A Model of Vertical Oligopolistic Competition

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Abstract

This paper develops a general model of successive oligopolies with endogenous market entry. We allow for varying degrees of product differentiation and entry cost to capture how the competitive environment in upstream and downstream markets interact. We show in particular that upstream and downstream markets affect each other asymmetrically and that the overall market outcome is dominated by the competitive conditions on the downstream market. Furthermore, we find that the implications of downstream competition are underestimated when ignoring its interaction with the upstream market. This underestimation is more pronounced the less symmetric the competitive environment in upstream and downstream markets are.

JEL classification: L13, D43, L40, L50

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1 Introduction

Studies on imperfect competition typically focus on analyzing one market, ignoring potential interaction with input suppliers (or business customers). Yet, there exists almost no market in which a producer directly sells to its customers. But there is little knowledge on how large the potential mistake is if one ignores this competitive interaction.

Vertical market structures are the focus of attention in the context of vertical mergers and their welfare implications. A drawback of this literature is that in order to be able to analytically solve the model at least one of the two markets, upstream or downstream market, is modelled in a very simplified way, with an exogenous number of firms and homogenous products.

In this paper we provide a general model of successive oligopolies with endogenous market entry. The key advantage of our model is that despite being more general than existing models it can still be solved analytically, rather than having to resort to numerical solutions. In this model we allow for varying degrees of product differentiation as well as different entry cost, reflecting different competitive environments in both markets. Thus, we can use the model to explore the endogenous two tier market structure as a function of both product differentiation and entry cost in both markets.

With this model we want to address three groups of questions.

1. How do input and output markets interact, i.e. how does the market structure in one market depend on the market conditions in the other market? In particular, we examine the possibility of multiple equilibria in the overall market structure arising from the interaction between two layers of markets .

2. Do upstream and downstream market conditions have symmetric or asymmetric effects on each other? In particular, we want to know which market conditions matter more for the overall market performance and welfare, those of the upstream or those of the downstream market.

3. How large is the mistake one makes in the welfare analysis when focussing on the market conditions of one market alone instead of considering the potential interaction between markets? In particular, we are interested in finding out what

determines the size of this mistake and how it depends on the market conditions in both markets.

The idea of our theoretical approach is to model each market like a Salop circle, with price competition and transportation cost that reflect different degrees of product differentiation. Such a market is straightforward to analyze if demand is continuous. For downstream markets selling to a large number of consumers this assumption is innocuous. For the upstream market, where demand is generated by a finite number of input buyers, the analysis is less straightforward. The innovation of our model is to find a demand specification that makes demand in the upstream market continuous, despite the small number of buyers, and hence allows us to use the first order condition approach. Still, analytically solving the model becomes extremely cumbersome. However, using symmetry arguments we can in fact find analytical solutions to the model that look surprisingly simple.

More specifically, we can derive the following results:

Firstly, our analysis reveals that the interaction between the two markets matters indeed for the overall two tier market structure. For instance, the zero profit condition in the downstream market can be fulfilled with both a large number of suppliers in both markets and a small number of suppliers. One might expect that this kind of interaction could give rise to multiple equilibria. Surprisingly, however, we find that there always exists a unique equilibrium, i.e. the overall market structure is uniquely determined by the exogenously given product differentiation and entry cost.

Secondly, we find next that upstream and downstream markets interact asymmetrically. For example, a higher number of upstream firms (caused by a reduction of market entry cost) always leads to a higher number of downstream firms while the reverse does not hold true. Furthermore, we show that the overall market outcome is dominated by the competitive conditions in the downstream market since the degree of competition in this market constrains upstream prices while the competitive pressure in the upstream market has less impact on downstream prices.

Thirdly, we find that the effect of varying downstream market competition as measured by product differentiation on the number of downstream firms is always underestimated when the interaction with the upstream market is ignored. For instance, stronger competition on the downstream market reduces also the profit and thus the number of upstream firms which in turn causes higher input prices and transportation costs for the downstream firms, causing a further reduction in the number of downstream firms. We characterize conditions under which this effect is particularly strong and find that this is less likely to be the case, the more similar the competitive environment in both upstream and downstream market.

