Endogenous Market Segmentation and the Law of One Price*

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Abstract

To the surprise of many, price deviations between markets characterized by imperfect competition have often been little affected by lower transport costs. In a Cournot model we show that if firms' decisions to segment markets are endogenous, then lower transport costs are, in many cases, associated with greater price differentials between markets. The intuition is that lower transport costs, by facilitating arbitrage, place a tighter restriction on the maximization problem and a firm is willing to take a greater cost in order to segment. We examine how the resulting equilibria depend on transport costs, product differentiation and costs of segmenting.

Keywords: price discrimination; market integration; law of one price.

JEL: D43, F15, L13

Do lower transport costs lead to greater market integration? Intuition would lead most economists to answer this question with a yes. However, with the exception of commodity markets, such as wheat or gold (see Goodwin, 1992 or O'Rourke and Williamson, 1999), it has proved hard to establish such a relationship. Price deviations between markets (a standard way of measuring market integration) have been remarkably unaffected by the dismantling of various barriers to trade (see Engel and Rogers, 1996, Goldberg and Knetter, 1997, Obstfeld and Rogoff, 2000). Why? The answers to many questions in international economics and economic geography hinge on whether markets are seen as segmented

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or integrated and on the magnitude of transport costs, it is therefore interesting to try to deepen our understanding of the frictions that segment markets.[1]

This paper explores a reason for why we shouldn't be surprised that it has proved difficult to establish a simple relationship between transport costs and market integration – we make the decision to segment markets endogenous. By controlling distribution, marketing and product design, a firm can affect the price differential needed to make arbitrage attractive. In this paper we will take transport costs to mean actual shipping costs and tariffs.[2] By endogenous segmentation we mean that the firm raises the cost of arbitrage to the extent that even when transport costs, narrowly defined, are zero, arbitrage is unprofitable.

We examine the implications of a fixed cost for segmenting markets in a Cournot duopoly. Endogenous segmentation breaks the prediction that price differentials between markets should decrease in tandem with transport costs. We show that the price differential between markets can increase as transport costs fall (both in the form of a discrete jump and a continued increase), it can decrease (one for one with the transport cost, or at a slower rate) or, it can be totally unaffected by transport costs. The main insight is that as transport costs between markets decrease, arbitrage places a tighter constraint on the maximization problem – as a result, the incentives for a firm to segment markets increase. While we focus on a simple setup, this main insight is robust to many changes in the specification of demand and nature of competition. All in all, how price differences between markets respond to changes in transport costs will depend on the characteristics of demand and the costs of segmenting, rather than just being determined by a simple arbitrage condition.

By making the decision to segment markets endogenous, we extend a large literature originating with Brander (1981) and Brander and Krugman (1983). Their "segmented markets" model has become a standard model of trade under imperfect competition (see, for instance, Baldwin and Venables, 1995, for a discussion). Markets are assumed to be exogenously segmented in the sense that decisions on quantities

[1] For instance, market delineations for anti-trust cases and the constraints faced by monetary and fiscal policy in an open economy. Transport costs play a central role in determining the location of production (see for instance Fujita et al, 1999) and for trade patterns in gravity models of trade (see for instance Feenstra et al 2001).

[2] See Hummels (1999) for a recent discussion of transport costs and an attempt to measure these.

are made separately for each market. An alternative is to analyze games where capacity is first set at a global level, whereafter competition under various assumptions is analyzed – this is explored in Venables (1990, segmented and integrated markets, differentiated goods) and Ben-Zvi and Helpman (1992, price competition in homogenous goods). In the aforementioned analysis, the countries are generally assumed to be symmetric – optimal prices are therefore equal and arbitrage will not pose binding constraints on the optimizing decisions of firms.[3] The focus of the analysis has been welfare consequences of trade and whether or not we observe cross-hauling, i.e. two-way trade in identical goods. In contrast, the current paper focuses on understanding the interaction between transport costs and price deviations across markets.

The ability to segment customer groups with differing willingness to pay (or markets where marginal costs differ), increases profits for a monopolist by allowing for third degree price discrimination. By considering the incentives to segment markets under oligopoly, we relate to a small literature examining price discrimination under imperfect competition (Holmes, 1989, and Corts, 1998). Different mechanisms allowing for (some degree of) segmentation are vertical restraints (see, for instance, Gould, 1977), having different brand names in different locations, bundling with non-traded goods (explored in Horn and Shy, 1996) and adulteration of the good such as having different technical standards in different regions or countries (see Shapiro and Varian, 1999, for a discussion of how to segment markets in a low transport cost environment - the Internet). Rather than focusing on any specific way of segmenting markets we note that a firm can, in a number of ways, deter arbitrage and that this is likely to be associated with some cost.[4]

[3] Transport costs are typically assumed to be positive for the export market and zero for the domestic market. We therefore observe price discrimination ("dumping") even if prices are equal across markets, since markups differ between the home and export market. Anderson et al (1995) and Anderson and Schmitt (2000) use the symmetric markets case to examine issues related to our study – in a first stage, governments decide in a non-cooperative game whether to impose non-tariff barriers (antidumping laws).

[4] The mechanisms which help segmenting markets may clearly also be motivated on other grounds, vertical restraints for instance may be motivated by several factors (see Martin, 2001). We merely note that the optimal usage of these mechanisms will be different if market segmentation is also an issue. The assumption of fixed costs of segmenting is also used in Friberg (2001) which examines how sunk costs of segmenting may create an option value of segmenting when there is real exchange rate variability. Related to the present paper is also Chen and Maskus (2000) who examine the optimal wholesale price for a manufacturer that sells on two national markets. The manufacturer is vertically integrated on one market but sells to an independent retailer in the other market, which opens up for parallel imports if wholesale price is set low enough.

1 The Model

We examine a simple partial equilibrium model where firms play Nash in quantities (Cournot). Let there be two countries, Home and Foreign, with one firm located in each country. Variables in lower case letters denote the Home market and capital letters denote the Foreign market. Thus x represents the quantity produced by the Home firm for the Home market and X the quantity it produces for the Foreign market. Similarly, let y be the Foreign firm's export to the Home market and let Y be the production of the Foreign firm for its domestic market. Denote prices in the Home country by p and by P in the Foreign country.

We assume linear demands for each market with inverse demand curves given by the following matrix,

	Home country	Foreign country
Home product	$p(x) = 1 - x - \gamma y$	$P(X) = A - X - \gamma Y$
Foreign product	$p(y) = 1 - y - \gamma x$	$P(Y) = A - Y - \gamma X$

where the degree of product differentiation is given exogenously by $\gamma \in [0, 1)$. In the case of homogenous goods ($\gamma = 1$), there will be multiple equilibria and we will analyze a limiting case where $\gamma \to 1$. We confine the attention to the case where $A > 1$ which means that we can think of the Foreign market as a relatively rich and large market. Let t be the cost of transporting a unit of the good between Home and Foreign (the firm and the consumers face the same t). Each firm has the ability to invest in market segmentation for its own good such that by spending an amount K, arbitrage is ruled out and consumers are then not able to benefit from a lower price abroad. If the firm has not paid the fixed cost of market segmentation, profit maximization will be subject to the constraint that the difference in price is less than or equal to the transport cost ($|P - p| \leq t$). We will refer to this as the LOP-constraint (law of one price constraint).

