System goods, tying and vertical foreclosure

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Abstract: With the development of e-commerce, upstream firms have the possibility to sell their products on BtoC markets. I explore the consequences of this observation on the analysis of vertical integration and more specifically vertical foreclosure. I consider the same industry structure as in OSS (1990), but I allow the integrated firm to sell the intermediate good either on a BtoB market (as assumed by OSS) and/or on a BtoC market (in which case it is in fact no longer an intermediate good). I also consider the possibility that the competing producer of the intermediate good sells it on a BtoC market. In this enriched strategic framework, the firm has to decide on how to combine vertical foreclosure and tying, which sheds new light on the relation between these two possibly anticompetitive practices.

1 Introduction

The typical paper on vertical relations will start by characterizing each product as either intermediate or final. Intermediate products are sold by upstream firms to downstream firms on an intermediate (BtoB) market, while final products are sold by downstream firms to final customers on a final (BtoC) market. Some firms may be operating on both markets, that is, they may be vertically integrated, and vertical integration may be endogenous. However, the possibility that a given product may be sold either on a BtoB or on a BtoC market, depending on the choice of the firm producing this product, is ignored. While this was certainly a reasonable approach in 1990, when Ordover, Saloner and Salop published their seminal paper on vertical integration in the AER, it is more questionable now, in particular due to the development of e-commerce, which makes it much easier for firms to reach final customers and thus makes it possible to sell virtually any product either on a BtoB or a BtoC market, or on both.

Consider for example tire replacement. Unless one is able and willing to replace his car's tires himself, tire replacement is a bundle of two products: the tires and the service provided by a mechanic to install the tires. The

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traditional approach is for the customer to go to a car workshop and pay for the bundle. The mechanic will provide the service and purchase the tires from another firm, typically a wholesaler. Here, the tires are intermediate goods and the bundle is a final good, while service is not offered separately from the tires. This corresponds to a standard situation of vertical relations. Alternatively, one can purchase the bundle on internet from a wholesaler. The wholesaler will instruct the customer to go to a given workshop, where his tires will be replaced. The costs of the service is included in the price paid to the wholesaler. Of course, the wholesaler will pay the workshop. It is still a standard vertical relations setting, but turned upside down. Still another possibility is that the customer purchases the tires from the wholesaler and the service from the car workshop. Then, since both products are sold on a BtoC market, there are no vertical relations, but rather firms selling complementary products. Firms' decisions regarding the market on which they will sell their product thus determine whether the relevant framework of analysis is that of vertical relations or that or complementary products, or a mix of both. It is then natural to ask what determines this choice and endogenize firms' choice between BtoB and BtoC (or a combination of both) markets.

In this paper, I focus on the implications of the previous observations on the analysis of vertical integration and more specifically vertical foreclosure. I consider the same industry structure as in OSS (1990), but I allow the integrated firm to sell the intermediate good either on a BtoB market (as assumed by OSS) and/or on a BtoC market (in which case it is in fact no longer an intermediate good). I also consider the possibility that the competing producer of the intermediate good sells it on a BtoC market. In this enriched strategic framework, the firm has to decide on how to combine vertical foreclosure and tying, which sheds new light on the relation between these two possibly anticompetitive practices.

2 Literature review

While the strands of literature on vertical foreclosure, on one hand, and tying, on the other hand, are very large and reviewing them is beyond the scope of this paper, there are remarkably few papers that I could find dealing with both practices. Blair and Kaserman [1978] demonstrate the equivalence of tying and vertical integration for a monopolist producing an input that is used in variable proportion by a competitive downstream industry to produce the final good. However, in their paper, the authors consider tying inputs on the intermediate market rather than complementary goods on the final market and the possibility that inputs are sold on the BtoC market is not considered. In Gilo [2003], vertical integration and the tying of intermediate goods are alternative ways for suppliers to preserve their ability to charge high wholesale prices when contracts between suppliers and retailers are secret. Church and Gandal [2000] indiscriminately use the expressions "vertical foreclosure" and "tying" to designate the same practice, namely the fact for a firm producing two elements of a system good to make one of the elements they produce incompatible with the other element of the system good produced by its rivals. For example, the firm's software will work only with its own hardware. This terminology may seem confusing but actually reflects the fact that the model in Church and Gandal [2000] combines elements consistent with the "tying" terminology - both elements of the system good are sold to final customers - and elements consistent with the "vertical foreclosure" terminology - prices are set and orders placed on the market for one element before the market for the second element opens, which introduces a flavor of vertical relations. None of these papers analyses vertical foreclosure and tying on the final market as part of a firm's choice of its distribution strategy.

This paper is also related to the literature on endogenous timing. This is because I maintain the assumption that BtoB markets operate before BtoC markets, so that choosing to sell on one or the other of these markets is also a choice of timing and the model is an extended game with observable delay in the terminology introduced by Hamilton and Slutsky (1990). Exploring the literature on endogenous timing, I could not find any paper similar to this one. While Din and Sun (2018), Arya and Mittedord (2018) and Madden and Pezzino (2019) consider competition between a vertically integrated firm and a downstream competitor, they consider the timing of offers of the final good rather than the timing of offers of the intermediate good. The issue is whether the integrated firm puts prices (or quantities) for the final (system) good before or after its downstream competitor. In contrast, the question I adress here is that of the timing of offers of the intermediate good.

3 The model

I consider an industry composed of three firms. $\mathscr{A}$ produces an homogeneous product A, $\mathscr{B}$ produces the variety B_2 of a differentiated product B and $\mathscr{S}$ produces both product A and the variety B_1 of product B. Products A and B have no value for customers unless they are combined into system goods, be it S_1 (the combination of one unit of A and one unit of B_1) or S_2 (the combination of one unit of A and one unit of B_2). While $\mathscr{S}$ can offer S_1 autonomously, $\mathscr{B}$ can offer S_2 only if it purchases product A either from $\mathscr{S}$ or from $\mathscr{A}$. Whether $\mathscr{S}$ supplies $\mathscr{B}$ with product A or not is the "vertical foreclosure" issue discussed, e.g., in OSS (1990). Contrary to OSS (1990), I consider the possibility that customers compose the system good S_2 from one unit of A purchased on the BtoC market from either $\mathscr{S}$ or $\mathscr{A}$ and one unit of the B_2 product purchased from $\mathscr{B}$. Whether $\mathscr{S}$ supplies or not customers with product A is the "'tying"' issue discussed, e.g., in Whinston (1990). For the sake of comparability with OSS (1990), I assume that $\mathscr{A}$'s distribution strategy is exogenous, with four possibilities, depending on whether $\mathscr{A}$ operates on the BtoB market, the BtoC market, both markets or none. In OSS(1990), A operates on the BtoB market and the possibility that it may operate on the BtoC market is not considered. $\mathscr{S}$ also has these four options, but it decides between these options. The aim of this paper is to determine the optimal choice of $\mathscr{S}$ regarding it's distribution strategy and assert the conditions under which vertical foreclosure and tying will emerge, separately or in combination, thus shedding new light on the relations between these two practices.

For each of the possible market positionings of $\mathscr{A}$, I consider the following three stage game:

- Stage 1: $\mathscr{S}$ decides on which markets it will sell product A.
- Stage 2: firms operating on the BtoB market (if any) put prices for product A on this market.
- Stage 3: firms operating on the BtoC markets put prices for the products they sell on these markets. This includes (at most) the price of product A offered on the BtoC market by $\mathscr{S}$ and/or $\mathscr{A}$, the price of product B_2 offered on the BtoC market by $\mathscr{B}$, the price of the system good S_2 offered on the BtoC market by $\mathscr{B}$ and (for sure) the price of the system good S_1 offered on the BtoC market by $\mathscr{S}$.