The existing literature that deals with vertical market structures is mostly interested in the question under which conditions vertical integration arises and whether it can be welfare enhancing or welfare reducing. To this end a realistic description of successive markets is needed. In most parts of this literature the basic markets, upstream and downstream, are modelled in a very simplified way, with an exogenous number firms in each market and firms producing homogeneous products. Moreover, to get some interesting implications with homogeneous goods, the papers usually assume competition a la Cournot (see for example, Greenhut and Ohta (1979), Salinger (1988), Gaudet and van Long (1996), or Abiru, Nahata, Raychaudhuri, and Waterson (1998).)[1] Ordover, Saloner and Salop (1990) or Chen (2001) allow for price competition in the vertical integration framework. But to keep the model simple they firstly assume homogeneous products in the upstream market resulting in perfect Bertrand competition and secondly restrict the number of downstream firms to two. They show that in this framework it is possible to generate asymmetric equilibria in which one firm is integrated and the other one not.

A paper that has a similar structure as our model is Ghosh and Morita (2005). They allow for endogenous entry in the upstream sector and compare the market outcome with the socially optimal number of firms. They find that insufficient entry may arise, because part of the profit of an upstream firm is captured by the downstream firms. In contrast to our paper they assume that products in both markets are homogenous and that firms compete in Cournot fashion. As a con-

[1]For a paper that is not interested in vertical integration but also assumes Cournot competition and considers different brands in the upstream market see Belleflamme and Toulemonde (2003).

sequence, their paper does not consider varying degrees of competition in both markets and especially how the competitive conditions of the two markets interact with each other.

To sum up, the literature about vertical market structure so far normally supposes very specific market conditions and often quantity competition but there does not exist a general framework to deal with the question how vertically interrelated oligopolies work and which market is the dominant one under different circumstances. On of the reasons for this lack of more generality is that more realistic models quickly become very complicated. The main contribution of this paper is to provide such a general model that gives intuitive results and may serve as a framework to deal with other questions like supply chains, as well.

The remainder of the paper is organized as follows. The next Section sets out the model. In Section 3 we solve for the subgame perfect equilibrium of the model. Section 4 provides some comparative static results and analyzes the size effect of ignoring the upstream market. In Section 5 we give a welfare analysis and Section 6 concludes.

2 The Model

Consider an industry with two successive oligopolies, an upstream and a downstream market. In the upstream sector firms produce an intermediate good at marginal cost that is normalized to zero.[2] The upstream firms sell the intermediate good to firms in the downstream market and the downstream firms transform the intermediate good on a one-to-one basis to output at zero costs.[3]

There is free entry in both sectors but all firms that enter in the upstream market must incur a fixed set-up cost of F_u while firms entering in the downstream market must incur a fixed set-up cost F_d. We will determine the number of firms that enter in each sector and denote the number of upstream firms by m and the number of downstream firms by n.

[2]This normalization is without loss of generality and the qualitative results stay unchanged if we assumed constant marginal cost of $c_u > 0$.

[3]Again this normalization is without loss of generality and assuming positive marginal costs of $c_d > 0$ would only increase downstream prices but not alter the qualitative results.

An upstream firm i sells its intermediate good to the downstream firms at a linear price that is denoted by $r_i, i \in (1, ..., m)$.[4] Similarly, a downstream firm j sells the final good to the consumers at the price that we denote by $p_j, j \in (1, ..., n)$.

First, we describe the downstream market. We model the downstream market in a similar way as Salop (1979). There exists a continuum of consumers of mass 1 that is uniformly distributed on a circle with unit circumference. Consumers incur a transportation cost t_d per unit of distance. We assume that the consumers' gross utility of the differentiated good is sufficiently high such that all consumers buy for the range of prices considered. The n downstream firms are equidistantly distributed on the circle with distance $1/n$ between each other. So the marginal consumer between firm j and $j+1$ lies at distance x_m from firm j, with

$$x_m = \frac{1}{2n} + \frac{p_{j+1} - p_j}{2t_d}.$$

When setting its price p_j, firm j does not know from which upstream firms its two neighboring downstream firms buy the intermediate good and so it does not know the prices they face for the input. Since the prices for the intermediate good influence the final good prices, downstream firms that buy from different upstream firms might set different final good prices. Thus, firm j must form expectations about the prices of its rivals and so its expected demand is given by