We assume that the firms simultaneously choose quantities and whether they want to segment in a one-shot game. We allow only for pure strategies. We say that a strategy profile is an equilibrium if the strategy profile is a Nash equilibrium. A firm that plays a Cournot game conjectures a zero quantity response to marginal changes in its own quantity. The LOP constraint thus only enters the integrating firms maximization problem.[5]

Let Π^H and Π^F denote profits (excluding segmenting costs) of the Home and Foreign firm, respectively. To simplify, we assume the marginal cost of production to be zero. The firms' maximization problems are:

$$\Pi^H - I_s^H K = \underbrace{\max_{x,X,I_s^H} xp(x) + XP(X) - tX - \left(1 - I_s^H\right)\lambda^H (P(X) - p(x) - t)}_{\Pi^H} - I_s^H K,$$

for the Home firm and the Foreign firm's problem is

$$\Pi^F - I_s^F K = \underbrace{\max_{y,Y,I_s^F} yp(y) + YP(Y) - ty - \left(1 - I_s^F\right)\lambda^F (P(Y) - p(y) - t)}_{\Pi^F} - I_s^F K,$$

where I_s is an indicator function for the case that the firm segments and λ is a Lagrange multiplier. Suppressing the quantity choices, there are four possible strategy profiles with respect to the segmentation decision, (S,S), (N,S), (S,N) and (N,N) where the first letter indicates the action of the Home firm (Segment, S, or not, N) and the second the action of the Foreign firm. Solving for the optimal quantity in each case under the appropriate constraints, gives functions $\Pi^H(A,\gamma,t)$ and $\Pi^F(A,\gamma,t)$. We use subindexes to indicate which strategy profile a profit refers to. For example $\Pi^F_{N,S}$ denotes the operating

[5] Thus, a firm's reaction functions will not be dependent on whether the other firm integrates or segments. The equilibrium quantities, given by the intersection of reaction curves, will clearly be dependent on both firms' strategies however. If the segmenting firm incorporated the constraint, that the price differential between markets should equal t for the other firm, then in one sense the segmenting firm is also responsible for fulfilling the constraint. There will potentially be multiple equilibria unless the relative responsibility for making the price differential equal t, is exogenously specified. The Cournot setup amounts to such an exogenous specification that highlights non-strategic effects. Interesting extensions could be to examine sequential decisions on market segmentation, for instance examining Stackelberg-type equilibria.

profit for the Foreign firm, given the strategy profile (N, S). The payoff matrix is then given by:

		Foreign	
		Segment	Not Segment
Home	Segment	$\Pi^{\bar{H}}_{S,S} - K, \Pi^{F}_{S,S} - K$	$\Pi^{H}_{S,N} - K, \Pi^{F}_{S,N}$
	Not Segment	$\Pi^{\bar{H}}_{N,S}, \Pi^{F}_{N,S} - K$	$\Pi^{H}_{N,N}, \Pi^{F}_{N,N}$

(1)

To find the equilibria of the game, we need to compare the relative benefits of strategies, that is, compare the difference in profits between segmenting and integrating for the cases where the rival firm segments and integrates, respectively. See Appendix A for the derivation of these profits. The difference between payoffs will depend on t, and we wish to explore how the resulting equilibria then depend on t. To find the equilibria of the game represented by matrix (1) we plot the differences in profits implied by the following relations, which determine the difference in payoffs for the respective strategies, given the other firms strategy.

$$\Pi^{H}_{S,S}(A, \gamma, t) - \Pi^{H}_{N,S}(A, \gamma, t),$$
$$\Pi^{H}_{S,N}(A, \gamma, t) - \Pi^{H}_{N,N}(A, \gamma, t),$$

and

$$\Pi^{F}_{S,S}(A, \gamma, t) - \Pi^{F}_{S,N}(A, \gamma, t),$$
$$\Pi^{F}_{N,S}(A, \gamma, t) - \Pi^{F}_{N,N}(A, \gamma, t).$$

For example, $\Pi^{H}_{S,S} - \Pi^{H}_{N,S}$ (we suppress the dependency on parameters hereafter) gives the gain in operating profits for the Home firm of segmenting compared to not segmenting, given that the Foreign firm segments. For instance, if $\Pi^{H}_{S,S} - \Pi^{H}_{N,S} > K$ and $\Pi^{H}_{S,N} - \Pi^{H}_{N,N} > K$, segmenting is a dominant strategy for the Home firm. The payoff gain from segmenting outweighs the cost of segmenting, notwithstanding the actions of the Foreign firm. On the other hand, the game would be a coordination game if $\Pi^{H}_{S,S} - \Pi^{H}_{N,S} >$

K, $\Pi^H_{S,N} - \Pi^H_{N,N} < K$, $\Pi^F_{S,S} - \Pi^F_{S,N} > K$ and $\Pi^F_{N,S} - \Pi^F_{N,N} < K$. We let the range of t for which we study the game be set by the tighter of two restrictions.

Firstly, each firm has to receive a greater payoff from the outcome of the above game than it would if it sold only on one market. In particular, at some point the Foreign firm will prefer to shut down the Home market rather than let pricing on the Foreign market be restricted by arbitrage opportunities. We model the opportunity to shut down a market as a first stage of the game. Thus, we can think of the above game as a second stage in a two stage game, where in the first stage the two firms non-cooperatively decide on what markets to be active; see Appendix B.

Secondly, we limit attention to the case where arbitrage poses a binding constraint for both firms. With high transport cost, it will be profitable for firms to enter the other market, but transport costs will still be sufficiently high to make arbitrage unprofitable for consumers.[6] For low transport costs, arbitrage possibilities will restrict the firms' profit maximization problems, unless the firms take the cost of segmenting markets. Under the assumption that both firms segment, neither of the conditions $P(Y) - p(y) < t$ and $P(X) - p(x) < t$ hold if[7]

$$t < (A-1)\frac{2-\gamma}{(\gamma+2)(3-2\gamma)} \approx \frac{A-1}{3}. \tag{2}$$

Thus, arbitrage by consumers poses a problem for firms when transport costs are low in relation to country asymmetries; the larger the difference between willingness to pay, the larger is the potential difference in prices and the larger is the range of t for which consumers find arbitrage profitable. On the other hand, if the countries were identical ($A = 1$), then we would be in the Brander-Krugman world where arbitrage is not an issue, since optimal prices are equal on identical markets with identical firms.

After these preliminaries we are ready to analyze the resulting equilibria. Throughout we set $A = 2$. To isolate the effects of market asymmetries, we first study the case where $\gamma = 0$ and demand for the goods are independent. We proceed with an analysis of the polar case where goods are homogenous

[6] For even higher transport costs, each firm will of course have a local monopoly.

[7] The constraint is fairly unsensitive to γ. A series expansion shows that $(2-\gamma)/((\gamma+2)(3-2\gamma)) = 1/3 - \gamma/9 + 5\gamma^2/54 + O(\gamma^3) \approx 1/3$. Further, the constraint is non-linear in γ, with maxima at γ equal to 0 and 1, where the condition becomes $t < (A-1)/3$. The constraint is derived at the end of Appendix A.

($\gamma \to 1$). Lastly we examine the intermediate case of $\gamma = 1/2$.

The forces that determine the equilibria are two, with their relative strength varying with the degree of product differentiation and transport costs:

Observation 1 *In general, firms segment in order to hold back on quantities on the rich market and thereby raise profits – a third degree price discrimination mechanism.*

Observation 2 *If products are similar, the price increase following from a firm's quantity reduction will make some customers choose the competitor's product.*

Thus, in general, we expect less segmentation in the oligopoly case ($\gamma > 0$). The literature examining price discrimination under oligopoly is so far very limited. Holmes (1989) analyzes the interaction of these two mechanisms by examining oligopolistic firms that set prices on differentiated products. Holmes examines symmetric firms and does not analyze the case of transport costs.

1.1 Independent demands

When the products are perfectly differentiated ($\gamma = 0$), the relative benefit from segmentation compared to integration for a firm is independent of the strategy of the other firm. In Figure 1a, we plot the difference in profits between the integrated and segmented markets case, as a function of transport costs (for $A = 2$). The fat line gives the gain in revenue from operating under segmented markets rather than under integrated markets for the Foreign firm, and the thin line is the equivalent for the Home firm.[8] For instance, if $t = 0.05$ the operating profits for the Home firm are about 0.12 higher if it segments than if it integrates. Clearly Home will segment if this gain is larger than the cost of segmenting, K.

Figure 1a and 1b about here

For low transport costs (such as $t = 0.05$), and intermediate costs of segmentation (such as $K = 0.06$), the gain from segmenting outweighs the cost and both firms segment. This is true for the whole region below the fat line, which is marked with S,S, denoting that both firms segment in equilibrium.[9] Now,

[8] Since payoffs are independent of what the other firm does, $\Pi^H_{S,S} = \Pi^H_{S,N}$ and $\Pi^H_{N,S} = \Pi^H_{N,N}$.

[9] Note that K and t have the same magnitude in Figure 2. This might seem surprising as t is a per-item cost and K is a fixed cost, which we think is large. However, if both firms segment, and $t = 0.05$, then, for instance, $y = 0.475$, so that the

for values of t and K such that we are above both lines, neither of the firms will find it beneficial to segment.

