail stores together with the mail order business yields extra profits, despite the additional fixed set-up costs. Then, ignoring integer problems, the monopolist's optimal decision is to serve the whole market by retail stores. In that case, the mail order business serves no consumers. Therefore, the monopolist opens no mail order business. If, on the contrary, opening the extra retail store does not yield extra profits, he opens a single mail order business.

4 Oligopoly

Let there be a fixed number of firms in the market, indexed by $i = 2, \ldots, N$. The model presented in section 2 is analyzed as a two-stage game. In the first stage, firms decide on whether to become traditional stores (and consequently are appointed a position on the circle) *or* mail order businesses (and consequently have their location at the center of the circle). In the second stage, having observed each other's decision in the first stage and the corresponding location, they compete in prices. I solve the game for its Subgame Perfect Nash Equilibria in pure strategies by the method of backward induction.

Before moving to the two relevant cases, consider the case in which more than one firm operates as a mail order business. A standard Bertrand result appears for these firms, since they are not differentiated at all with respect to each other. Price competition results in charging a price equal to marginal cost. Since set-up costs are strictly positive, in pure strategies at most one firm will open a mail order business. This results in two

possible alternatives: (i) no firm operates a mail order business, and (ii) exactly one firm sells through the mail.

The first case is identical to Salop's circle model of product differentiation. All N firms decide to open a store on the circle. The distance between every pair of firms equals $1/N$. Suppose firm i chooses a price p_i, and that $\overline{p}$ is the price charged by the other firms. Then, a consumer located at distance x from firm i, with $x \in [0, 1/N]$, is indifferent between buying from firm i and its neighbor if

$$p_i + tx = \overline{p} + t(\frac{1}{N} - x). \tag{1}$$

The difference $(1/N - x)$ is the distance between the indifferent consumer's location x and the neighboring firm. Solving (1) for x, one obtains firm i's demand at both sides. Define profits as total demand times price, and firm i's profit equals

$$\pi_i(p_i, \overline{p}) = 2xp_i = \frac{\overline{p} - p_i + t/N}{t} p_i \tag{2}$$

Optimizing this with respect to p_i, $p_i^* = 0.5(\overline{p} + t/N)$ is firm i's optimal price, given $\overline{p}$. By symmetry, set $p_i = \overline{p}$. This yields the symmetric solution, so that $p_i^* = p^* = t/N$.[7] Firm i's market share then becomes $1/N$. It follows that every firm's gross profit, expressed as a function of the number of firms N, equals

$$\pi_S^*(N) = \frac{t}{N^2} \tag{3}$$

Expression (3) will be referred to as the *S-equilibrium* profit.

In the second case, only one firm decides to become a mail order business; the other $(N - 1)$ firms are equally spaced around the circle. Each of the $(N - 1)$ firms on the circle is at distance $1/(N - 1)$ from its two neighbors on the circle. Each firm i on the circle now faces three competitors: the two nearest ones on the circle *and* the mail order business. In between every two neighboring firms on the circle, two indifferent consumers

[7] This analysis also assumes that the market equilibrium lies in the competitive region of firm i's demand curve. That is, the reservation price $r \geq 3t/2$ (see Salop (1979) for the exposition).

can be defined. One is indifferent between firm i and its neighboring firm on the circle. Given a price $\overline{p}$ charged by this competitor on the circle, this indifferent consumer is located at y, where

$$p_i + ty = \overline{p} + t(\frac{1}{(N-1)} - y) \tag{4}$$

as long as $y \leq 1/(N-1)$. The other is indifferent between firm i and the mail order business. Given a price $\overline{q}$ charged by the mail order business, this indifferent consumer is located at z such that

$$p_i + tz = \overline{q} + \varphi \tag{5}$$

Figure 1 clearly illustrates that if $y \leq z$, the mail order business gains no positive market share. and consequently, zero profits. If $y > z$. the mail order business can serve a positive share of the market (see figure 2).

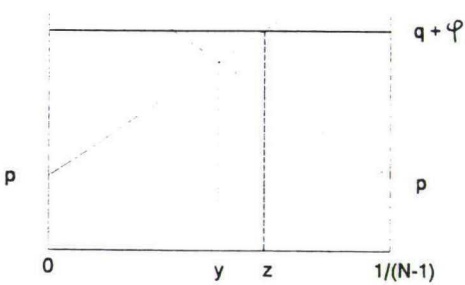

figure 1: the mail order business has no market share.

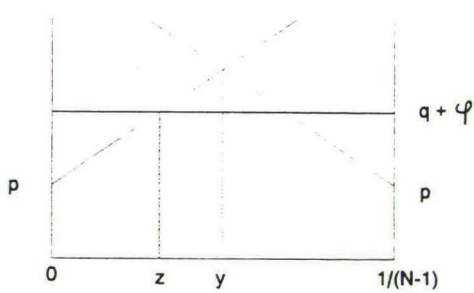

figure 2: the mail order business has a positive market share.