$$E[D_j] = \frac{1}{n} + \frac{E[p_{j-1}] + E[p_{j+1}] - 2p_j}{2t_d}.$$

We will spell out later how these expectations are formed.[5] Consequently, the expected profit of firm j in the downstream market when buying its input from upstream firm k is given by

$$E[\Pi_j^k(p_j, r_k, p_{j-1}, p_{j+1})] = (p_j - r_k)\left(\frac{1}{n} + \frac{E[p_{j-1}] + E[p_{j+1}] - 2p_j}{2t_d}\right).$$

Now let us turn to the upstream market. Here again, we consider a Salop

[4] For models that look at non linear prices in a vertical relationship, see Hart and Tirole (1990) or the survey by Rey and Tirole (2006).

[5] For models that have this similar structure see e.g. Aghion and Schankerman (2004) or Syverson (2004).

circle on which the upstream firms are located with equal distance $1/m$ from each other. In contrast to the downstream market there is no continuous demand from consumers since only the n downstream firms buy in the upstream market. When buying from upstream firm k a downstream firm j faces per unit cost of r_k for the intermediate good and additionally a fixed cost, that is given by $t_u|x_j - x_k|$, where t_u is the transportation cost in the upstream market and $|x_j - x_k|$ is the distance from the location of firm j to the location of firm k in the upstream market. These costs reflect how well the intermediate goods fit the particular needs of the final good producer. For instance, the characteristics of the intermediate good provided by firm k may not exactly fit the technology of firm j and so firm j must costly reposition its machine or must incur some other fixed cost of changing the input good.[6] Thus, firm j buys from upstream firm k if

$$E[\Pi_j^k(p_j, r_k, p_{j-1}, p_{j+1})] - t_u|x_j - x_k| \geq$$

$$E[\Pi_j^i(p_j, r_i, p_{j-1}, p_{j+1})] - t_u|x_j - x_i| \qquad \forall i \neq k.$$

We assume that at the time when an upstream firm k decides about its price for the intermediate good it does not know the locations of the downstream firms. Instead, its expectation of the location of a downstream firm is uniformly distributed over the whole upstream circle. The advantage of this particular demand specification is that it avoids dealing with discontinuities in demand.[7] As a consequence, the probability that firm k puts on the event that downstream firm j buys its intermediate good is given by[8]

$$q_k = \left(\frac{1}{m} + \frac{2E[\Pi_j^k] - E[\Pi_j^{k-1}] - E[\Pi_j^{k+1}]}{2t_u}\right). \tag{1}$$

We consider the following three stage game. In the first stage a large number of firms can enter either in the upstream or in the downstream market at the re-

[6] One can also imagine that firm k is a producer from abroad and so firm j needs some instructions to correctly handle the input that results in additional costs for firm j.

[7] For an in-depth discussion of that problem, see e.g. Gabszewicz and Thisse (1986).

[8] For the sake of notation, here and in the following we abbreviate $E[\Pi_j^i(p_j, r_i, p_{j-1}, p_{j+1})]$ by $E[\Pi_j^i]$.

spective entry costs F_u or F_d. After entry both upstream and downstream firms are distributed with equal distance in their respective markets. At this point of time, the location of the downstream firms as customers in the upstream market is still uncertain and each downstream firm can be distributed over the whole circle with equal probability. In the second stage upstream firms set their prices r_i. Then downstream firms learn their position in the upstream market and choose their preferred supplier of the intermediate good. In stage three, downstream firms set prices in the downstream sector.

To make the problem interesting we finally assume that the fixed set-up costs are low enough such that in both sectors at least two firms enter. It turns out that this is fulfilled if $F_d < \frac{t_d}{4} - \frac{t_u}{8}$ and $F_u < \frac{t_u t_d}{t_u + 2t_d}$.

3 Solution to the Model

In this section we solve for the equilibrium upstream and downstream prices and for the number of firms that enter in both markets. We solve the game by backwards induction.