The assumption that BtoB markets operate before BtoC markets and that firms operating on BtoC markets are price takers on the BtoB market, standard in the literature on vertical relations since OSS(1990), is maintained. For the sake of clarity, I will define the price charged for the system goods as the sum of the price paid by the firm for product A and a (gross) margin associated with the production of product B. The combination of B with product A into the system good is assumed to be costless. I also assume that once a unit of product A and a unit of product B are combined into a unit of a system good, it is not possible to separate them. So, purchasing a unit of S_1 and a unit of B_2 does not, for example, allow a customer to enjoy the consumption of system good S_2.

The production of product A is associated with a constant marginal cost c, while the production of a quantity Q^i of product B_i costs $v_i(Q^i)$. Denoting by w the unit price paid by $\mathscr{B}$ for product A, the demand function for system good S_i is $Q^i(c+m_1, w+m_2)$, where m_1 is the margin charged by $\mathscr{S}$ and m_2 is the margin charged by $\mathscr{B}$.

4 The distribution strategy of firm $\mathscr{S}$ in equilibrium

4.1 $\mathscr{A}$ absent from both the BtoB and the BtoC market

4.1.1 $\mathscr{S}$ enters only on the BtoC market

As illustrated in figure 1, $\mathscr{S}$ and $\mathscr{B}$ compete on the BtoC market. $\mathscr{B}$ offers B_2, while $\mathscr{S}$ offers both A and S_1.

The profits are given by

$$\Pi_{\mathscr{S}} = m_1 Q^1(c+m_1, w_1+m_2) - v_1(Q^1(c+m_1, w_1+m_2)) + (w_1 - c)Q^2(c+m_1, w_1+m_2) \quad (1)$$

$$\Pi_{\mathscr{B}} = m_2 Q^2(c+m_1, w_1+m_2) - v_2(Q^2(c+m_1, w_1+m_2)) \quad (2)$$

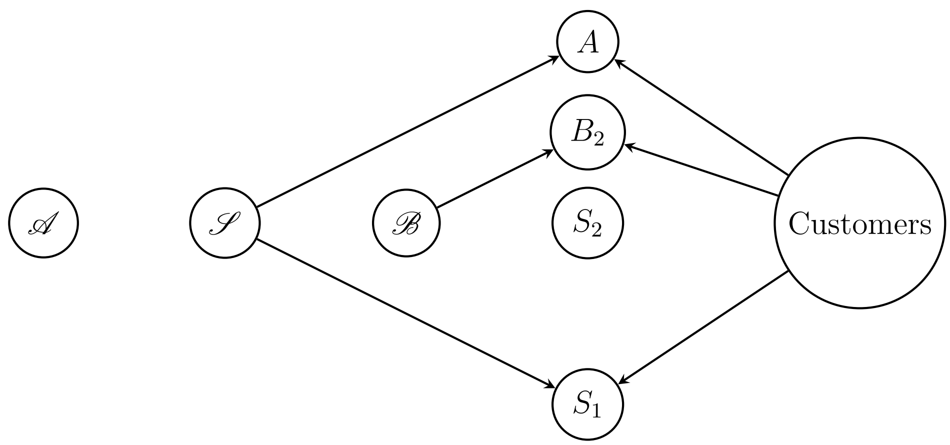


Figure 1: $\mathscr{A}$ absent from BtoB and BtoC markets ; $\mathscr{S}$ on BtoC market

The equilibrium values of m_1, m_2 and w_1 are the solutions to the system composed of equations (3), (4) and (5), in which the arguments of demand functions are dropped.

$$Q^1 + (m_1 - v_1'(Q^1))Q_1^1 + (w_1 - c)Q_1^2 = 0 \tag{3}$$

$$Q^2 + (m_2 - v_2'(Q^2))Q_2^2 = 0 \tag{4}$$

$$(m_1 - v_1'(Q^1))Q_2^1 + Q^2 + (w_1 - c)Q_2^2 = 0 \tag{5}$$

Equations (3) and (4) are the first order conditions with respect to respectively m_1 (chosen by $\mathscr{S}$) and m_2 (chosen by $\mathscr{B}$). In both equations, one recognizes the price effect and the quantity effect of an increase in price. The third term in (3) reflects the fact that part of the demand lost by $\mathscr{S}$ when it increases m_1 comes back to $\mathscr{S}$ as a demand for product $\mathscr{A}$. This is an incentive for $\mathscr{S}$ to charge higher prices than $\mathscr{B}$.

Let us denote by $m_1^*(w_1)$ and $m_2^*(w_1)$ the solution of the system composed of (3) and (4). Equation (5) captures a price effect (second term) and a quantity effect (third term): When $\mathscr{S}$ increases w_1 for given values of m_1 and m_2, it makes more profit on each unit of product S_2, but less units of this product will be sold. The first term reflects the fact that part of this reduction in the sales of S_2 is compensated for $\mathscr{S}$ by an increase in its own sales of the system good S_1. Let's denote by w_1^* the equilibrium price of good A on the BtoB market. The equilibrium markups are $m_1^*(w_1^*)$ and $m_2^*(w_1^*)$. Final customers can obtain the system good S_1 from $\mathscr{S}$ at the price of $c+m_1^*(w_1^*)$ or the system good S_2 at the price of $w_1^*+m_2^*(w_1^*)$ by purchasing product A from $\mathscr{S}$ and product B_2 from $\mathscr{B}$.

4.1.2 $\mathscr{S}$ enters only on the BtoB market

As illustrated in figure 2, $\mathscr{S}$ and $\mathscr{B}$ compete on the BtoC market, each firm offering its variety of the system good. There is no point for $\mathscr{B}$ putting a price for B_2, since no customer is interested in B_2 without A.

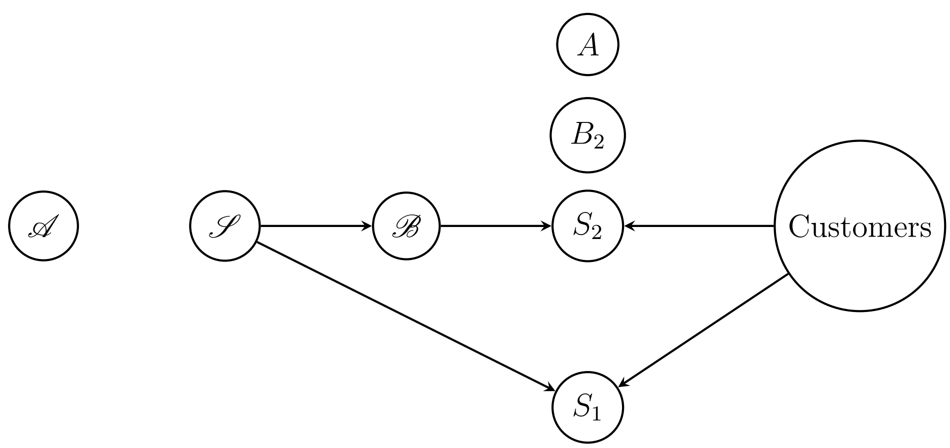


Figure 2: $\mathscr{A}$ absent from BtoB and BtoC markets ; $\mathscr{S}$ on BtoB market

In the BtoC stage, the expressions of profits are identical to equations (1) and (2), so that the first order conditions are equations (3) and (4) and the equilibrium values of m_1 and m_2 in a subgame corresponding to a given value of w_1 are $m_1^*(w_1)$ and $m_2^*(w_1)$. In the BtoB stage, however, the first order condition with respect to w_1 is different from (5). This is because a change in w_1 will induce a change in the values of m_1 and m_2 in the next stage. Indeed, in (6) one recognizes (5) but also a supplementary term capturing the modulation of the quantity effect associated with the modification of m_2.

$$(m_1^* - v_1'(Q^1))Q_2^1 + Q^2 + (w_1 - c)Q_2^2 + m_2^{*'}(w_1)[(m_1^* - v_1'(Q^1))Q_2^1 + (w_1 - c)Q_2^2] = 0 \quad (6)$$

Because of the difference between equation (5) and equation (6), $\mathscr{S}$ will not charge the same price for product A in equilibrium when is operates on the BtoB market and when it operates on the BtoC market. Let us denote by w_1^{**} the price charged by $\mathscr{S}$ for product A. Customers can purchase S_1 from $\mathscr{S}$ at $c + m_1^*(w_1^{**})$ or S_2 from $\mathscr{B}$ at $w_1^{**} + m_2^*(w_1^{**})$.