Firm i's total demand D_i is defined as

$$D_i(p_i, \overline{p}, \overline{q}) \equiv \begin{cases} 2y & \text{if } 0 \leq p_i \leq 2(\overline{q}+\varphi) - (\overline{p} + t/(N-1)) \\ 2z & \text{if } 2(\overline{q}+\varphi) - (\overline{p} + t/(N-1)) \leq p_i \leq \overline{q}+\varphi \\ 0 & \text{if } \overline{q}+\varphi \leq p_i \end{cases} \tag{6}$$

Then, profits for firm i on the circle are

$$\pi_i(p_i, \overline{p}, \overline{q}) = D_i(p_i, \overline{p}, \overline{q})p_i. \tag{7}$$

Since the mail order business's location is in the center of the circle, it faces $(N-1)$ neighbors. For a given price $\overline{p}_i$ charged by every firm i on the circle, the mail order business first competes for the consumers in the middle between every two firms on the circle, i.e. at distance $1/(2(N-1))$. The consumer, who is indifferent between buying at firm i or at the mail order business charging a price q, is located at $\tilde{z}$ such that

$$\overline{p_i} + t\tilde{z} = q + \varphi. \tag{8}$$

Equation (8) applies for each side of all $(N-1)$ firms on the circle. Therefore, the mail order business's total demand D_M is defined as

$$D_M(\overline{p}_i, q) \equiv \begin{cases} 0 & \text{if } q \geq \overline{p}_i + t/2(N-1) - \varphi \\ (\frac{2(N-1)}{t}(\overline{p}_i - \varphi - q + \frac{t}{2(N-1)}) & \text{if } \overline{p}_i - \varphi \leq q \leq \overline{p}_i + t/2(N-1) - \varphi \\ 1 & \text{if } q \leq \overline{p}_i - \varphi \end{cases} \tag{9}$$

The profit for the mail order business equals

$$\pi_M(\overline{p}_i, q) = D_M(\overline{p}_i, q)q. \tag{10}$$

Expression (10) is continuous and quasi-concave in q. Optimizing expression (7) with respect to p_i, and expression (10) with respect to q, the first-order conditions are

$$p_i = \frac{\overline{q}+\varphi}{2}, \tag{11}$$

$$q = \frac{\overline{p_i} - \varphi + t/2(N-1)}{2} \tag{12}$$

if all firms on the circle and the mail order business have a positive market share. Using the assumption of symmetry ($p_i = \overline{p_i} = p$) for the firms on the circle and using $\overline{q} = q$ for the mail order business, define the Nash-equilibrium (p^*, q^*) of the pricing-game by a mill price of

$$p^* = \frac{2\varphi + t/(N-1)}{6} \tag{13}$$

at every store on the circle, and a mill price of

$$q^* = \frac{t/(N-1) - \varphi}{3} \tag{14}$$

at the mail order business. If $t/(4(N-1)) > \varphi$, the price the mail order business charges is higher than the firms on the circle charge. For higher values of φ, lower prices result. The price the mail order business and the firms on the circle charge are always lower compared to the situation in which firms can operate only on the circle.

Substitute expressions (13) and (14) into (7) and (10) to see that the profits expressed as a function of the number of firms N are

$$\pi_C^*(N) = \frac{1}{18t}(\frac{t}{(N-1)} + 2\varphi)^2 \tag{15}$$

for every firm on the circle, and

$$\pi_M^*(N) = \frac{2(N-1)}{9t}(\frac{t}{(N-1)} - \varphi)^2 \tag{16}$$

for the mail order business. The expressions (15) and (16) will be referred to as the *M-equilibrium* profits.

Before starting with the main proposition of this section, I define the function

$$h(N) \equiv t(\frac{1}{N-1} - \frac{3}{N\sqrt{2(N-1)}}). \tag{17}$$

The function $h(N)$ is non-negative for all $N \geq 3$; furthermore, $h(3) = 0$, $h(\infty) = 0$ and $h(2) < 0$.

Proposition 2 : *(a) If $\varphi \leq h(N)$, then exactly one firm operates a mail order business and the remaining firms locate on the circle. (b) Otherwise, the unique equilibrium in pure strategies is that all firms locate on the circle.*

Proof : Consider firm i's profit if all other firms are located on the circle. If firm i decides to locate on the circle, its profit equals t/N^2, as can be seen from expression (3). If, however, firm i decides to become a mail order business, its profit is $2((N-1)/9t)(t/(N-1)-\varphi)^2$ by (16). Therefore, firm i finds it optimal to start up a mail order business if $t/N^2 \leq 2((N-1)/9t)(t/(N-1)-\varphi)^2$. This condition is equivalent to $\varphi \leq h(N)$. Given firm i's decision to become a mail order business, the remaining firms on the circle have a profit of $\pi^*_C(N) = (1/18t)(t/(N-1)+2\varphi)^2$ by (15). It is not profitable for any of the firms on the circle to switch to the center and become mail order businesses. The standard Bertrand argument implies that switching to the center would reduce their profits to zero. Since $\pi^*_C(N) > 0$, the firms on the circle do not switch to the center. This establishes part (a). If, however, $t/N^2 > 2((N-1)/9t)(t/(N-1)-\varphi)^2$, the opposite inequality holds, i.e. $\varphi > h(N)$. Firm i locates on the circle and no other firm switches to the center. This establishes part (b). □

Proposition 2 implies that if some firm sets up a mail order business, the cost of sending the good through the mail should be small enough. In that case, the parametric constellations result in an M-equilibrium. Since φ is non-negative, and in an M-equilibrium not larger than $h(N)$, we have that $h(N) \geq 0$. From the properties of this function, the lower bound on the number of firms in an M-equilibrium is $N \geq 3$. The intuition is that a firm has an incentive to open a mail order business only if its profit as a firm on the circle is relatively small. In an M-equilibrium, the mail order business foregoes some market power by a decrease in the equilibrium prices. Therefore, a single firm on the circle has no incentive to become a mail order business if the gain in market share is not large enough. The mail order business has a larger market share in comparison with the firms' market shares in the S-equilibrium. Indeed, $\varphi \leq h(N)$ implies that

$(2(N-1)/3t)(t/(N-1)-\varphi) > 1/N$. As φ increases from 0 to $h(N)$, the mail order business's market share decreases from 2/3 to $\sqrt{2(N-1)}/N$. The total market share for the firms on the circle increases from 1/3 to $1-\sqrt{2(N-1)}/N$. The mail order business's market share, therefore, always exceeds that of the firms on the circle. For low values of N, the equilibrium mill price at a store is lower than at the mail order business. For high values of N, the opposite relationship holds.