Figure 1b examines the resulting price differential between markets. If markets are integrated this differential clearly equals t. As t passes a critical threshold, lower transport costs will be associated with an upward jump in the price differential. The reason is that it becomes sufficiently valuable for the firm to buy itself free from the arbitrage constraint. When markets are segmented, decreases in transport costs will affect the price differential less than one-for-one. Price on the domestic market is unaffected by t and changes in t are imperfectly passed through to the Foreign market. More generally, the extent of pass-through to the Foreign price is determined by the curvature of demand and cost functions (see for instance Feenstra, 1989). Finally, note that the price differential does not go to zero as transport costs go to zero.

As seen in Figure 1a in the region above the fat line, but below the thin line, the Home firm segments whereas the Foreign firm integrates.

Remark 1 *Given that there is no strategic interaction and markets are segmented, the firm from Home (the poor market) sets prices such that the price difference between countries is higher than what the firm from Foreign (the rich market) sets.*

The intuition for this result, which can be proved for the general case, is the following: Optimal prices are higher on the Foreign market, since that is the rich market. For the Home firm, transport costs serve to further increase the Foreign price (since that is its export market). On the other hand, for the Foreign, rich country firm, transport costs raise the price on the cheaper market, and therefore serve to decrease price differentials. Given that firms face the same linear demand functions (which feature a pass-through of transport costs of 1/2, see Feenstra, 1989) we know that in the case when both firms segment

$$\begin{cases} P(X) - P(Y) = t/2 \\ p(y) - p(x) = t/2 \end{cases} \Rightarrow P(X) - p(x) = P(Y) - p(y) + t.$$

total cost of exports is roughly equal to 0.02 for the Foreign firm. Then, $K = 0.06$ is three times the size of total export costs for the Foreign firm, which is in line with what we expect.

Thus, as stated in Remark 1, $P(X) - p(x) > P(Y) - p(y)$. In the figure below, we illustrate the optimal prices under segmented markets for the two firms.

Figure 2 about here

Since the difference between optimal prices is greater for the Home firm, it is willing to bear a higher cost to avoid the constraint that the price differential should equal t.

1.2 Homogeneous goods

If there is no difference between the firms' products ($\gamma = 1$), then the firms play a standard Cournot game when markets are segmented. However, when $\gamma = 1$ we will have multiple equilibria in the case where both firms integrate; both firms then have to fulfill the *same* LOP constraint and we are not able to uniquely determine the optimal quantities of the firms. In consequence this section relies on quantities calculated for the limiting case as $\gamma \to 1$.[10] Figure 3a below illustrates the resulting equilibria as a function of K and t following the same logic as Figure 1a. Differences in revenue are measured on the vertical axis and are a function of transport costs, measured along the horizontal axis. For $t > 0.2$ the foreign firm will prefer to close the Home market rather than sell on both markets and face an arbitrage constraint. In consequence the figure is given for $t \leq 0.2$, which is the range in which all markets are open.

Figure 3a and 3b about here

Consider, for example, the cost $K = 0.03$ of segmentation. If the transport cost is $t = 0.15$, then we are in the top-most region of Figure 3a, which means that $\Pi^H_{S,S} - \Pi^H_{N,S} < K$, $\Pi^H_{S,N} - \Pi^H_{N,N} < K$, $\Pi^F_{S,S} - \Pi^F_{S,N} < K$ and $\Pi^F_{N,S} - \Pi^F_{N,N} < K$ such that it is a dominant strategy for each of the firms to integrate markets. A comparison with the equilibria of Figure 1a shows that there is less segmentation when producers sell identical goods.[11] For a broad range of values of K and t, the unique equilibrium is that neither firm segments.

The interdependence of the firms' decisions is apparent in the case when transport costs are low –

[10] In particular, $\gamma = 0.99$

[11] Note that we are not really doing a comparative statics exercise; we are holding the intercepts of the demand function fixed as we increase γ.

we then have a coordination game and there are two equilibria – either both firms segment or both integrate.[12] For the parameter values where a segmenting equilibrium exists each firm achieves higher profits in the (S, S) equilibrium than in the (N, N) equilibrium. We could therefore expect firms to be able to coordinate on the equilibrium where they both segment when transport costs and the costs of segmentation are low.

Thisse and Vives (1988) examine the choice of price discrimination (zone pricing) vs. uniform pricing (basing point system) for homogenous goods when consumers are continuously distributed in geographic space. They find a robust tendency for firms to choose discriminatory pricing but do not consider any costs of segmenting markets. In terms of our model, they examine the equilibria along the t-axis (where $K = 0$). Parallel to their result we find that the (S, S) equilibrium is the unique equilibrium for very low costs of segmenting and low t. The difference $\Pi^H_{S,N} - \Pi^H_{N,N}$, which is not drawn in the figure, almost coincides with the t-axis but is positive for $\gamma < 1$.[13] This means that for $\gamma < 1$ there is always a region where segmentation is the unique equilibrium outcome.

Price differentials between markets The price differential between markets will typically equal t when goods are homogeneous, as seen in Figure 3b. However, as we just saw, for low transport costs and low costs of segmenting, we can be in the (S, S) equilibrium. Remarkably, the price differential between markets is then totally independent of t.

Figure 4 about here

This result can be understood by examining the reaction functions of the firms when markets are segmented. In Figure 4, R_Y is the reaction function of the Foreign firm on the Foreign market, and R_y is its reaction function on the Home market. Similarly, R_X and R_x are the reaction functions of the Home firm. The short lines show the export market reaction functions R_X and R_y absent of transport

[12] In a model of Bertrand competition in differentiated goods, Corts (1998) examines the incentives for firms to set a uniform price (integrate) or price discriminate (segment) in vertically segmented markets. Similar to our approach, each firm has a relative advantage in a specific market. Our model differs from Corts' in that both our firms see the Foreign market as the strong market. Our model then does not feature the same same incentives for customer poaching as his and price discrimination will not be associated with "all-out competition". Corts does not consider any explicit costs of segmenting.

[13] For instance, for $\gamma = 0.99$, the difference varies between $5 * 10^{-5}$ and $3 * 10^{-5}$ over the plotted range.

costs. Thus, the equilibrium quantities, absent transport costs, are given by the intersections of the short lines with the local market reaction function in each country, the firms then split each market equally (the equilibrium points are on the 45-degree line). Transport costs shift the equilibrium quantities in each market from equal shares to local advantage, by shifting the firms' reaction functions on their export markets inward. As the reaction function of firms' are shifted in their respective export markets, the resulting quantity changes are traced out along each local firm's reaction functions (R_Y and R_x, respectively). In each case, the change in a firm's own quantity is read along its own axis, where the perceived slopes of reaction functions are *equal.* A change in t thus changes local quantities by a factor of 1/2, so that when t increases, Y increases and x increases, each with a factor of 1/2. The same reasoning applies to each firms' exports, where each firm's exported quantity decreases by a factor of 2. On each market, increases in t lead to a greater market share for the local firm. An increase in t will thus reduce aggregate quantities on each market ($X + x$ and $Y + y$) *by the same amount,* since the decrease in exported quantities is the same for both countries (the change in X equals the change in y, and the change in Y equals the change in x). Thus, in the case that the demand functions in each country have the same slope, we have the following result.

Remark 2 *When goods are homogenous* ($\gamma = 1$)*, if both firms segment, the price differential* $P - p$ *does not depend on* t*.*

The important point is that functional forms, rather than a simple constraint, will determine how price differentials respond to changes in transport costs. This concludes our analysis of the homogeneous goods case. After studying the two polar cases of homogeneous goods and independent demands, we now turn to the intermediate case of imperfect substitutes.