Obviously, $\mathscr{S}$ prefers to operate on the BtoB market rather than on the BtoC market. Indeed, $\mathscr{S}$ can charge w_1^* in the BtoB stage and obtain the profits it would get in the BtoC equilibrium. Thus, as in fact $\mathscr{S}$ prefers to charge a different price, this is because it leads to higher profits than in the BtoC equilibrium.

4.1.3 The comparison between w_1^* and w_1^{**}

It is possible to determine whether the BtoB price of good A is larger or smaller than the BtoC price. Indeed, evaluated at $w_1 = w_1^*$, the left-hand side of (6) is equal to $-m_2^{*'}(w_1^*)Q^2$. Consequently, if $m_2^{*'}(w_1^*) > 0$, then the marginal profit of w_1 in the BtoB case is lower than 0 at w_1^* and $\mathscr{S}$ will charge a lower price for good A in BtoB than in BtoC: $w_1^{**} < w_1^*$. Conversely, in the more plausible case where $m_2'(w_1^*) < 0$, $\mathscr{S}$ will charge a higher price in BtoB than in BtoC for product A: $w_1^{**} > w_1^*$.

Lemma 1 $w_1^{**} > w_1^*$ *if and only if* $m_2'(w_1^*) < 0$

Let us now consider the two remaining alternatives for $\mathscr{S}$.

4.1.4 $\mathscr{S}$ enters on both the BtoB and the BtoC market

At the BtoC stage, the price w_1 set at the BtoB stage works as a constraint on $\mathscr{S}$. Any price higher than this price $\mathscr{S}$ would announce on the BtoC market would be ineffective, since $\mathscr{B}$ will strictly prefer to sell the system good S_2 rather than product B_2 and will charge prices such that, indeed, A and B_2 are not sold. In general, when product A is offered on both the BtoB and the BtoC market, $\mathscr{B}$ charges prices such that only the system good S_2 is

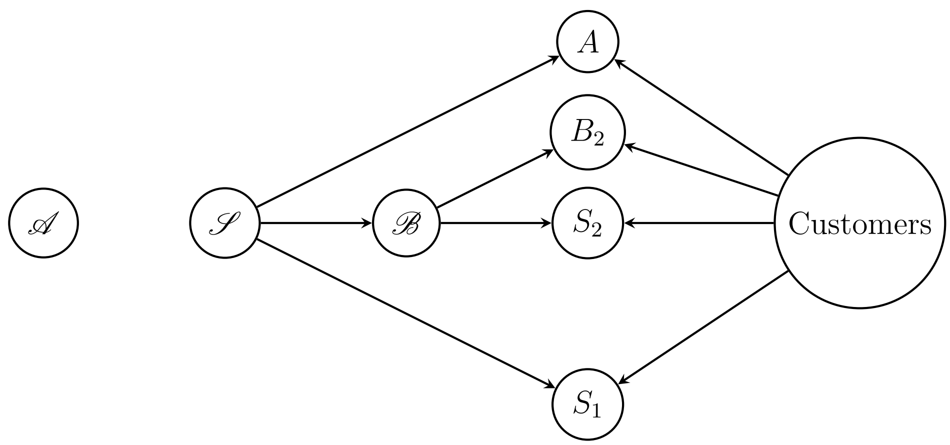


Figure 3: $\mathscr{A}$ absent from BtoB and BtoC markets ; $\mathscr{S}$ on BtoB and BtoC markets

sold if the price of A is lower on the BtoB market than on the BtoC market. Conversely, when A is cheaper on the BtoC market, $\mathscr{B}$ charges prices such that customers purchase A and B_2 separately rather than S_2. Due to that, there is no need to consider two different values of m_2. Given the previous observations, if $w_1^{**} < w_1^*$, then the outcome will be identical to the outcome when $\mathscr{S}$ sells only on the BtoB market. It will charge w_1^{**} on the BtoB market and stick to this price on the BtoC market. In the absence of any benefit from operating on the BtoC market, I conclude that $\mathscr{S}$ prefers to enter only on the BtoB market in this case. If, conversely, $w_1^{**} > w_1^*$, then product A will be sold at w_1^* and $\mathscr{S}$ will make lower profits than if it were only on the BtoB market. In fact, since operating only on the BtoB market is more profitable than operating only on the BtoC market and the BtoC market opens after the BtoB market, it is rather intuitive that operating on both markets cannot increase profits and under plausible assumptions reduces them.

4.1.5 $\mathscr{S}$ stays out of both the BtoB and the BtoC market

This strategy is a combination of vertical foreclosure and tying. Product A is not sold to $\mathscr{B}$ on the BtoB market and it is not sold to customers on the BtoC market. The consequence is of course that $\mathscr{B}$ is driven out of the

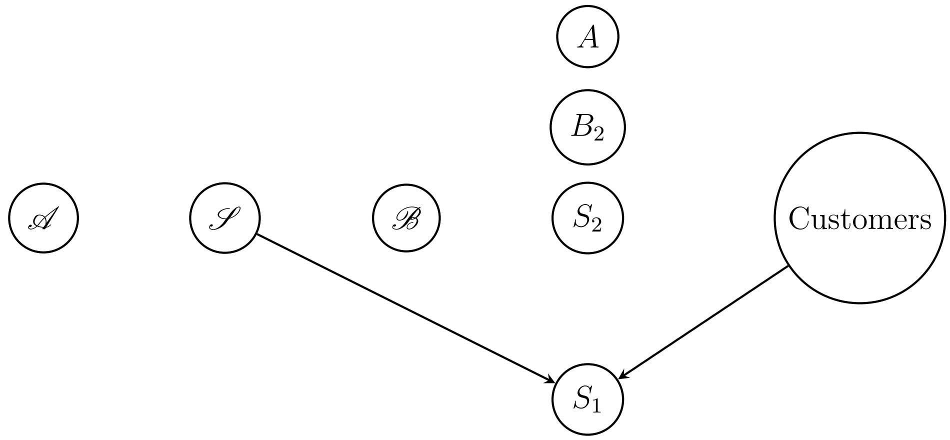


Figure 4: $\mathscr{A}$ absent from BtoB and BtoC markets ; $\mathscr{S}$ absent from BtoB and BtoC markets

market of both product B (which is completely useless in the absence of a possibility to obtain product A) and product S_2 (which $\mathscr{B}$ is not able to produce without access to product A). If this is optimal for $\mathscr{S}$, then in the case where $\mathscr{S}$ operates on the BtoB market only, it puts a price so high that B is actually driven out of the market. This is however very costly due to product differentiation between B_1 and B_2 (and thus between S_1 and S_2). In the linear case (see in appendix), $\mathscr{S}$ prefers to operate on the BtoB market (and offer a price w_1 such that $\mathscr{B}$ is viable in equilibre, as we assumed when dealing with this case) rather than foreclosing $\mathscr{B}$. I assume that the demand and cost functions are such that this is indeed the case in what follows.

4.1.6 Conclusion

I now summarize the results above in proposition (1).