In the S-equilibrium, each firm competes with its two neighbors in only a direct way. The cross-price elasticities are positive for neighboring firms, but zero for all other firms. Using the terminology of Anderson and de Palma (1990), there is localized competition. In the M-equilibrium, the firm in the center competes directly with every firm on the circle. Clearly, this generates some form of nonlocalized competition, as the cross-price elasticity $(\partial D_i/\partial q)(q/D_i)$ is positive and identical for all i. The mail order business shoulders itself in between every firm on the circle. The firms on the circle have only one direct competitor, i.e. the mail order business. A small change in their own price, affects only the mail order business's market share. The cross-price elasticity $(\partial D_M/\partial p_i)(p_i/D_M)$ is positive and identical for all i. The cross-price elasticity $(\partial D_i/\partial p_j)(p_j/D_i)$ equals zero for all $j \neq i$. They are engaged in some form of localized competition. Figure 3 shows an example with $N = 7$. The bold lines represent the mail order business's market share.

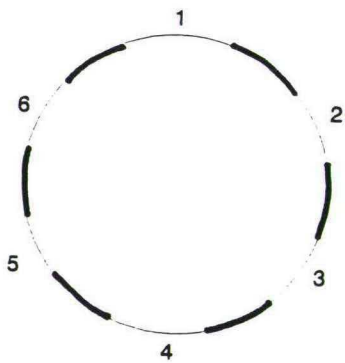

figure 3:
market shares in an M-equilibrium with $N = 7$.

Proposition 3: *The firms on the circle earn higher profits in the S-equilibrium than they do in the M-equilibrium:* $\pi_S^*(N) > \pi_C^*(N)$.

Proof: Expression (3) is strictly larger than expression (15) if and only if $\varphi < t(3/\sqrt{2}N - 1/2(N-1))$. Compare the right-hand side of this inequality with $h(N)$ to see that $t(3/\sqrt{2}N - 1/2(N-1)) > h(N)$ if and only if $\sqrt{2} > N/(N-1) - \sqrt{2/(N-1)}$. For all $N \geq 2$, the right-hand side of the latter inequality is an increasing function. By applying l'Hôpital's rule, it reaches its maximum of 1 for N approaching infinity. Since $\varphi \leq h(N)$ in the M-equilibrium, the result follows. □

Proposition 3 holds because prices in the M-equilibrium are lower than they are in the S-equilibrium. As already noted before, the mail order business has a larger market share *vis-à-vis* the firms' market shares in the S-equilibrium. Therefore, lower prices and market shares for firms on the circle result in lower profits.

5 Free Entry Equilibrium

This section studies entry into the industry. In order to have a finite number of firms, I introduce a fixed set-up cost of production F. The oligopoly two-stage game of the previous section is now enlarged by an additional stage. The three-stage game proceeds as follows: In the first stage, each firm decides whether or not it will enter the market. Having observed the number of firms entering the market, the entrants play the two-stage game of the previous section. Those who do not enter receive zero profits.

The previous section established that the S- and M-equilibrium are possible candidates satisfying the subgame perfectness condition. Our concept of free-entry equilibrium requires that entering firms earn non-negative profits, and all other firms anticipate non-positive profits when entering (see Anderson, de Palma, and Thisse, 1992). This motivates the following two definitions:

Definition 1: N_S^* is the number of firms in a free-entry S-equilibrium if (i) $\pi_S(N_S^*) = F$; and (ii) $\pi_S(N_S^*) \geq \pi_M(N_S^*)$.

Condition (i) ensures that all firms make zero profits. It implies that $N_S^* = \sqrt{t/F}$, by (3). Condition (ii) guarantees that with the equilibrium number of firms in the market, no firm wants to switch to a mail order business. The condition is equivalent to $\varphi \geq h(N_S^*)$ (i.e., the condition in Proposition 2). In the free-entry S-equilibrium, therefore, $\varphi \geq h(\sqrt{t/F})$.

Definition 2: N_M^* is the number of firms in a free-entry M-equilibrium if (i) $\pi_C(N_M^*) = F$; and (ii) $\pi_M(N_M^*) \geq \pi_S(N_M^*)$.

The first condition ensures that all firms on the circle make zero profits. Proposition 3 established that $\pi_C(N) < \pi_M(N)$. It follows that only the firms on the circle must satisfy the zero-profit conditions for free entry. The second condition guarantees that with the equilibrium number of firms in the market, exactly one firm wants to switch to the mail order business. Define the following function:

$$g(N_M^*) \equiv \frac{1}{2}(\sqrt{18tF} - \frac{t}{N_M^* - 1}). \tag{18}$$

The function $g(.)$ is increasing and, by (18), the equality $g(N_M^*) = \varphi$ represents the zero-profit condition for the firms on the circle. Condition (ii) in definition 2 is equivalent to $\varphi \leq h(N_M^*)$. Therefore, N_M^* satisfies the requirements (i) and (ii) of definition 2 if and only if $g(N_M^*) = \varphi \leq h(N_M^*)$. [8]

Proposition 4: *Let $\pi_S(N_S^*) = \pi_C(N_M^*) = F$; then $N_S^* > N_M^*$. That is, if N_M^* and N_S^* are determined by the zero-profit condition, the number of firms in the S-equilibrium is higher than it would be in the M-equilibrium.*

Proof: Suppose $N_S^* \leq N_M^*$. Since expression (15) is decreasing in N, $\pi_C^*(N_M^*) \leq \pi_C^*(N_S^*)$. Proposition 3 implies that in case there is a mail order business, the profits of the firms on the circle are smaller compared to the number under the free-entry S-equilibrium. Therefore, $\pi_C^*(N_S^*) < \pi_S^*(N_S^*)$. The free-entry S-equilibrium requires that $\pi_S^*(N_S^*) = F$. But then $\pi_C^*(N_M^*) < F$, and N_M^* cannot be the number of firms under a free-entry equilibrium. A contradiction. □

[8] Assume that $F < t/18$, such that with $N_M^* = 2$, a firm on the circle is not prevented from entering the market.