1.3 Differentiated products

Now set the degree of differentiation γ equal to 1/2. The resulting equilibria are given in Figure 5a, whose layout is analogous to Figures 1a and 3a

Figure 5a and 5b about here

Consider, for example, the cost $K = 0.06$ of segmentation. If transport costs are intermediate, then we are in region V in Figure 5a. This means that $\Pi^H_{S,S} - \Pi^H_{N,S} > K$, $\Pi^H_{S,N} - \Pi^H_{N,N} < K$, $\Pi^F_{S,S} - \Pi^F_{S,N} < K$ and $\Pi^F_{N,S} - \Pi^F_{N,N} < K$. Only $\Pi^H_{S,S} - \Pi^H_{N,S}$ is larger than K. Using these relations (compare with matrix (1)), we can then establish that the unique Nash equilibrium is that neither of the firms' segment markets. The regions where neither of the firms segment are shaded in light grey. Intuitively, these regions are associated with relatively high fixed segmentation costs and relatively high transport costs. Similarly, the regions where both firms segment (I and II) are shaded in dark grey and characterized by a low segmentation cost and low transport costs.

In regions III and VII, the unique equilibrium is that the Home firm segments, while the Foreign firm does not. The only region with two equilibria is region IV, where there is a coordination game. Both firms either segment or not. So, for intermediate levels of segmentation costs and low transport costs, the interdependence of firms' decisions is especially pronounced in the sense of having a coordination game.

Price differentials between markets Given the equilibria in Figure 5a, we are interested in the price differences between the two countries as t changes. Set $K = 0.02$, then, as t decreases from 0.3, we move from region III to regions II and I. The Home firm will segment for all t, while for $t = 0.13$, the Foreign firm starts to segment as t decreases. Also, note that LOP will not hold for any of the goods at zero transport costs. Since the firms segment, and demand on the Home and Foreign markets differ, the optimal quantities and prices differ even though the costs are the same.

A prominent feature is that the price differential between markets for the Foreign producer's good *increases* as transport costs fall; not only is there a discrete increase as the Foreign firm starts to segment, but also a continuing increase as transport costs fall further. The intuition is simple; on the Foreign market

$$\frac{\partial (P(Y))}{\partial t} = 2/15,$$

and on the Home market

$$\frac{\partial (p(y))}{\partial t} = 7/15.$$

Thus, both prices increase if t increases; on the Home (export) market, simply because transport costs are passed through (incompletely) onto the price that Home consumers face. On the Foreign market the effect of transport costs on prices is only indirect through the lower quantities of imports from Home. Similarly, for the Home firm, the corresponding difference in prices comes from a comparison of its export price minus the price it sets on the Home market. As transport costs increase, the Home firm's export price increases more than does the price on the Home market and therefore, the deviation from LOP is a mirror image of the Foreign firm's. Further, as the Foreign firm starts to segment, and thereby reduces its quantity on the Foreign market, this is associated with a discrete increase in the price charged by the Home firm on the Foreign market and thus with a discrete jump in the deviation from LOP, albeit smaller than for the Foreign firm.

2 Home bias and exported quantities

Instead of using price differentials between markets as a measure of market integration we can study quantities. In this area as well, evidence abounds of surprisingly segmented markets (see Obstfeld and Rogoff, 2000). Trade between countries is lower and the market share of domestic goods is higher than what can be easily explained by observed transport costs.[14]

Clearly, endogenous segmentation has implications not just for price differentials, which are the focus of this paper, but also for trade flows, aggregate quantities sold on the respective markets and the market share of domestic firms. Common to all cases studied is that endogenous segmentation is associated with decreased quantities on the Foreign market, and increased quantities on the Home market relative to an integrated outcome. We let it suffice with one example to illustrate the potential magnitude of the

[14] As stressed by many authors, for instance Obstfeld and Rogoff (2000), transport costs are not the whole story however. If goods are close substitutes even small transport costs can lead to a large share of consumption being domestic. Trying to infer the degree of market integration based on studies of the volume of trade will therefore require taking a stand on the elasticity of substitution of goods with different origin. The difference in prices of the same good between markets is a more direct measure of market integration, which explains our choice of focus in the present paper.

effects. Take the case of homogenous goods ($\gamma \to 1$), $K = 0.03$ and transport costs of $t = 0.04$. As seen in Figure 3a both an (N, N) and an (S, S) equilibrium are then possible outcomes. Total quantity on the Foreign market is 11 percent higher when markets are integrated rather than segmented and exports from Home to Foreign are some 15 percent higher. These are substantial effects.

The "home market bias" produced by endogenous segmentation is less pronounced however. For the same parameter values, the Foreign firm has a 52 percent market share on its domestic market when markets are segmented. The reason for the relatively small effect is that transport costs in this case are so low that they give the Home firm only a small cost disadvantage.

The most striking feature of the analysis of quantities however is that when both firms integrate

$$\begin{aligned} Y &= X = k_1 \\ y &= x = k_2 \end{aligned}$$

where k_1 and k_2 are constants.[15]

Remark 3 *When markets are integrated (N, N) the Foreign firm and the Home firm split both markets equally ($X = Y$ and $x = y$).*

So, when markets are integrated, the location of the producer does not matter for market shares. A trivial implication of this is that market shares are unaffected by decreases in transport costs as long as we remain in the (N, N) equilibrium. Notably, this result does not depend on the degree of substitutability (γ) or differences between willingness to pay across markets ($A - 1$).

A closer look at the monopoly case ($\gamma = 0$) helps us with the intuition. If we substitute the LOP-constraint into the maximization problem, the location of a firm influences the problem only through the transport cost of exports. Consider a comparison of the situation where the Home firm locates in Home with one where it locates in Foreign. If it locates in Home, its transport cost is tX whereas if it locates in Foreign its transport cost is tx. A binding LOP constraint implies that the quantity sold on the Foreign

[15] $k_1 = (2\gamma A - 2\gamma t - 3t - 1 + 3A) / (2(\gamma + 2)(\gamma + 1))$ and $k_2 = (2\gamma + 3 - A + t) / (\gamma + 1)$.

market is equal to that sold on the Home market plus a constant, $X = A - 1 - t + x$. Clearly the maximization of profits with respect to x under transport costs tx will give the same optimum quantity as maximization under $t(A - 1 - t) + tx$. Profits will be lower if the firm locates away from the rich market but the produced quantities will not be affected under the LOP-constraint.[16]

3 Discussion

We have explored the implications of endogenous segmentation in a simple Cournot framework. Considering the cases in this paper, one might conclude that anything can happen to price differentials between markets as transport costs change. That any response of endogenous variables to changes in exogenous ones can be rationalized, is typically not a hallmark of good theory, since one might ask how the model could be tested. One response to this is that it emphasizes a fundamental point of the paper; we should not expect price deviations to respond to changes in transport costs in markets for differentiated goods in the same way as in commodity markets.

Another response is that the outcome will partly be determined in an intuitive way by observable variables: We are more likely to observe endogenous segmentation, the greater the asymmetry of markets, the lower the transport costs, and for differentiated goods.[17] Finally, it deserves to be pointed out that this richness of results comes from using the standard workhorse model of international oligopoly with a simple addition of endogenous segmentation.

The segmented markets model analyzed here was originally applied to understand how monopoly power could be a driving force of trade and welfare aspects of this. It has also been of much use in strategic trade policy; see Brander (1995) for an overview. We here note that it also offers a large potential for examining issues of market segmentation on the forefront of today's policy discussion.

[16] We can also see this by examining the Lagrange mulitpliers. As seen from remark 1 the Home firm is more constrained by the LOP-constraint. The optimal quantities on the Foreign market under (N, N) and $\gamma = 0$ are given by $X = \left(A - t + \lambda^H\right)/2$ and $Y = \left(A + \lambda^F\right)/2$, so that if maximization were unconstrained by LOP, Foreign would set a lower quantity. The fact that Home's constraint binds tighter by an amount of t ($\lambda^F = \lambda^H + t = (A - 1 - t)/2$) makes the optimal quantities equal.

[17] Somewhat more worrying is that the outcome will also depend on the costs of segmenting which are not readily observable. In reality they are likely to depend on a large number of issues and one might expect the cost of segmenting to increase as transport costs decrease. In terms of the previous analysis, the K-line would be upward sloping and we would be more likely to observe integrated markets when transport costs are low.

The analysis in this paper can be seen as a response to the call by Baldwin and Venables (1995, p. 1612): "European experience suggests that the removal of tariffs is not sufficient to create a 'single market'...merely comparing the outcomes of different games leaves the analysis incomplete, as it leaves open the more difficult question of how different degrees of market segmentation or integration could arise. Ultimately we wish to know what policy instruments might be used to change the degree of market integration".