Proposition 1 *When $\mathscr{A}$ operates neither on the BtoB or the BtoC market, the optimal strategy for $\mathscr{S}$ is to enter on the BtoB market, but not on the BtoC market. Customers purchase either the system good S_1 from $\mathscr{S}$ or the system good S_2 from $\mathscr{B}$. This is an equilibrium with tying ($\mathscr{S}$ does not offer A on the BtoC market, but without vertical foreclosure ($\mathscr{S}$ offers A on the BtoB market).*

4.2 $\mathscr{A}$ operates on the BtoB market, but not on the BtoC market

In what follows, w_2 is the price charged by $\mathscr{A}$ for product A on the BtoB market.

4.2.1 $\mathscr{S}$ stays out of both the BtoB and the BtoC markets

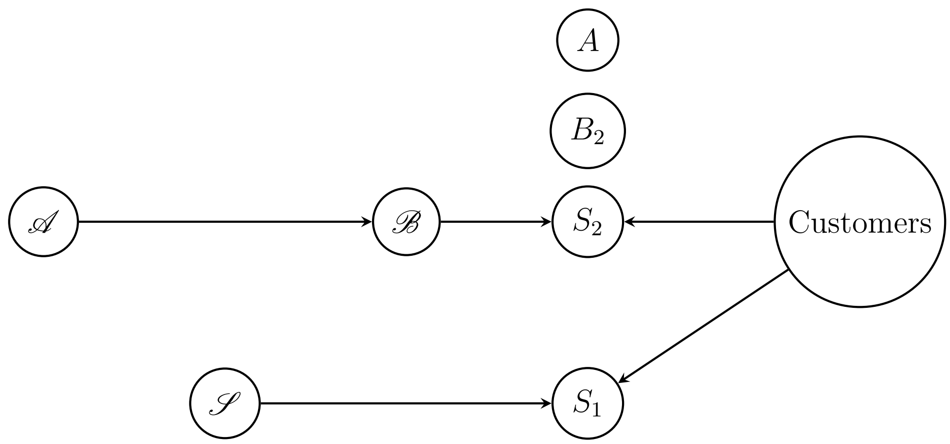


Figure 5: $\mathscr{A}$ on BtoB market ; $\mathscr{S}$ absent from BtoB and BtoC markets

In stage 2, $\mathscr{S}$ and $\mathscr{B}$ compete, $\mathscr{S}$ offering the system good S_1 and $\mathscr{B}$ offering the system good S_2, with profits given by:

$$\Pi_{\mathscr{S}} = m_1 Q^1(c + m_1, w_2 + m_2) - v_1(Q^1(c + m_1, w_2 + m_2)) \tag{7}$$

$$\Pi_{\mathscr{B}} = m_2 Q^2(c + m_1, w_2 + m_2) - v_2(Q^2(c + m_1, w_2 + m_2)) \tag{8}$$

The first order conditions are:

$$Q^1 + (m_1 - v_1'(Q^1))Q^1_1 = 0 \tag{9}$$

$$Q^2 + (m_2 - v_2'(Q^2))Q_2^2 = 0 \tag{10}$$

Note that (9) is different from (3) because $\mathscr{S}$ is not supplying $\mathscr{B}$ with product A. As a consequence, the solution of the system composed of (9) and (10) is, for any value of w_2, different from $m_1^*(w_2)$ and $m_2^*(w_2)$. We denote it by $m_1^\$(w_2)$ and $m_2^\$(w_2)$.

In the BtoB stage, $\mathscr{A}$'s profits are given by:

$$(w_2 - c)[Q^2(c + m_1^\$(w_2), w_2 + m_2^\$(w_2)) \tag{11}$$

The first order condition with respect to w_2 is:

$$(w_2 - c)(m_2^{\$'}(w_2) + 1)Q_2^2 + (w_2 - c)m_1^{\$'}(w_2)Q_1^2 + Q^2 = 0 \tag{12}$$

Let the equilibrium value of w_2 be denoted by $w_2^{\$\$}$. The equilibrium values of m_1 and m_2 are $m_1^\$(w_2^{\$\$})$ and $m_2^\$(w_2^{\$\$})$.

4.2.2 $\mathscr{S}$ is present on the BtoB market

Since product A is homogeneous, w is driven down to the marginal cost c as soon as $\mathscr{S}$ is present on the BtoB market, regardless of whether it is also present on the BtoC market or not. Entry on the BtoB market is not profitable for $\mathscr{S}$. There is still one possibility left to explore, namely that $\mathscr{S}$ operates on the BtoC market only.

4.2.3 $\mathscr{S}$ operates on the BtoC market only

$\mathscr{S}$ will undercut $\mathscr{A}$ by offering $w_1 < w_2$. This means that $\mathscr{A}$ will make no profit whatever the value of w_1, which is thus irrelevant for $\mathscr{A}$. In order to avoid an indeterminacy of w_1, I assume that, when choosing w_1, $\mathscr{A}$ considers that there is some very small probability η that $\mathscr{S}$ fails to enter the BtoC market. As a consequence of this assumption, $\mathscr{A}$ charges $w_2^{\$\$}$ in the BtoB stage. Then, in the BtoC stage, $\mathscr{S}$ will charge $Min(w_1^*, w_2^{\$\$} - \epsilon)$, where ϵ

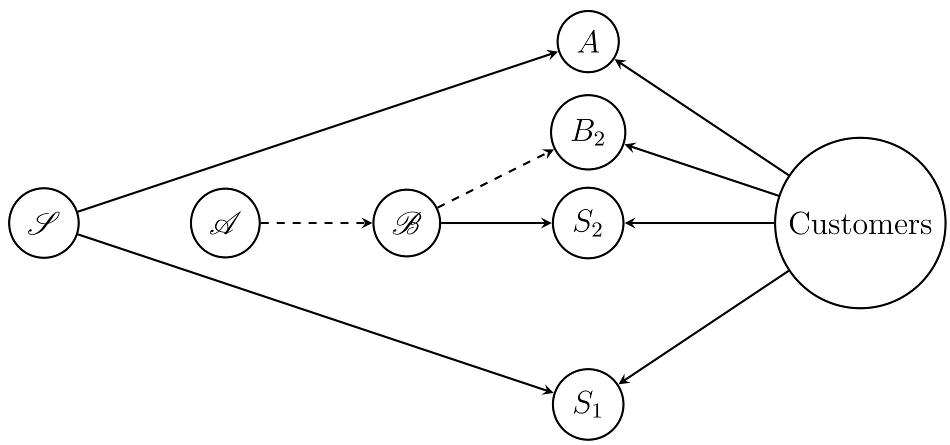


Figure 6: $\mathscr{A}$ on BtoB market ; $\mathscr{S}$ on BtoC market

is a (small) rebate such that customers strictly prefer to purchase from $\mathscr{S}$ rather than from $\mathscr{A}$.

It is difficult to compare w_1^* and $w_2^{\$\$}$ in the general case. In the linear case presented in appendix, the comparison between the two prices depends on the degree of product differentiation between $B1$ and $B2$. However, this is of no consequence on $\mathscr{S}$'s optimal choice, which is to enter on the BtoC market. Indeed, compared to remaining out of the BtoC market, this allows $\mathscr{S}$ to capture the profits from selling A without lowering the cost of $\mathscr{B}$.

4.2.4 Conclusion

The previous analysis in summarized in proposition (2).

Proposition 2 *When $\mathscr{A}$ operates on the BtoB market, $\mathscr{S}$ enters the BtoC market. Customers either purchase the system good S_1 from $\mathscr{S}$ or compose the system good S_2 from product A they purchase from $\mathscr{S}$ and product $B2$ they purchase from $\mathscr{B}$. This is an equilibrium with vertical foreclosure ($\mathscr{S}$ does not offer A on the BtoB market), but without tying ($\mathscr{S}$ offers A on the BtoC market).*

4.3 $\mathscr{A}$ operates on the BtoC market, but not on the BtoB market

It is not optimal for $\mathscr{S}$ to enter the BtoC market in this case, because it would drive the price of product A on the BtoC market to c, therefore making the system good S_2 cheaper, without providing any profit to $\mathscr{S}$ from selling product A. We are thus left with two alternatives to examine: $\mathscr{S}$ either stays out of both markets or enters the BtoB market.