Proposition 4 states that the number of firms in the free-entry S-equilibrium is larger than it would be in the free entry M-equilibrium. Therefore, the market with a mail order business is more competitive. This accords with the result that nonlocalized competition yields fewer firms in a free-entry equilibrium than it would in localized competition (see Deneckere and Rothschild, 1992). The conditions for an S- and M-equilibrium are now analyzed.

Lemma 3: *(i) $h(3) = 0$ and $h(N) > 0$ for all $N > 3$; (ii) $g(3) \geq 0$ if and only if $t/F \leq 72$; (iii) $g'(N) > h'(N)$ for all $N > 3$; (iv) $g(N) > h(N)$ for all N large enough.*

The proof of Lemma 3 is relegated to the Appendix. From Lemma 3, the following results can be obtained.

Proposition 5: *(i) N_M^* is increasing in φ, and decreasing in F; (ii) If a free-entry M-equilibrium exists, then $N_M^* \geq 3$.*

Proof: (i) Inspection of expression (18) yields the comparative static results; (ii) From Lemma 3, $g'(N) > 0$. Proposition 5 establishes that no equilibrium exists if $g(3) > 0$. Since $\varphi \geq 0$, $N_M^* \geq 3$ if an M-equilibrium exists. □

An increase in φ implies more friction in the market and prevents the mail order business from decreasing the prices drastically. Therefore, more firms can enter the market.

Proposition 6: *(i) Let $F \leq t/72$; then there exists a $\overline{\varphi} > 0$, such that an M-equilibrium with free entry exists if and only if $0 \leq \varphi \leq \overline{\varphi}$. (ii) If $F > t/72$, free entry does not result in an M-equilibrium.*

Proof: (i) By Lemma 3, there exists a $\overline{N}$ such that $h(\overline{N}) = g(\overline{N}) \equiv \overline{\varphi}$. Since $g(3) \leq 0$ and $g'(N) > h'(N)$ for all $N > 3$ with $g'(N) > 0$, for $\varphi \leq \overline{\varphi}$ there is a unique N such that $g(N) = \varphi < h(N)$; (ii) Since $h(3) = 0$ and $g'(N) > h'(N)$ for all $N \geq 3$, the condition for a free-entry M-equilibrium $0 \leq g(N) = \varphi \leq h(N)$ (as stated in definition 2) can never be satisfied. □

If the fixed set-up cost is too large compared to the marginal cost of transportation, the zero-profit condition for firms on the circle cannot be satisfied.

Proposition 7: *Let N_M^* and N_S^* satisfy the zero-profit conditions of the free-entry equilibrium. (a) Let $h(N_M^*) < h(N_S^*)$. Then, (i) the S-equilibrium with free entry is unique if $h(N_S^*) \leq \varphi$; (ii) if $\varphi \leq h(N_M^*)$, the M-equilibrium with free entry is unique; (iii) if $h(N_M^*) < \varphi < h(N_S^*)$, no pure strategy equilibrium exists. (b) If $h(N_S^*) \leq h(N_M^*)$, then for all (i) $\varphi < h(N_S^*)$, the M-equilibrium is unique; (ii) $\varphi > h(N_M^*)$, the S-equilibrium is unique; (iii) $h(N_S^*) \leq \varphi \leq h(N_M^*)$ both the free entry S-equilibrium and the free entry M-equilibrium coexist.*

Proof: (a) (i) from definition 1, a free-entry S-equilibrium exists, since $\varphi \geq h(N_S^*)$ holds, while condition (ii) of definition 2 is violated; (ii) Similarly, no free-entry S-equilibrium exists, since condition (ii) of definition 1 is violated, while definition 2 holds; (iii) In the same fashion, both conditions for the free-entry S- and M-equilibrium are violated if $h(N_M^*) < \varphi < h(N_S^*)$. (b) can be proven in a similar fashion. □

A numerical example can illustrate part (a) of Proposition 7. Take $t = 100$ and $F = 1$. It follows that $N_S^* = 10$, and so $h(N_S^*) \simeq 4.04$. If $\varphi = h(N_S^*)$, $N_M^* \simeq 3.91$ and $h(N_M^*) \simeq 2.56$, the free entry S-equilibrium is thus unique, since $h(N_M^*) < h(N_S^*) = \varphi$. For every $\varphi > 4.04 \simeq h(N_S^*)$, we are in the free-entry S-equilibrium. If $\varphi = 1$, the only equilibrium is the free-entry M-equilibrium, since $N_M^* \simeq 3.47$, and thus $\varphi \leq h(N_M^*) \simeq 1.59 \leq h(N_S^*)$. If, however, $\varphi = 2$, $h(N_M^*) \simeq 1.9$, and no equilibrium exists, since $h(N_M^*) < \varphi < h(N_S^*)$. As a numerical example of part (b) of Proposition 7, take $t = 200$ and $F = 1$. It follows that $N_S^* \simeq 14.14$ and $h(N_S^*) \simeq 3.48$. If $\varphi = 1$, then $N_M^* \simeq 4.45$, and so $h(N_S^*) < h(N_M^*) \simeq 6.64$ and the free-entry M-equilibrium is unique. If φ is large enough, the free-entry S-equilibrium is unique; e.g. $\varphi = 10$, $N_M^* = 6$ and so $h(N_S^*) < h(N_M^*) \simeq 8.37 < \varphi$. For intermediate values of φ, the free-entry M- and S-equilibrium may co-exist; for instance if $\varphi = 4$, it follows that $N_M^* \simeq 4.85$, and so $h(N_S^*) < \varphi < h(N_M^*) \simeq 7.36$.