Our model can be used to gain some insight into the European car markets, for instance. As Goldberg and Verboven (2001) note, price differentials on cars between European countries have been remarkably unaffected by lower border barriers. The actual cost of transporting a car from one European country to another is low, so in terms of our model, t is low. Goldberg and Verboven observe that car manufacturers have actively been trying to segment markets by, for instance, working to maintain the selectivity of the distribution system.[18] For a policy maker that wishes to lower price differentials between markets the present paper provides a rationale for focusing on exclusive territories, pursuing cases of price discrimination to court, harmonizing taxes and other mechanisms that can be considered as raising the cost of segmentation or lowering the incentives for segmentation, rather than a narrow focus on transport costs and trade barriers. In the present setup that goal can be motivated on welfare grounds. As shown by Varian (1985), a necessary condition for price discrimination to raise welfare (the sum of producer and consumer surplus in both countries) is that total output increases. With linear demand, total output is the same under price discrimination as under integrated markets. Market segmentation does therefore not enhance global welfare under the present setup, as long as both markets are served. Worth noting however, is that endogenous segmentation offers an alternative to market shutdown, which in some cases will be the response to the tight arbitrage constraints implied by low transport costs.

While some of our most striking results do depend on the functional forms chosen, the intuition for results extend beyond this special case. For instance, that the value of segmenting markets increases as transport costs fall, can be shown to hold generally for the monopoly case (if the inverse demand

[18] And in some cases refusing to sell to foreign customers and pursuing retailers that do. See, for instance, the 1998 court case against Volkswagen for punishing Italian dealers selling to German and Austrian customers.

function on the Foreign market is not too convex). Examining how results generalize is a worthwhile task for future research. Our aim in the present paper has been more humble; to understand why we shouldn't be surprised by a failure of lower transport costs to generate market integration.

4 Appendix A

In the following section we exemplify the calculation of profits, prices and quantities under the (N, N) strategy profile. For the other strategy profiles only the maximization problems and resulting profits are given. The derivations for these strategy profiles involve the same, tedious but straightforward steps as in the (N, N) case and are not included in the paper. They are available in a separate appendix available upon request from the authors (downloadable at http://www.hhs.se/personal/friberg).

4.1 No Segmentation

Examine the case where no firm segments. The Home firm's problem is

$$\Pi^H_{N,N} = \max_{x,X} xp(x) + XP(X) - tX,$$

$$\text{s.t. } |\, p(x) - P(X)\,| \leq t.$$

and the Foreign firm's problem is

$$\Pi^F_{N,N} = \max_{y,Y} yp(y) + Y\ P(Y) - ty,$$

$$\text{s.t. } |\, p(y) - P(Y)\,| \leq t.$$

4.1.1 FOCs

Given that the Home firm must fulfill the LOP constraint on its market, the firm can only choose one of its quantities freely. The LOP constraint

$$t = P(X) - p(x) = A - X - \gamma Y - 1 + x + \gamma y,$$

gives x as a function of X. For Home the LOP-constraint becomes

$$x = -A + X + \gamma Y + 1 - \gamma y + t,$$

and the FOC is then (given restriction on x)

$$\frac{\partial}{\partial X}\left(x(1 - x - \gamma y) + X(A - X - \gamma Y) - tX\right) = 3A - 4X - 3\gamma Y - 3t - 1 + \gamma y = 0.$$

For Foreign the LOP-constraint becomes

$$y = -A + Y + \gamma X + 1 - \gamma x + t,$$

and its first order condition is then (given restriction on y)

$$\frac{\partial}{\partial Y}\left(y(1 - y - \gamma x) + Y(A - Y - \gamma X) - ty\right) = 3A - 4Y - 3\gamma X - 3t - 1 + \gamma x = 0.$$

4.1.2 Equilibrium

There are four equations that have to be fulfilled,

$$\begin{aligned}
0 &= -\gamma x + \gamma X - y + Y - A + 1 + t : \quad y - \text{constraint} \\
0 &= \gamma x - 3\gamma X + 0 * y - 4Y + 3A - 3t - 1 : \ Y - \text{FOC} \\
0 &= -x + X - \gamma y + \gamma Y - A + 1 + t : \quad x - \text{constraint} \\
0 &= 0 * x - 4X + \gamma y - 3\gamma Y + 3A - 3t - 1 : \ X - \text{FOC}
\end{aligned}$$

As a linear system

$$\begin{pmatrix} -\gamma & \gamma & -1 & 1 \\ \gamma & -3\gamma & 0 & -4 \\ -1 & 1 & -\gamma & \gamma \\ 0 & -4 & \gamma & -3\gamma \end{pmatrix} \begin{pmatrix} x \\ X \\ y \\ Y \end{pmatrix} = \begin{pmatrix} A - 1 - t \\ -3A + 3t + 1 \\ A - 1 - t \\ -3A + 3t + 1 \end{pmatrix}.$$

The determinant of the matrix is $D = 4(\gamma - 1)(\gamma - 2)(\gamma + 2)(\gamma + 1)$, which is non-zero for $\gamma \in [0, 1)$. For $\gamma = 1$, there is a problem, since there is only one single LOP constraint and the firms then both optimize under the same constraint.

The solution to this linear equation system for $\gamma \neq 1$ is

$$\begin{aligned}
Y &= \frac{1}{2} \frac{2\gamma A - 2\gamma t - 3t - 1 + 3A}{(\gamma + 2)(\gamma + 1)}, \\
x &= \frac{1}{2} \frac{2\gamma + 3 - A + t}{(\gamma + 2)(\gamma + 1)}, \\
y &= \frac{1}{2} \frac{2\gamma + 3 - A + t}{(\gamma + 2)(\gamma + 1)}, \\
X &= \frac{1}{2} \frac{2\gamma A - 2\gamma t - 3t - 1 + 3A}{(\gamma + 2)(\gamma + 1)}.
\end{aligned}$$

4.1.3 The profits

The Home firm's profit is

$$\begin{aligned}\Pi^{H}_{N,N} &= x\left(1-x-\gamma y\right)+X\left(A-X-\gamma Y\right)-tX \\ &= \frac{1}{2}\frac{\left(A-t+1\right)^{2}}{\left(\gamma+2\right)^{2}},\end{aligned}$$

and the Foreign firm's profit is

$$\begin{aligned}\Pi^{F}_{N,N} &= y\left(1-y-\gamma x\right)+Y\left(A-Y-\gamma X\right)-ty \\ &= \frac{1}{2}\frac{\left(A-t+1\right)^{2}}{\left(\gamma+2\right)^{2}}+t\frac{A-1-t}{\gamma+1}.\end{aligned}$$

4.2 Both segment

Assume that both firms segment, then the Home firm's problem is

$$\Pi^{H}_{S,S}-K=\max_{x,X}\ xp\left(x\right)+XP\left(X\right)-tX-K,$$

and the Foreign firm's problem is

$$\Pi^{F}_{S,S}-K=\max_{y,Y}\ y\ p\left(y\right)+YP\left(Y\right)-ty-K.$$

Maximizing these profit functions, solving for optimal quantities and plugging then into the profit function yields

$$\begin{aligned}\Pi^H_{S,S} - K &= \frac{1}{2} t \frac{-2(A-1) - \gamma t - 2t}{(\gamma+2)(2-\gamma)} + \\ &+ \left(\frac{1}{4} \frac{(2A-t)^2}{(\gamma+2)^2} + \frac{1}{2} \frac{t^2}{(\gamma-2)^2} + \frac{1}{4} \frac{(t-2)^2}{(\gamma+2)^2} + \frac{1}{2} \frac{t^2}{2-\gamma} - K \right),\end{aligned}$$

and

$$\begin{aligned}\Pi^F_{S,S} - K &= \frac{1}{2} t \frac{2(A-1) - \gamma t - 2t}{(\gamma+2)(2-\gamma)} + \\ &+ \left(\frac{1}{4} \frac{(2A-t)^2}{(\gamma+2)^2} + \frac{1}{2} \frac{t^2}{(\gamma-2)^2} + \frac{1}{4} \frac{(t-2)^2}{(\gamma+2)^2} + \frac{1}{2} \frac{t^2}{2-\gamma} - K \right).\end{aligned}$$