4.3.1 $\mathscr{S}$ stays out of both the BtoB and the BtoC markets

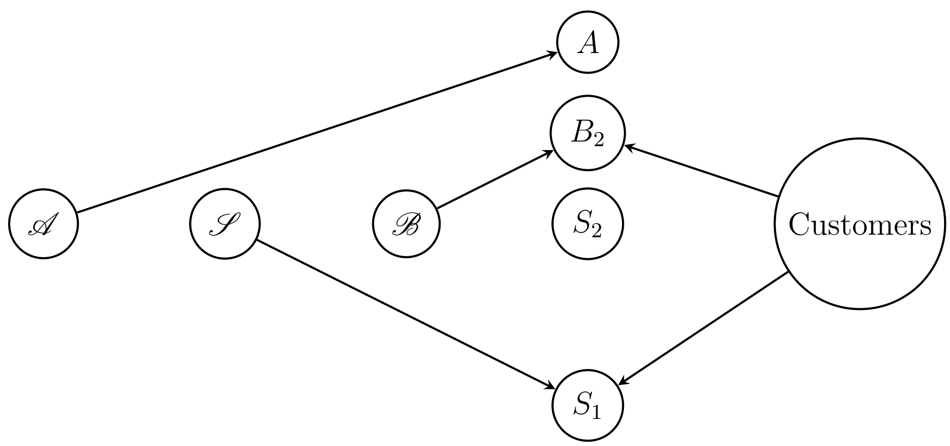


Figure 7: $\mathscr{A}$ on BtoC market ; $\mathscr{S}$ absent from BtoB and BtoC markets

If $\mathscr{S}$ stays out of both markets, then there is no BtoB stage. In the BtoC stage, the profits of $\mathscr{S}$ and $\mathscr{B}$ are given by equations (7) and (8) and the corresponding first order conditions by equations (9) and (10). For $\mathscr{A}$, the profit is different from (11) because m_1 and m_2 are no longer functions of w_2, due to the simultaneity in the determination of these three variables. So, $\mathscr{A}$'s profit is:

$$(w_2 - c)[Q^2(c + m_1, w_2 + m_2) \tag{13}$$

and the FOC is:

$$(w_2 - c)Q_2^2 + Q^2 = 0 \tag{14}$$

The solution to the system composed of equations (9), (10) and (14) is denoted by $w_2^\$$, $m_1^\$(w_2^\$)$ and $m_2^\$(w_2^\$)$.

4.3.2 The comparison between $w_2^\$$ and $w_2^{\$\$}$

Depending on the sign of $(w_2^\$ - c)m_2^{\$\prime}(w_2^\$)Q_2^2 + (w_2^\$ - c)m_1^{\$\prime}(w_2^\$)Q_1^2$, the price charged by $\mathscr{A}$ on the BtoB market will be higher (if the expression is positive) or lower (if the expression is negative) than the price charged on the BtoC market.

Lemma 2 $w_2^{\$\$} > w_2^\$$ *if and only if* $(w_2^\$ - c)m_2^{\$\prime}(w_2^\$)Q_2^2 + (w_2^\$ - c)m_1^{\$\prime}(w_2^\$)Q_1^2 > 0$

In the linear case presented in appendix, $w_2^\$ < w_2^{\$\$}$. The price charged by $\mathscr{A}$ when it operates only on the BtoB market is higher than the price charged by $\mathscr{A}$ when it operates only on the BtoC market.

4.3.3 $\mathscr{S}$ enters the BtoB market

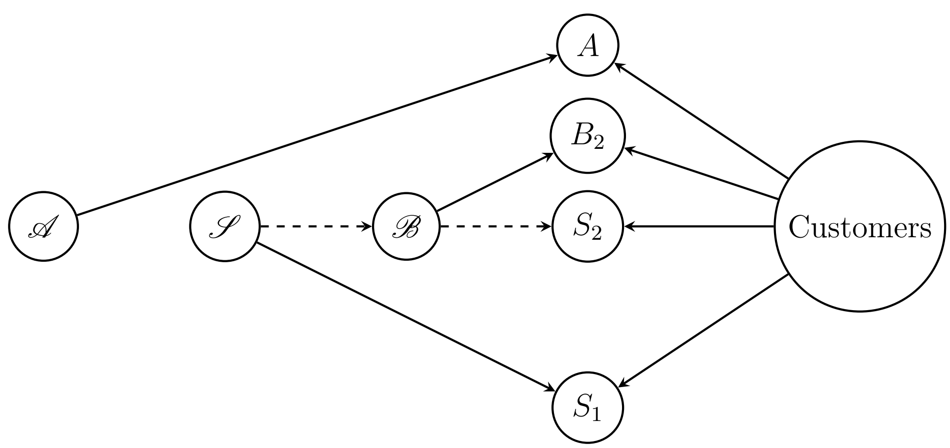


Figure 8: $\mathscr{A}$ on BtoC market ; $\mathscr{S}$ on BtoB market

$\mathscr{A}$ will of course undercut $\mathscr{S}$ by offering a price w_2 lower than w_1 in the BtoC stage. Consequently, $\mathscr{S}$ will not make any profit on the BtoB market, unless (with a small probability), $\mathscr{A}$ fails to enter the BtoC market. Because of this small probability that $\mathscr{A}$ fails to enter the BtoC market, $\mathscr{S}$ has an incentive to charge w_1^{**} on the BtoB market. However, if w_1^{**} is lower than $w_2^{\$}$, this leads $\mathscr{A}$ to lower its price on the BtoC market, which negatively affects $\mathscr{S}$'s profits. Consequently, in the BtoB market, $\mathscr{S}$ charges $w_1 = Max(w_1^{**}, w_2^{\$})$ and in the BtoC market, $\mathscr{A}$ charges $w_2^{\$} - \epsilon$.

4.3.4 Conclusion

Proposition (3) summarizes the previous results.

Proposition 3 *When $\mathscr{A}$ operates on the BtoC market only, $\mathscr{S}$ enters on the BtoB market. Unless $\mathscr{A}$ fails to enter the BtoC market (with a very small probability), customers purchase the system good S_1 from $\mathscr{S}$ and compose the system good S_2 from product A purchased from $\mathscr{A}$ and product $B2$ purchased from $\mathscr{B}$. This is an equilibrium without vertical foreclosure, but with tying.*

Note that while there is no formal vertical foreclosure, in the sense that $\mathscr{S}$ offers product A on the BtoB market at a price such that $\mathscr{B}$ could compete on the market for the system good, it still holds that $\mathscr{S}$ does not actually sell product A on the BtoB market. This equilibrium is reminiscent of the equilibrium in OSS (1990) in which the vertically integrated firm commits to a price on the intermediate market and is undercut by the non-integrated upstream firm. The difference here is that the non-integrated producer of product A sells on the BtoC market rather than on the BtoB market.

4.4 $\mathscr{A}$ operates on both the BtoB and the BtoC market

To avoid competition with $\mathscr{A}$, which would lead to $w = c$, $\mathscr{S}$ stays out of both markets. If $w_2^{\$\$} > w_2^{\$}$, $\mathscr{A}$ offers product A on the BtoC market at $w_2^{\$}$. Because with some very small probability $\mathscr{A}$ may fail to enter the BtoC market, it offers product A on the BtoB market at $w_2^{\$\$}$. If $w_2^{\$\$} < w_2^{\$}$, $\mathscr{A}$ offers product A on the BtoB market at $w_2^{\$\$}$. On the BtoC market, he may offer product A at $w_2^{\$\$}$, in which case $\mathscr{B}$ will charge the same margin on B_2 and S_2 and customers can indifferently obtain S_2 from $\mathscr{B}$ or by combining product A obtained from $\mathscr{A}$ and product B_2 obtained from $\mathscr{B}$. $\mathscr{A}$ may also not offer product A on the BtoC market (or offer it at a price larger than $w_2^{\$\$}$), in which case customers interested in S_2 can obtain it only from $\mathscr{B}$, which does not make any real difference.