6 Welfare Analysis

From the social planner's point of view, the socially optimal selling policy minimizes the sum of total transportation costs and set-up costs of production. If the social planner can only open stores on the circle, as in Salop (1979), he opens $\sqrt{t/4F}$ stores. Straightforward calculations show that total costs equal $\sqrt{tF}$. If the social planner can only open n_m mail order businesses, it is optimal to open only one. This generates a social cost of

$\varphi + F$.[9]

Proposition 8: *The social planner opens $\sqrt{t/4F}$ stores on the circle if $\varphi + F > \sqrt{tF}$. Otherwise, he opens one mail order business.*

Proof: If the social planner can offer both selling policies, he has to minimize

$$W(n_c, n_m, x) = (\frac{1}{2n_c} - x)2n_c\varphi + 2n_c\frac{tx^2}{2} + (n_c + n_m)F \tag{19}$$

subject to $0 \leq x \leq 0.5/n_c$; $n_c, n_m \geq 0$. The variable x is the distance of the indifferent consumer between two neighboring stores on the circle.

Optimizing this expression with respect to x, its optimal value x^* satisfies $x^* = min(\varphi/t, 0.5/n_c)$. Substituting this back into expression (19) , the optimization problem reduces to

$$\widetilde{W}(n_c, n_m) = (\frac{1}{2n_c} - (min(\frac{\varphi}{t}, \frac{1}{2n_c})))2n_c\varphi + 2n_c(min(\frac{\varphi}{t}, \frac{1}{2n_c}))t\frac{min(\frac{\varphi}{t}, \frac{1}{2n_c})}{2} + (n_c + n_m)F \tag{20}$$

If $\varphi/t \leq 0.5/n_c$, expression (20) simplifies to

$$\widetilde{W}(n_c, n_m) = \varphi - n_c(\frac{\varphi^2}{t} - F) + n_m F.$$

The term $(\varphi^2/t - F)$ is the marginal contribution of a store to the total cost minimization. If $\varphi^2/t - F \leq 0$, if and only if $\varphi \leq \sqrt{tF}$, n_c should be as small as possible, i.e. 0. This results in a total welfare cost of $\varphi + F$ if $n_m = 1$.

If, however, $\varphi^2/t - F > 0$, n_c should be as large as possible. Having a maximum at $t/2\varphi$, the expression becomes

$$\widetilde{W}(n_c, n_m) = \frac{\varphi}{2} + n_m F + \frac{tF}{2\varphi}. \tag{21}$$

Since $\varphi = 0.5t/n_c$, the constraint is binding. Substituting this into expression (21), the social planner faces the following minimization problem:

$$\widetilde{W}(n_c, n_m) = \frac{t}{4n_c} + (n_c + n_m)F \tag{22}$$

[9]The cost of transportation by mail equals φ per unit of delivery. Since the technology operates with or without a mail order business, its cost is only marginal.

Expression (22) coincides with the minimization problem the social planner faces if $\varphi/t > 0.5n_c$ and yields an optimal outcome of $(n_c^*, n_m^*) = (\sqrt{t/4F}, 0)$. This outcome results in a total welfare cost equal to $\sqrt{tF}$. The social planner, therefore, prefers to open the optimal number of stores n_c^* if $\varphi + F > \sqrt{tF}$. Otherwise, he opens one mail order business. □

Proposition 8 tells us that, similar to the monopolist, the social planner will operate only one type of business. Indeed, suppose $\varphi + F < \sqrt{tF}$ and the social planner opens a store in addition to the mail order business. The consumer located at $x = \varphi/t$ from the store is indifferent between the mail order business and the store. The total transportation costs are therefore reduced by φ^2/t. If the additional fixed set-up cost $F > \varphi^2/t$, it is not worthwhile to open the store. Since $\varphi + F < \sqrt{tF}$, it is not optimal to open this additional store. Similarly, if $F \leq \varphi^2/t$, it follows that $\varphi + F > \sqrt{tF}$. In other words, it is not optimal to open a mail order business in addition to the stores on the circle. Also, the surplus per consumer is independent of the number of mail order businesses. Therefore, the social planner opens only one. Of course, a higher t and lower φ make the mail order business constellation more likely. Any increase in F favors the mail order business constellation if $n_c^* > 1$.

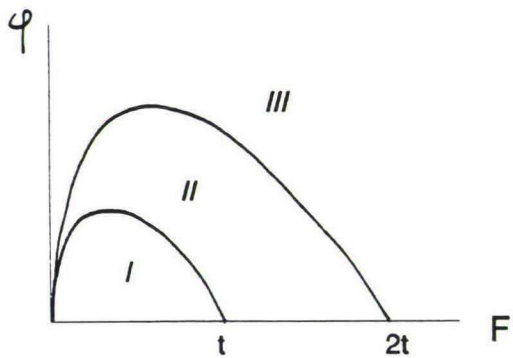

figure 4:

comparison between the social planner and the monopolist in (φ, F)-space.