4.3 Home segments / Foreign doesn't

The Home firm's problem is

$$\Pi^H_{S,N} - K = \max_{x,X} xp(x) + XP(X) - tX - K,$$

and the Foreign firm's problem is

$$\Pi^F_{S,N} = \max_{y,Y} y\ p(y) + Y\ P(Y) - ty,$$

$$\text{s.t. } |\ p(y) - P(Y)| \leq t.$$

Maximizing these profit functions, solving for optimal quantities and plugging then into the profit function yields

$$\Pi^H_{S,N} - K = \frac{1}{2} \frac{(A-t+1)^2}{(\gamma+2)^2} + \frac{1}{2} (A-1-t)^2 \frac{(\gamma-1)^2}{(2-\gamma^2)^2} - K,$$

and

$$\Pi^F_{S,N} = \frac{1}{2} \frac{(A-t+1)^2}{(\gamma+2)^2} + t(A-1-t) \frac{2-\gamma}{2-\gamma^2}.$$

4.4 Foreign segments / Home doesn't

The Home firm's problem is

$$\Pi^H_{N,S} = \max_{x,X} xp(x) + XP(X) - tX,$$

$$\text{s.t. } |p(x) - P(X)| \leq t,$$

and the Foreign firm's problem is

$$\Pi^F_{N,S} - K = \max_{y,Y} y\ p(y) + Y\ P(Y) - c(y+Y) - ty - K.$$

Maximizing these profit functions, solving for optimal quantities and plugging then into the profit function yields

$$\Pi^H_{N,S} = \frac{1}{2}\frac{(t-A-1)^2}{(\gamma+2)^2},$$

and

$$\Pi^F_{N,S} - K = \frac{1}{2}\frac{(t-A-1)^2}{(\gamma+2)^2} + \frac{1}{2}\frac{((A-1)(1-\gamma)+\gamma t+t)^2}{(2-\gamma^2)^2} - K.$$

4.5 The region of interest

In Eq. 2, we state that, in terms of our model, none of the conditions $P(Y)-p(y) < t$ and $P(X)-p(x) < t$, hold if

$$t < (A-1)\frac{2-\gamma}{(\gamma+2)(3-2\gamma)} \approx \frac{A-1}{3}.$$

This constraint is derived by looking at the equilibrium prices under the (S,S) strategy:

$$\begin{aligned} P(X) &= \frac{2A-\gamma A-\gamma^2 t+2t}{(2-\gamma)(\gamma+2)}, \\ p(x) &= \frac{2-\gamma+\gamma t}{(2-\gamma)(\gamma+2)}, \\ P(Y) &= \frac{2A-\gamma A+\gamma t}{(2-\gamma)(\gamma+2)}, \\ p(y) &= \frac{2-\gamma+2t-\gamma^2 t}{(2-\gamma)(\gamma+2)}, \end{aligned}$$

Now,

$$P(X)-p(x)=\frac{1-\gamma}{2-\gamma}t+\frac{A-1}{\gamma+2},$$

and

$$P(Y)-p(y)=-\frac{1-\gamma}{2-\gamma}t+\frac{A-1}{\gamma+2}.$$

Then, $P(X)-p(x)>t$, if

$$t<(A-1)\frac{2-\gamma}{\gamma+2},$$

and $P(Y)-p(y)>t$, if

$$t<(A-1)\frac{2-\gamma}{(\gamma+2)(3-2\gamma)},$$

which is the tightest condition, since

$$(A-1)\frac{2-\gamma}{(\gamma+2)(3-2\gamma)}<(A-1)\frac{2-\gamma}{\gamma+2}.$$

Thus, if

$$t<(A-1)\frac{2-\gamma}{(\gamma+2)(3-2\gamma)},$$

then $P(Y)-p(y)>t$, and $P(X)-p(x)>t$.

5 Appendix B

As discussed, we need to check whether firms would rather keep both markets open, or close the Home market. We model this as a two stage game, where the second stage is the segmentation-quantity game treated in the paper. In the first stage, a firm can choose whether to close the Home market. For simplicity, we assume that a closed market is also segmented (at zero cost). In this extended (a first and a second period) game, we call a strategy profile an equilibrium if it is subgame perfect. Hence, we use backwards induction to find the equilibria of the extended game. Given the profits in the second stage, we analyze a stage one game of the following form:

		Foreign	
		Sell on both markets	Close Home market
Home	Sell on both markets	1	2
	Close Home market	3	4

Each numbered square represents the equilibrium profits in the stage two game, given the strategies in the first stage. These various profits are calculated, and compared, in the same document as referred to in Appendix A.

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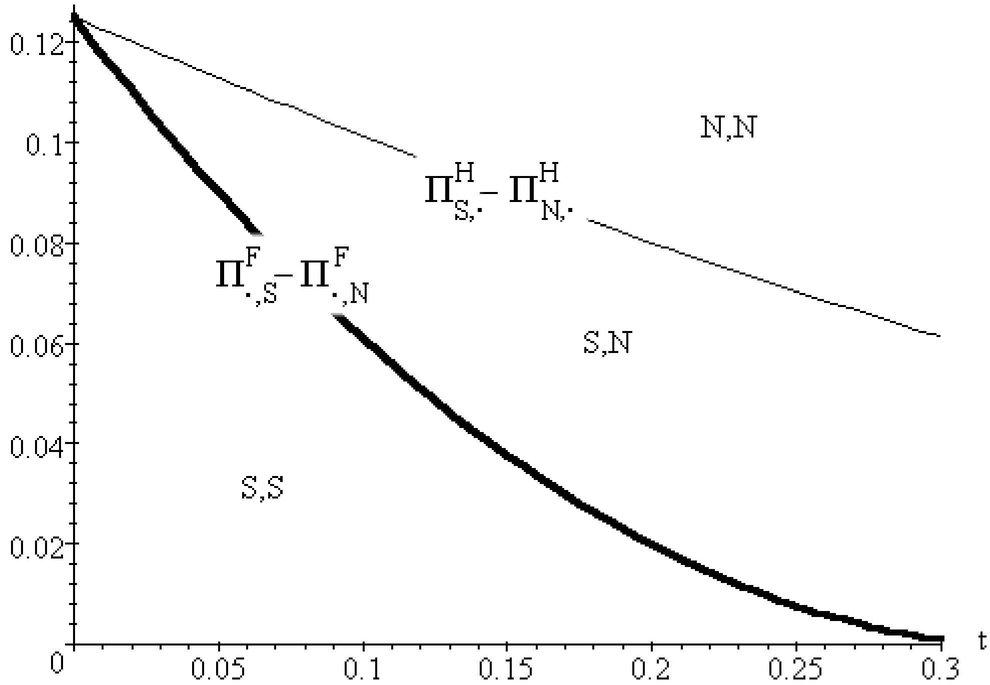

Figure 1a. Integration vs. Segmentation with perfectly differentiated goods ($\gamma = 0$).

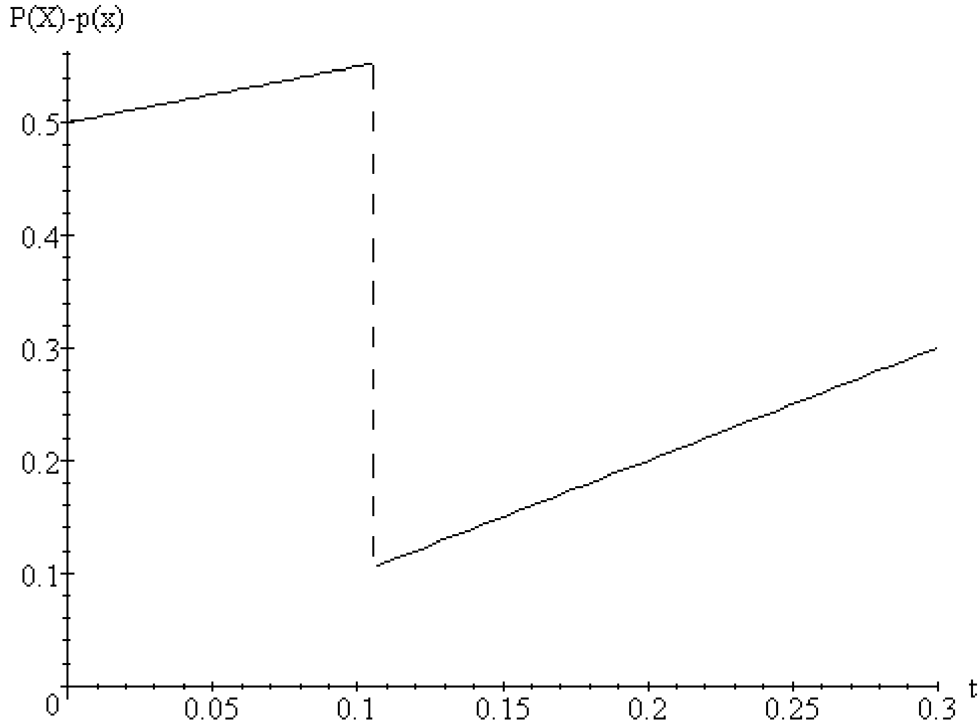

Figure 1b. Price differentials when goods are perfectly differentiated ($\gamma = 0$) and $K = 0.1$.