Proposition 4 *When $\mathscr{A}$ operates on both the BtoB and the BtoC market, $\mathscr{S}$ stays out of both markets. This is an equilibrium with vertical foreclosure and tying. If $w_2^{\$\$} > w_2^{\$}$, customers purchase the system good S_1 from $\mathscr{S}$ and compose the system good S_2 from product A purchased from $\mathscr{A}$ and product $B2$ purchased from $\mathscr{B}$. If $w_2^{\$\$} < w_2^{\$}$, customers purchase the system good S_1 from $\mathscr{S}$ and the system good S_2 from $\mathscr{B}$ or, equivalently, may purchase separately product A from $\mathscr{A}$ and product B_2 from $\mathscr{B}$.*

5 Conclusion

An integrated firm's profit maximization typically requires a high market price of intermediate goods. In particular, the integrated firm will avoid head-to-head competition on the markets for homogeneous intermediate goods. One way to avoid competition is of course to stay out of the market. This is indeed what happens in the seminal paper of Ordover, Saloner and Salop (1990): the integrated firm stays out of the intermediate market and leaves its upstream competitor exert monopoly power on this market. This is the vertical foreclosure strategy. In this paper, the integrated firm can sell the intermediate good both on the BtoB market (as in OSS(1990)) and on the BtoC market. Consequently, it must decide not only on vertical foreclosure, but also on tying. The optimal combination actually depends on its competitor's distribution strategy. If the competitor ($\mathscr{A}$) offers the intermediate good (A) on the BtoB market only, then the integrated firm will stay out of the BtoB market (vertical foreclosure), but tying is not optimal. Indeed, offering the intermediate good on the BtoC market allows the integrated firm to capture the sales of intermediate good from its competitor without triggering a price war and even without lowering the price of the intermediate good. If, however, ($\mathscr{A}$) is present on both the BtoB and the BtoC market, then the integrated firm will find optimal to stay out of both markets. We then end up with foreclosure and tying.

6 Appendix : The linear case

This appendix presents the resolution of the model in the linear case. I assume that $c = 0$ and $v_1(Q^1) = v_2(Q^2) = 0$ for any value of Q^1 and Q^2. As regards the demand functions, I assume that $Q^1 = 1 - m_1 + \alpha(w + m_2)$ and $Q^2 = 1 - (w + m_2) + \alpha m_1$, where w is the lowest price offered for product A on th BtoB and the BtoC market.

6.1 $\mathscr{A}$ absent from both the BtoB and the BtoC market

6.1.1 $\mathscr{S}$ enters only on the BtoC market

w is the price w_1 charged by $\mathscr{S}$ on the BtoC market. The first order conditions are

$$2m_1 - \alpha m_2 - 2\alpha w_1 = 1 \tag{15}$$

$$-\alpha m_1 + 2m_2 + w_1 = 1 \tag{16}$$

$$-2\alpha m_1 + m_2 + 2w_1 = 1 \tag{17}$$

Equations (15), (16) and (17) correspond to equations (3), (4) and (5). Combining equations (15) and (16) lead to

$$m_1^*(w_1) = \frac{2 + \alpha + 3\alpha w_1}{4 - \alpha^2} \tag{18}$$

and

$$m_2^*(w_1) = \frac{2 + \alpha - 2(1 - \alpha^2)w_1}{4 - \alpha^2} \tag{19}$$

Plugging these values into (17) leads to

$$w_1^* = \frac{2 + \alpha}{6(1 - \alpha)} \tag{20}$$

and finally $m_1^*(w_1^*) = \frac{1}{2(1-\alpha)}$, $m_2^*(w_1^*) = \frac{1}{3}$, $Q^1 = \frac{\alpha+3}{6}$ and $Q^2 = \frac{1}{3}$.

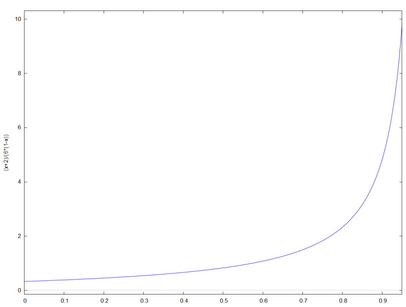
6.1.2 $\mathscr{S}$ enters only on the BtoB market

Solving for the first order condition with respect to w_1 leads to

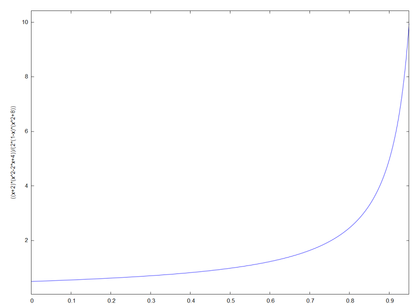
$$w_1^{**} = \frac{(2+\alpha)(\alpha^2 - 2\alpha + 4)}{2(1-\alpha)(8+\alpha^2)} \tag{21}$$

As can be seen on figure 10, $\mathscr{S}$ offers S_1 at a price lower than $\mathscr{B}$. The figure also shows that, in equilibrium, $Q^2 > 0$: $\mathscr{S}$ offers A on the BtoB market at a price such that $\mathscr{B}$ can indeed compete on the BtoC market for system goods.

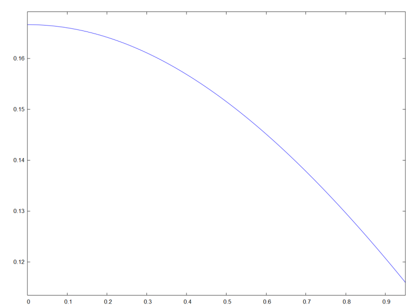
Since we know that $m_2^{*'} < 0$ for any w_1, $w_1^{**} > w_1*$. When operating on the BtoB market, increasing w_1 from w_1^* leads to a higher price of the system good S_2 (indeed, $m_2^{*'} > -1$), but the price of S_2 increases less than the price of A. $\mathscr{B}$ partially absorbs the increase in the price of A, thus reducing its impact on the quantity of S_2 sold on the BtoC market and encouraging $\mathscr{S}$ to charge a higher price for A on the BtoB market than on the BtoC market. One can also note that m_1 is increasing in w_1, with $m_1^{*'} < 1$. Increasing w_1 on the BtoB market allows $\mathscr{S}$ to charge a higher price for S_1 on the BtoB market.