Propositions 1 and 8 make it possible to compare the monopolist and the social planner. Figure 4 graphically illustrates this comparison in (φ, F)−space. If $\varphi < \sqrt{tF} - F$, the social planner and monopolist open only one mail order business (region I). If $\varphi > \sqrt{2tF} - F$, both open the optimal number of stores (region III). For any $\sqrt{tF} - F \leq \varphi \leq \sqrt{2tF} - F$, the social planner opens the optimal number of stores on the circle, whereas the monopolist opens only one mail order business (region II). The intuition is that the social planner is interested in the average consumer, whereas the monopolist seeks to serve the marginal consumer. Therefore, the monopolist locates closer to the marginal consumer than does the social planner. A higher critical φ supports this idea. It is, therefore, of no surprise that the social planner opens less stores compared to the monopolist.

The oligopoly and free-entry analysis showed that firms on the circle and a mail order business can coexist as an equilibrium. From proposition 4, the number of firms in the free-entry S-equilibrium is larger compared to the M-equilibrium. This result weakens the familiar proposition that competition creates too much variety compared to the social optimum (see e.g. Salop (1979)). Continuing the numerical example, take $t = 100$, $F = 1$ and $\varphi = 1$. The number of firms in a Salop model equals 10, whereas only 3.47 firms (of which one as a mail order business) enter the market in the free entry M-equilibrium. The monopolist opens only one mail order business. The free entry M-equilibrium is suboptimal, since firms on the circle and a mail order business appear. In the social optimum, only one mail order business appears.

7 Conclusion

This paper examined a spatial model on the circle where firms can either sell by a store or by a mail order business. Selling by a store implies a transportation cost for the consumers that increases with distance. In contrast, selling by a mail order business implies a fixed cost for the consumer, regardless of his location. In a free-entry context, at most one mail order business emerges. Competition increases and, as a consequence, the number of firms entering the market is lower, compared to the well-known Salop model. The mail order business competes with every firm on the circle, and therefore engages in nonlocalized competition. The stores on the circle face only one local competitor –

–i.e. the mail order business. In the monopoly and the social optimum, stores and mail order businesses never appear together.

The result that at most one mail order business will emerge, of course, depends on the implicit assumption that consumers are perfectly informed about the existence of the mail order business. The model, however, can be modified by introducing advertisements, for example. Then, consumers are informed about the existence of the products offered. A mail order business attracts consumers depending on its advertising costs. In addition, this model assumes that consumers are perfectly aware of the quality of the product. If quality inspection before purchase is costly, a mail order business may have a strategic disadvantage. Finally, in a multi-country framework, the mail order businesses may be able to use consumers' addresses as a price discriminating device – –yet another interesting topic for future research.

Appendix

Proof of Lemma 3:

(i) $h(3) = 0$, obvious. $h(N) > 0$ for all $N > 3$ if and only if $N/(\sqrt{N-1}) > 3/\sqrt{2}$. Since $N/(\sqrt{N-1})$ is strictly increasing in N and equals $3/\sqrt{2}$ at $N = 3$, the result follows.

(ii) $g(3) \geq 0$ if and only if $t/F \leq 72$. From evaluation of expression (18) at $N = 3$, we find that $t/F = 72$. Since $g(N)$ is strictly increasing, the result follows.

(iii) $g'(N) - h'(N) > 0$ for all $N > 3$ if and only if $3t/(2(N-1)^2) > 3\sqrt{2}t(3N - 2)/(4N(N-1)^{\frac{3}{2}}N)$. It can easily be checked that this holds for all $N > 3$.

(iv) From (i) and (ii), $h(3) = 0$ and $g(3) \leq 0$ if and only if $t/F \geq 72$. Since $g'(N) > 0$ for all finite N and $g'(N) - h'(N) > 0$ for all $N > 3$ from (iii), $g(N) > h(N)$ for some $N > 3$. If $t/F < 72$, then $g(3) > h(3) = 0$. □

References

Anderson, S.P. and A. de Palma (1990), "Localized Competition vs. Nonlocalized Competition," mimeo.

Anderson, S.P., A. de Palma and J.-F. Thisse (1992), *Discrete Choice Theory of Product Differentiation*, The MIT Press, Cambridge, Massachusetts, London, England.

Bester, H. (1993), "Bargaining versus Price Competition in Markets with Quality Uncertainty," *American Economic Review*, 83, 278-288.

Bonanno, G. (1987), "Location Choice, Product Differentiation and Entry Deterrence," *Review of Economic Studies*, 54, 37-45.

Darian, J. C. (1987), "In-Home Shopping: Are there Consumer Segments?," *Journal of Retailing*, 63, 163-186.

Deneckere, R. and M. Rothschild (1992), "Monopolistic Competition and Preference Diversity," *Review of Economic Studies*, 59, 361-373.

Furlong, W. J. and G.A. Slotsve (1983), ""Will that be Pickup or Delivery?": an Alternative Spatial Pricing Strategy," *Bell Journal of Economics*, 13, 271-274.

Heal, G. (1980), "Spatial Structure in the Retail Trade : a Study in Product Differentiation with Increasing Returns," *Bell Journal of Economics*, 11, 565-583.

Henriet, D. and J.-C. Rochet (1991), *Microéconomie de l'assurance*, Collection "Économie et statistiques avancées," Éditions Economica.

Lewis, W. A. (1945), "Competition in Retail Trade," *Economica*, 12, 202-234.

McWilliams, G. (1991), 'Mail-order madness: Need a PC at 3 a.m.? Just Pick up the phone,' *Business Week*, October 25th, No. 1, 128.