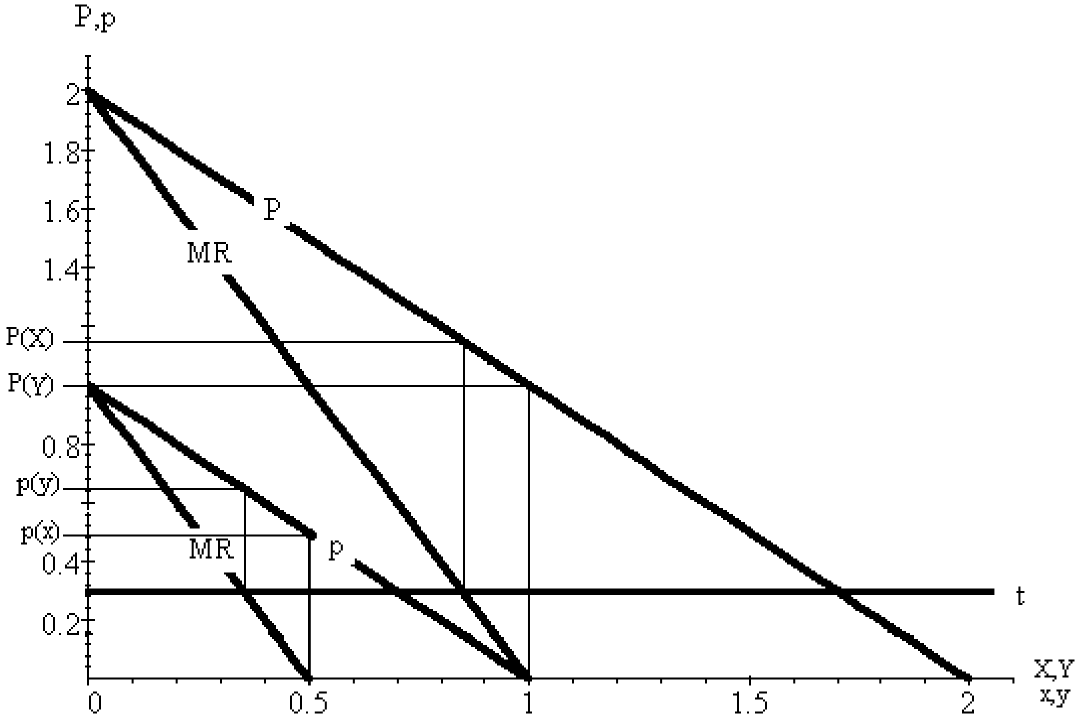

Figure 2. Price differences for perfectly differentiated goods ($\gamma = 0$).

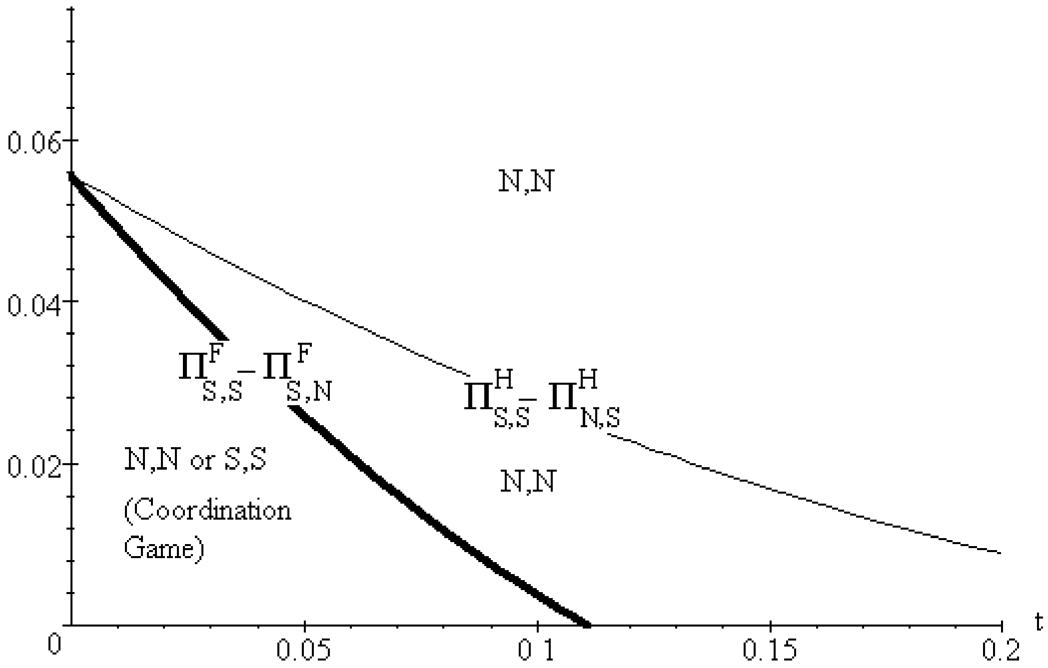

Figure 3a. Integration vs. Segmentation with homogenous goods($\gamma \rightarrow 1$).

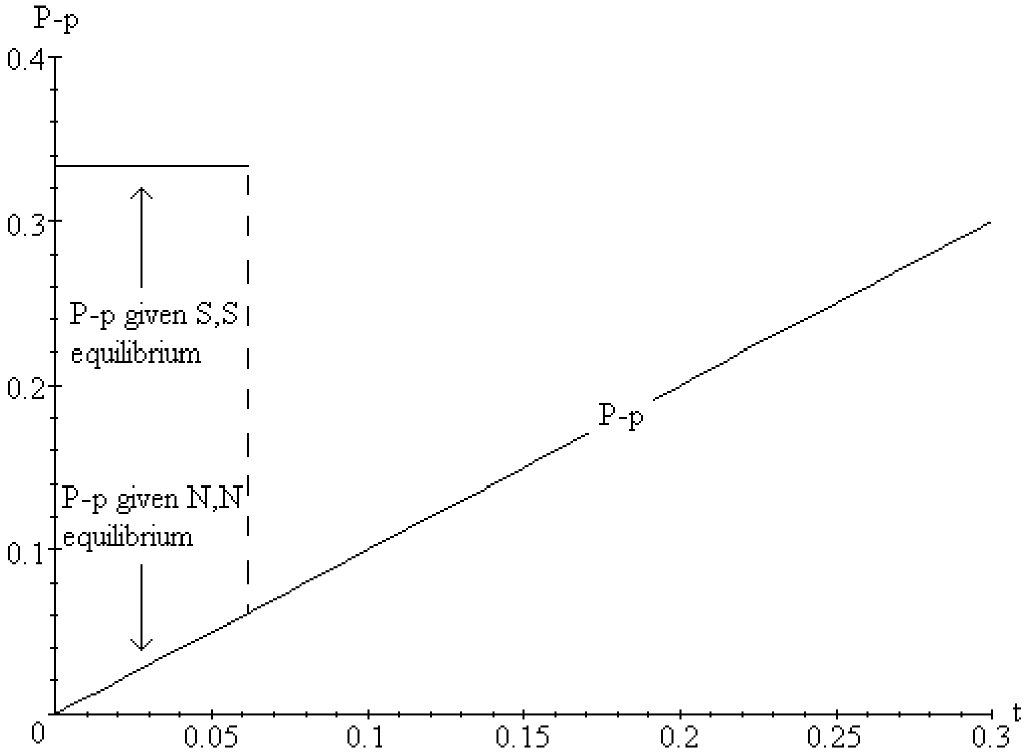

Figure 3b. Price differentials when goods are homogenous ($\gamma \rightarrow 1$) and $K = 0.025$.