(a) w_1^*

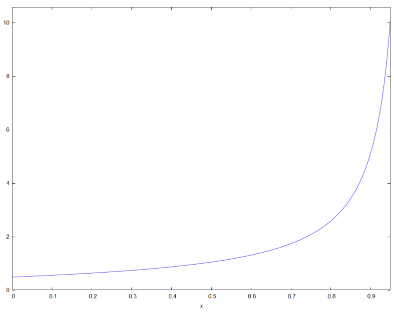


(b) w_1^{**}

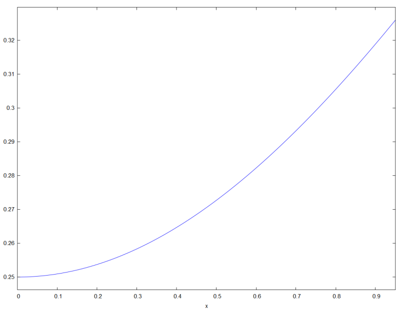


(c) $w_1^{**} - w_1^*$

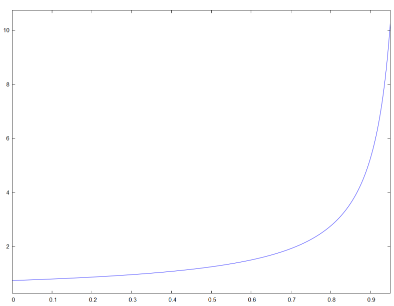
Figure 9: Comparison of w_1^* and w_1^{**}



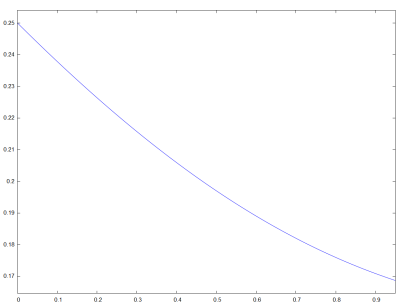
(a) $m_1^*(w_1^{**})$



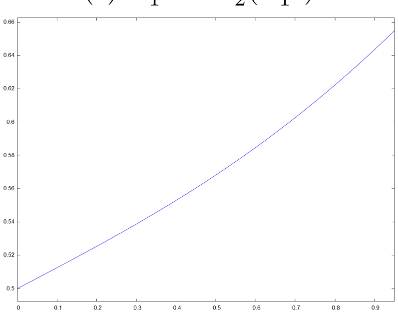
(b) $m_2^*(w_1^{**})$



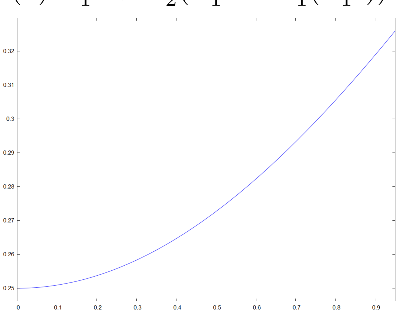
(c) $w_1^{**} + m_2^*(w_1^{**})$



(d) $w_1^{**} + m_2^*(w_1^{**} - m_1^*(w_1^{**}))$



(e) Q^1



(f) Q^2

Figure 10: Prices and quantities of the system goods on the BtoC market

6.2 $\mathscr{A}$ operates on the BtoB market, but not on the BtoC market

6.2.1 $\mathscr{S}$ stays out of both the BtoB and the BtoC markets

The first order conditions with respect to $m1$ and $m2$ are

$$2m_1 - \alpha m_2 - \alpha w_2 = 1 \tag{22}$$

$$-\alpha m_1 + 2m_2 + w_2 = 1 \tag{23}$$

Solving the system of (22) and (23) leads to

$$m_1^{\$}(w_2) = \frac{2 + \alpha + \alpha w_2}{4 - \alpha^2} \tag{24}$$

$$Q^2(w_2) = m_2^{\$}(w_2) = \frac{2 + \alpha - (2 - \alpha^2) w_2}{4 - \alpha^2} \tag{25}$$

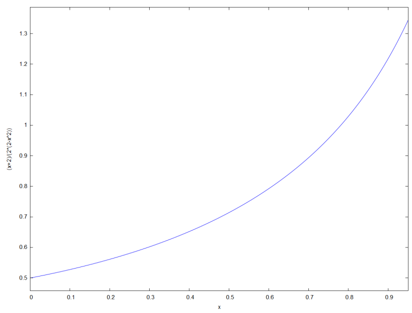
Solving the first order condition for $\mathscr{A}$ then leads to

$$w_2^{\$\$} = \frac{2 + \alpha}{2(2 - \alpha^2)} \tag{26}$$

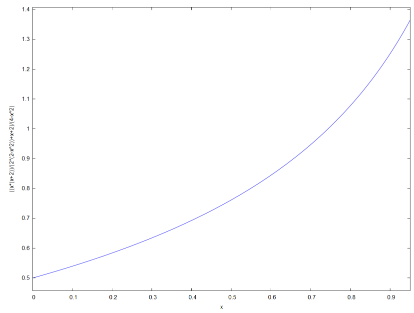
Finally,

$$m_1^{\$}(w_2^{\$\$}) = \frac{1}{2 - \alpha}\left(1 + \frac{\alpha(2 + \alpha)}{2(2 - \alpha^2)}\right) m_2^{\$}(w_2^{\$\$}) = \frac{1}{2(2 - \alpha)} \tag{27}$$

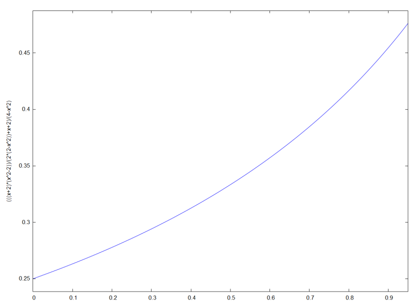
Figure 11 describes the market outcomes.
Figure 12 compares w_1^* and $w_2^{\$\$}$.



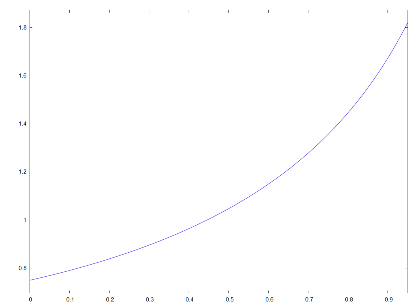
(a) $w_2^{\$\$}$



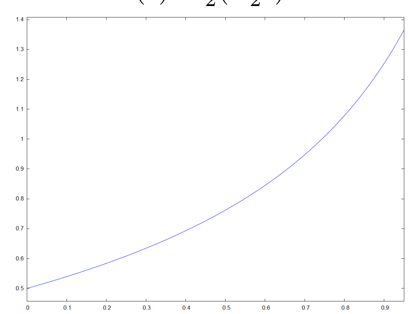
(b) $m_1^{\$}(w_2^{\$\$})$



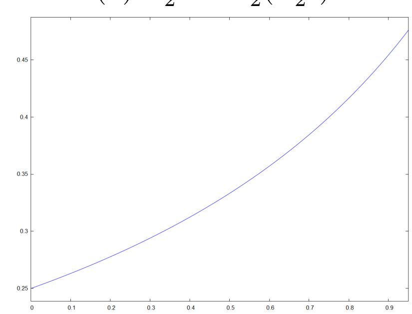
(c) $m_2^{\$}(w_2^{\$\$})$



(d) $w_2^{\$\$} + m_2^{\$}(w_2^{\$\$})$



(e) Q^1



(f) Q^2

Figure 11: Prices and quantities of product A and the system goods

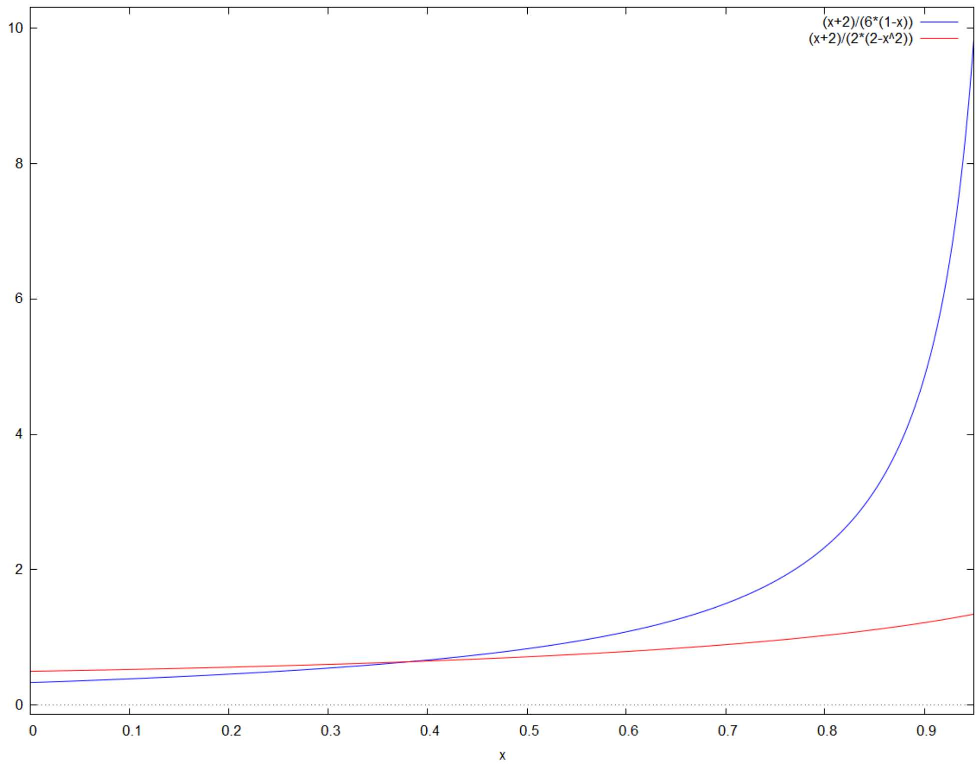


Figure 12: w_1^* (in blue) and $w_2^{\$\$}$ (in red)