Michael, S. C. (1994), "Competition in Organizational Form. Mail Order versus Retail Stores, 1910-1940," *Journal of Economic Behavior and*

Organization, 23, 269-286.

Phlips, L. (1983), *The Economics of Price Discrimination*, Cambridge: Cambridge University Press.

Thisse, J.F. and X. Vives (1988), "On The Strategic Choice of Spatial Price Policy," *American Economic Review*, 78, 122-137.

Salop, S. C. (1979), "Monopolistic Competition With Outside Goods," *Bell Journal of Economics*, 10, 141-156.

Spiegel, M. (1982), "Pricing Policies under Conditions of Spatial Competition," *The Journal of Industrial Economics*, 31, 189-194.

No.	Author(s)	Title
9487	W.B. van den Hout and J.P.C. Blanc	The Power-Series Algorithm for a Wide Class of Markov Processes
9488	F.C. Drost, C.A.J. Klaassen and B.J.M. Werker	Adaptive Estimation in Time-Series Models
9489	Z. Yang	A Simplicial Algorithm for Testing the Integral Property of Polytopes: A Revision
9490	H. Huizinga	Real Exchange Rate Misalignment and Redistribution
9491	A. Blume, D.V. DeJong, Y.-G. Kim, and G.B. Sprinkle	Evolution of the Meaning of Messages in Sender-Receiver Games: An Experiment
9492	R.-A. Dana, C. Le Van, and F. Magnien	General Equilibrium in Asset Markets with or without Short-Selling
9493	S. Eijffinger, M. van Rooij, and E. Schaling	Central Bank Independence: A Paneldata Approach
9494	S. Eijffinger and M. van Keulen	Central Bank Independence in Another Eleven Countries
9495	H. Huizinga	The Incidence of Interest Withholding Taxes: Evidence from the LDC Loan Market
9496	V. Feltkamp, S. Tijs and S. Muto	Minimum Cost Spanning Extension Problems: The Proportional Rule and the Decentralized Rule
9497	J.P.J.F. Scheepens	Financial Intermediation, Bank Failure and Official Assistance
9498	A.L. Bovenberg and R.A. de Mooij	Environmental Tax Reform and Endogenous Growth
9499	J. Ashayeri, R. Heuts, A. Jansen and B. Szczerba	Inventory Management of Repairable Service Parts for Personal Computers: A Case Study
94100	A. Cukierman and S. Webb	Political Influence on the Central Bank - International Evidence
94101	G.J. Almekinders and S.C.W. Eijffinger	The Ineffectiveness of Central Bank Intervention
94102	R. Aalbers	Extinction of the Human Race: Doom-Mongering or Reality?
94103	H. Bester and W. Güth	Is Altruism Evolutionarily Stable?

No.	Author(s)	Title
94104	H. Huizinga	Migration and Income Transfers in the Presence of Labor Quality Externalities
94105	F.C. Drost, T.E. Nijman, and B.J.M. Werker	Estimation and Testing in Models Containing both Jumps and Conditional Heteroskedasticity
94106	V. Feltkamp, S. Tijs, and S. Muto	On the Irreducible Core and the Equal Remaining Obligations Rule of Minimum Cost Spanning Extension Problems
94107	D. Diamantaras, R.P. Gilles and P.H.M. Ruys	Efficiency and Separability in Economies with a Trade Center
94108	R. Ray	The Reform and Design of Commodity Taxes in the Presence of Tax Evasion with Illustrative Evidence from India
94109	F.H. Page	Optimal Auction Design with Risk Aversion and Correlated Information
94110	F. de Roon and C. Veld	An Empirical Investigation of the Factors that Determine the Pricing of Dutch Index Warrants
94111	P.J.-J. Herings	A Globally and Universally Stable Quantity Adjustment Process for an Exchange Economy with Price Rigidities
94112	V. Bhaskar	Noisy Communication and the Fast Evolution of Cooperation
94113	R.C. Douven and J.E.J. Plasmans	S.L.I.M. - A Small Linear Interdependent Model of Eight EU-Member States, the USA and Japan
94114	B. Bettonvil and J.P.C. Kleijnen	Identifying the Important Factors in Simulation Models with Many Factors
94115	H. Uhlig and N. Yanagawa	Increasing the Capital Income Tax Leads to Faster Growth
9501	B. van Aarle, A.L. Bovenberg and M. Raith	Monetary and Fiscal Policy Interaction and Government Debt Stabilization
9502	B. van Aarle and N. Budina	Currency Substitution in Eastern Europe
9503	Z. Yang	A Constructive Proof of a Unimodular Transformation Theorem for Simplices
9504	J.P.C. Kleijnen	Sensitivity Analysis and Optimization of System Dynamics Models: Regression Analysis and Statistical Design of Experiments
9505	S. Eijffinger and E. Schaling	The Ultimate Determinants of Central Bank Independence