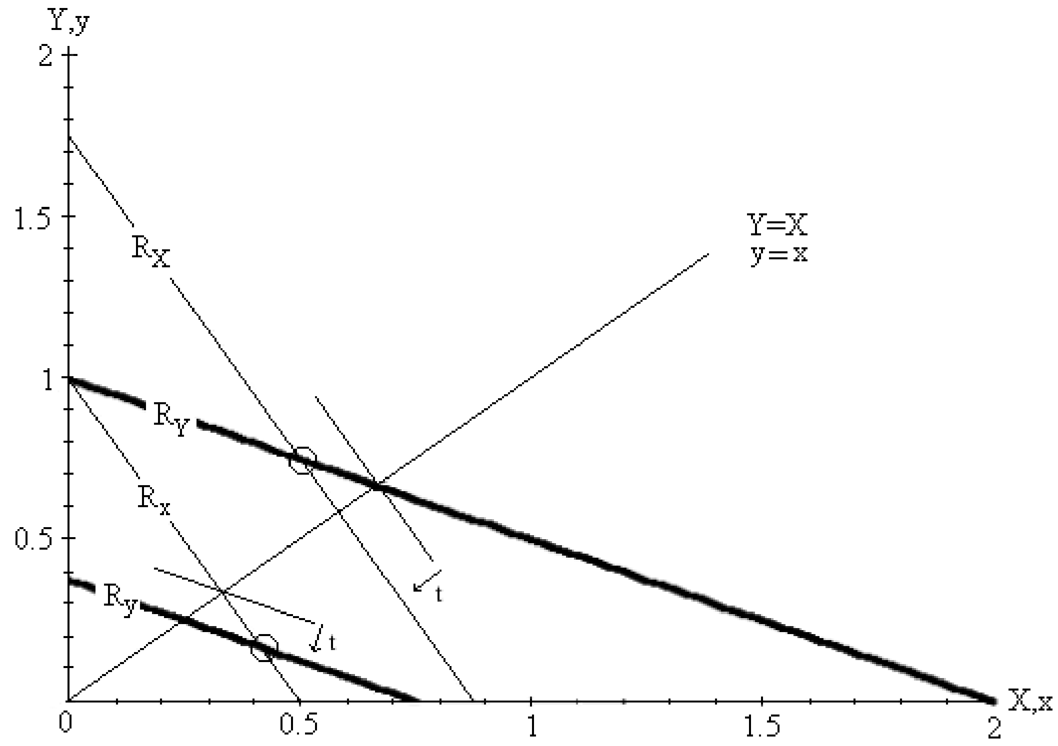

Figure 4. Reaction functions given that both firms segment markets and $\gamma = 1$.

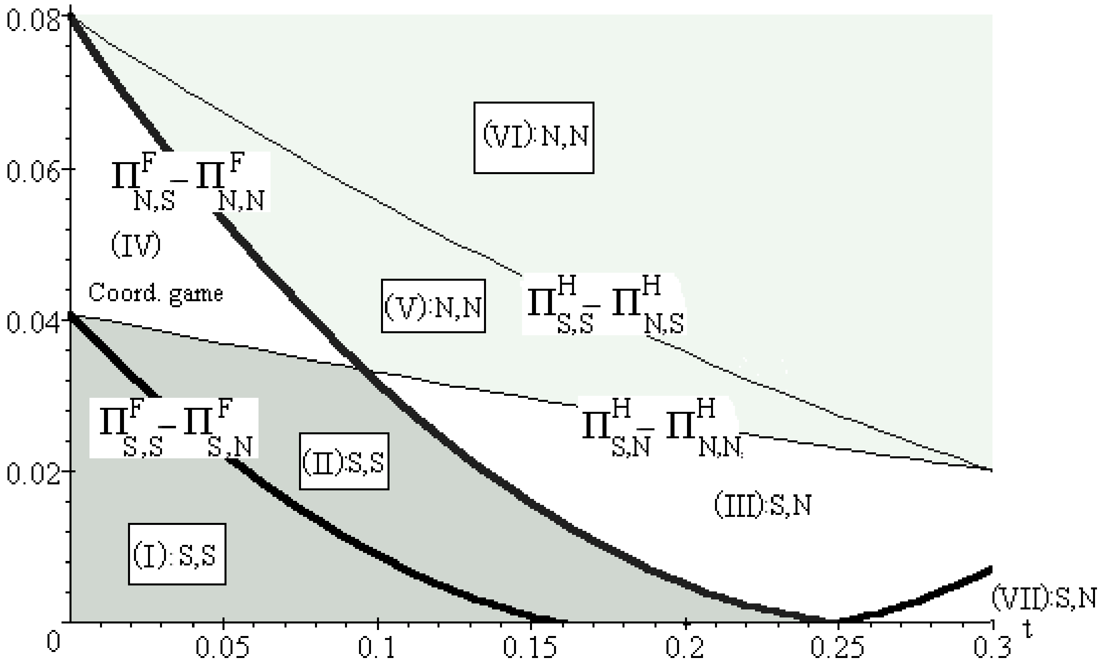

Figure 5a. Integration vs. Segmentation with differentiated goods ($\gamma = 1/2$).

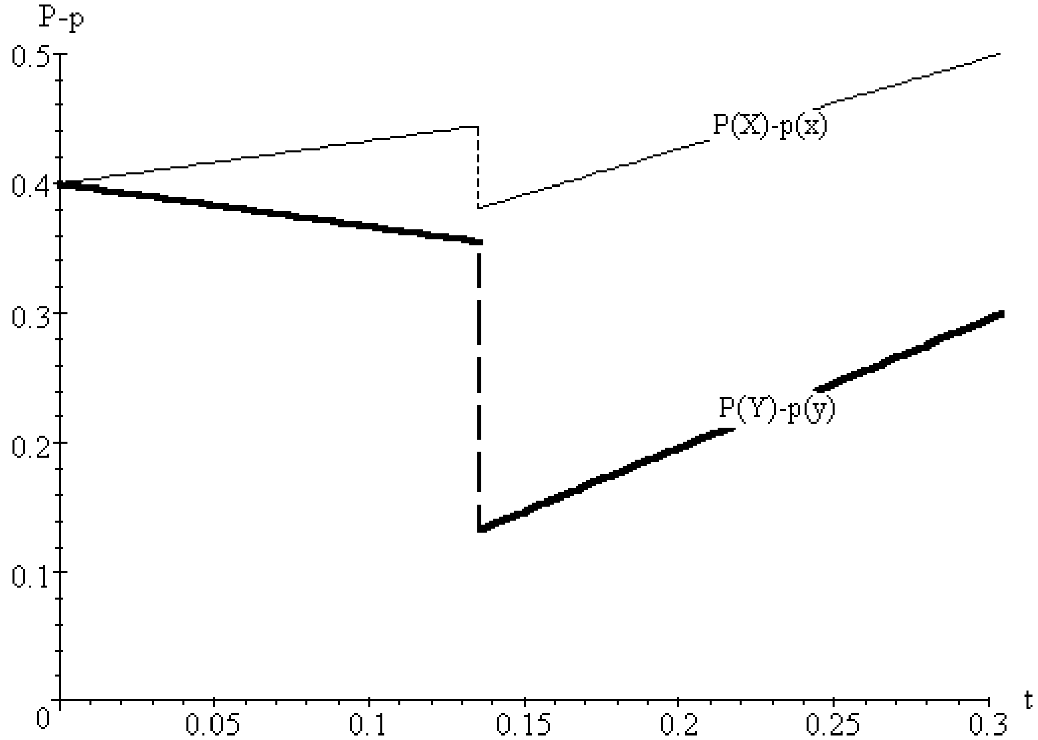

Figure5b. Price differentials when goods are differentiated ($\gamma = 1/2$).