6.3 $\mathscr{A}$ operates on the BtoC market, but not on the BtoB market

6.3.1 $\mathscr{S}$ stays out of both the BtoB and the BtoC markets

The first order conditions are

$$2m_1 - \alpha m_2 - \alpha w_2 = 1 \tag{28}$$
$$-\alpha m_1 + 2m_2 + w_2 = 1 \tag{29}$$
$$-\alpha m_1 + m_2 + 2w_2 = 1 \tag{30}$$

Solving the system of first order conditions leads to

$$m_1^{\$}(w_2^{\$}) = \frac{2\alpha + 3}{2(3-\alpha^2)} \tag{31}$$
$$m_2^{\$}(w_2^{\$}) = w_2^{\$} = \frac{\alpha + 2}{2(3-\alpha^2)} \tag{32}$$

Figure 13 describes the market outcomes.
Obviously, in the linear case, $w_2^{\$} < w_2^{\$\$}$.

6.3.2 $\mathscr{S}$ enters the BtoB market

In the linear case, $w_1^{**} > w_2^{\$}$, as shown on figure 14.

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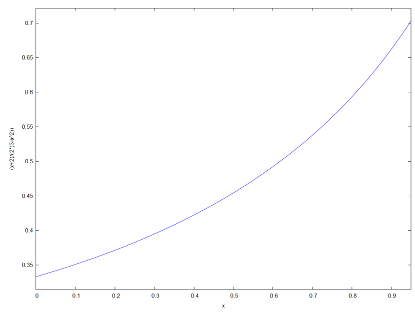
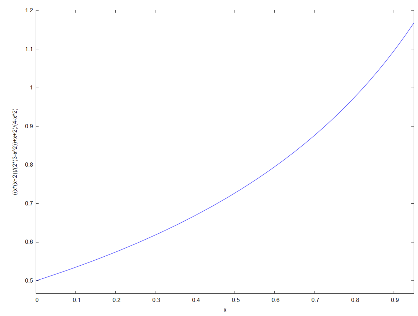
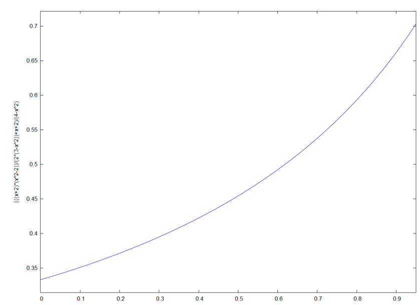


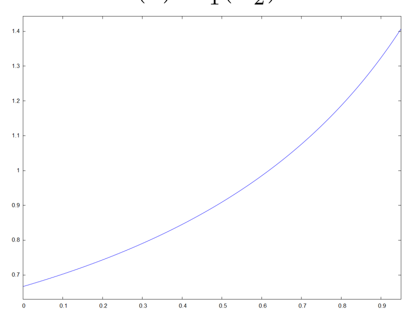
(a) $w_2^{\$}$



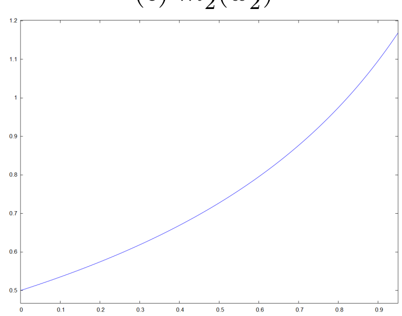
(b) $m_1^{\$}(w_2^{\$})$



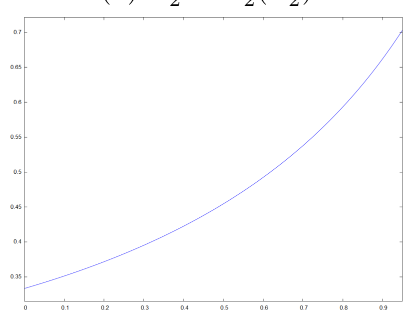
(c) $m_2^{\$}(w_2^{\$})$



(d) $w_2^{\$} + m_2^{\$}(w_2^{\$})$



(e) Q^1



(f) Q^2

Figure 13: Prices and quantities of product A and the system goods

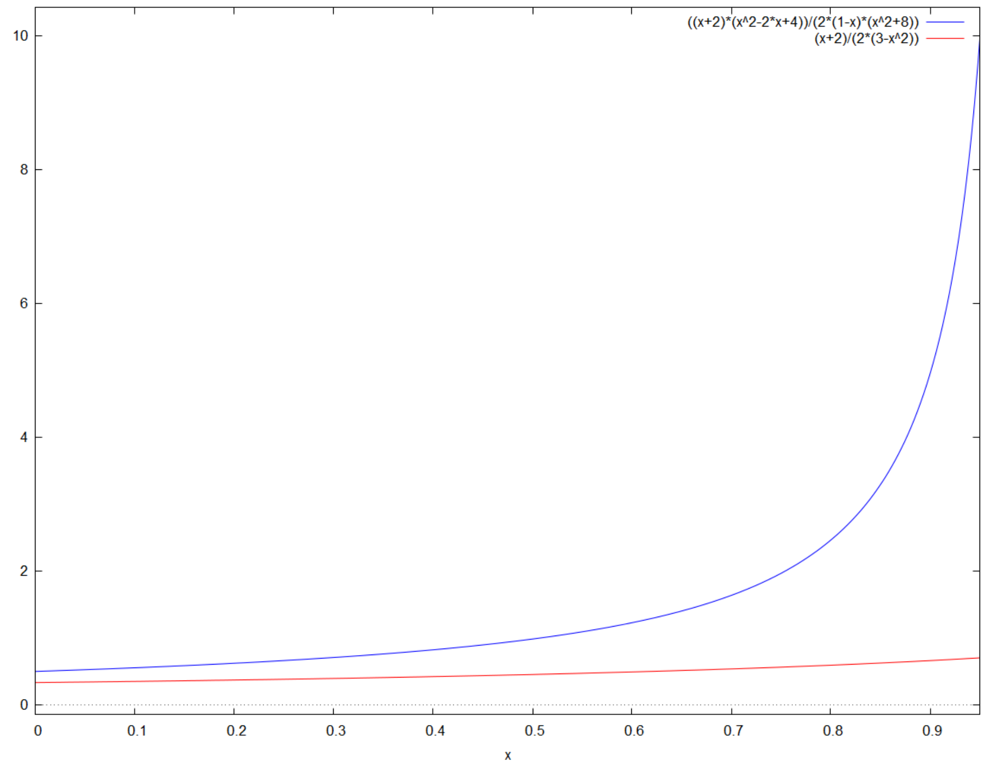


Figure 14: w_1^{**} (in blue) and $w_2^{\$}$ (in red)

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