No.	Author(s)	Title
9506	J. Ashayeri, A. Teelen and W. Selen	A Production and Maintenance Planning Model for the Process Industry
9507	J. Ashayeri, A. Teelen and W. Selen	Computer Integrated Manufacturing in the Chemical Industry: Theory & Practice
9508	A. Mountford	Can a Brain Drain be Good for Growth?
9509	F. de Roon and C. Veld	Announcement Effects of Convertible Bond Loans Versus Warrant-Bond Loans: An Empirical Analysis for the Dutch Market
9510	P.H. Franses and M. McAleer	Testing Nested and Non-Nested Periodically Integrated Autoregressive Models
9511	R.M.W.J. Beetsma	The Political Economy of a Changing Population
9512	V. Kriman and R.Y. Rubinstein	Polynomial Time Algorithms for Estimation of Rare Events in Queueing Models
9513	J.P.C. Kleijnen, and R.Y. Rubinstein	Optimization and Sensitivity Analysis of Computer Simulation Models by the Score Function Method
9514	R.D. van der Mei	Polling Systems with Markovian Server Routing
9515	M. Das	Extensions of the Ordered Response Model Applied to Consumer Valuation of New Products
9516	P.W.J. De Bijl	Entry Deterrence and Signaling in Markets for Search Goods
9517	G. Koop, J. Osiewalski and M.F.J. Steel	The Components of Output Growth: A Cross-Country Analysis
9518	J. Suijs, H. Hamers and S. Tijs	On Consistency of Reward Allocation Rules in Sequencing Situations
9519	R.F. Hartl and P.M. Kort	Optimal Input Substitution of a Firm Facing an Environmental Constraint
9520	A. Lejour	Cooperative and Competitive Policies in the EU: The European Siamese Twin?
9521	H.A. Keuzenkamp	The Econometrics of the Holy Grail: A Critique
9522	E. van der Heijden	Opinions concerning Pension Systems. An Analysis of Dutch Survey Data
9523	P. Bossaerts and P. Hillion	Local Parametric Analysis of Hedging in Discrete Time
9524	S. Hochgürtel, R. Alessie and A. van Soest	Household Portfolio Allocation in the Netherlands: Saving Accounts versus Stocks and Bonds

No.	Author(s)	Title
9525	C. Fernandez, J. Osiewalski and M.F.J. Steel	Inference Robustness in Multivariate Models with a Scale Parameter
9526	G.-J. Otten, P. Borm, T. Storcken and S. Tijs	Decomposable Effectivity Functions
9527	M. Lettau and H. Uhlig	Rule of Thumb and Dynamic Programming
9528	F. van Megen, P. Borm, and S. Tijs	A Perfectness Concept for Multicriteria Games
9529	H. Hamers	On the Concavity of Delivery Games
9530	V. Bhaskar	On the Generic Instability of Mixed Strategies in Asymmetric Contests
9531	E. Canton	Efficiency Wages and the Business Cycle
9532	J.J.G. Lemmen and S.C.W. Eijffinger	Financial Integration in Europe: Evidence from Euler Equation Tests
9533	P.W.J. De Bijl	Strategic Delegation of Responsibility in Competing Firms
9534	F. de Jong and T. Nijman	High Frequency Analysis of Lead-Lag Relationships Between Financial Markets
9535	B. Dutta, A. van den Nouweland and S. Tijs	Link Formation in Cooperative Situations
9536	B. Bensaid and O. Jeanne	The Instability of Fixed Exchange Rate Systems when Raising the Nominal Interest Rate is Costly
9537	E.C.M. van der Heijden, J.H.M. Nelissen and H.A.A. Verbon	Altruism and Fairness in a Public Pension System
9538	L. Meijdam and H.A.A. Verbon	Aging and Public Pensions in an Overlapping-Generations Model
9539	H. Huizinga	International Trade and Migration in the Presence of Sector-Specific Labor Quality Pricing Distortions
9540	J. Miller	A Comment on Holmlund & Lindén's "Job Matching, Temporary Public Employment, and Unemployment"
9541	H. Huizinga	Taxation and the Transfer of Technology by Multinational Firms
9542	J.P.C. Kleijnen	Statistical Validation of Simulation Models: A Case Study
9543	H.L.F. de Groot and A.B.T.M. van Schaik	Relative Convergence in a Dual Economy with Tradeable and Non-Tradeable Goods

No.	Author(s)	Title
9544	C. Dustmann and A. van Soest	Generalized Switching Regression Analysis of Private and Public Sector Wage Structures in Germany
9545	C. Kilby	Supervision and Performance: The Case of World Bank Projects
9546	G.W.J. Hendrikse and C.P. Veerman	Marketing Cooperatives and Financial Structure
9547	R.M.W.J. Beetsma and A.L. Bovenberg	Designing Fiscal and Monetary Institutions in a Second-Best World
9548	R. Strausz	Collusion and Renegotiation in a Principal-Supervisor-Agent Relationship
9549	F. Verboven	Localized Competition, Multimarket Operation and Collusive Behavior
9550	R.C. Douven and J.C. Engwerda	Properties of *N*-person Axiomatic Bargaining Solutions if the Pareto Frontier is Twice Differentiable and Strictly Concave
9551	J.C. Engwerda and A.J.T.M. Weeren	The Open-Loop Nash Equilibrium in LQ-Games Revisited
9552	M. Das and A. van Soest	Expected and Realized Income Changes: Evidence from the Dutch Socio-Economic Panel
9553	J. Suijs	On Incentive Compatibility and Budget Balancedness in Public Decision Making
9554	M. Lettau and H. Uhlig	Can Habit Formation be Reconciled with Business Cycle Facts?
9555	F.H. Page and M.H. Wooders	The Partnered Core of an Economy
9556	J. Stennek	Competition Reduces X-Inefficiency. A Note on a Limited Liability Mechanism
9557	K. Aardal and S. van Hoesel	Polyhedral Techniques in Combinatorial Optimization
9558	R.M.W.J. Beetsma and A.L. Bovenberg	Designing Fiscal and Monetary Institutions for a European Monetary Union
9559	R.M.W.J. Beetsma and A.L. Bovenberg	Monetary Union without Fiscal Coordination May Discipline Policymakers
9560	R. Strausz	Delegation of Monitoring in a Principal-Agent Relationship
9561	A. Lejour	Social Insurance and the Completion of the Internal Market
9562	J. Bouckaert	Monopolistic Competition with a Mail Order Business