Downstream Market

In stage three, downstream firms consider which prices to set, given the number of firms in each market, n and m and also the upstream prices r_k, $k \in \{1, ..., m\}$, that have been determined in the first two stages. The overall expected profit of a downstream firm j that buys from upstream firm k is given by

$$E[\Pi_j^k(p_j, r_k, p_{j-1}, p_{j+1})] = (p_j - c_k)\left(\frac{1}{n} + \frac{E[p_{j-1}] + E[p_{j+1}] - 2p_j}{2t_d}\right) - t_u|x_j - x_k| - F_d. \tag{2}$$

Firm j does not observe where its two neighboring firms $j-1$ and $j+1$ buy its input and has to form expectation about their input prices because different input prices may lead to different output prices. Since downstream firms are otherwise symmetric different input prices would be the only reason why their output prices might differ. Downstream firm j does not know the location of its rivals in the upstream market and so the probability that it places on the event that downstream firm $j-1$ or $j+1$ buys from upstream firm i is given by q_i. As a consequence, the expectation of firm j for $E[p_{j-1}]$ and $E[p_{j+1}]$ is the same and is

$$E[p_{j-1}] = E[p_{j+1}] = E[p_{-j}] = \sum_{k=1}^{m} q_k p_{-j}^k,$$

where p_{-j}^k is the price of firm $-j$ when it buys from upstream firm k. Now maximizing (2) with respect to p_j for all $j \in \{1, ..., n\}$ and solving yields a general formula for the price of downstream firm j when it buys from upstream firm i, that is given by

$$p_j^i = \frac{t_d}{n} + \frac{1}{4t_u}\left(\sum_{k=1}^{m} \Pi_j^k (2r_k - r_{k-1} - r_{k+1})\right) + \frac{1}{2m}\sum_{k=1}^{m} r_k + \frac{r_i}{2t_u}.$$

These downstream prices are still dependent on the profit Π_j^k. Plugging these prices into the profit function of a downstream firm gives its profit dependent on r_i and q_i, $i \in \{1, ..., m\}$. Since the probabilities q_i, $i \in \{1, ..., m\}$ are solely functions of the downstream profit, one can solve for these probabilities. Routine but tedious calculation show that they are given by

$$q_i^j = \left(\frac{1}{\sum\limits_{k=1}^{m} r_k(r_k - r_{k+1})t_u t_d n}\right)$$

$$\left(\frac{2n}{m}t_u^2 t_d^2 + n t_u t_d^2 (c_{i-1} + c_{i+1} - 2c_i) - \frac{1}{m} t_u t_d n \left(\sum_{k=1, j\neq i}^{m} r_k - (m-1)r_i\right) + \right.$$

$$+ \frac{n}{4}\left(\sum_{k=1, j\neq i}^{m} r_k^3 - r_i^3\right) + \frac{3n}{8} r_i^2 (r_{i+1} + r_{i-1}) - \frac{5n}{8} r_i (r_{i+1}^2 + r_{i-1}^2) \frac{n}{2} r_i \sum_{k=i+1}^{i-1} r_k r_{k+1} -$$

$$\left. - \frac{n}{8} r_{i+1}^2 r_{i+2} - \frac{n}{8} r_{i-1}^2 r_{i-2} - \sum_{k=i+2}^{i-2} n r_k^2 \left(\frac{1}{2} r_i - \frac{1}{8} r_{k+1} - \frac{1}{8} r_{k+1}\right)\right). \qquad (3)$$

Here, e.g. $\sum\limits_{k=i+2}^{i-2}$ means that if for example $i = 5$, the sum goes from $k = 7, 8, ..., m$ and then continues with $k = 1$ and ends at $k = 3$. If e.g. $m = 3$ then this sum does not exist and is equal to zero.

Plugging these probabilities back into the profit functions yield a general formula for the quantity that downstream firm j buys from upstream firm i which is

$$x_i^j = \left(\frac{1}{t_d n \sum\limits_{k=1}^{m} r_k(r_k - r_{k+1}) + 2t_u t_d}\right)$$

$$\left(2t_u t_d^2 + \frac{1}{m} t_u t_d n \left(\sum_{k=1, j\neq i}^{m} r_k - (m-1) r_i\right) + \frac{n}{4}\left(\sum_{k=1,j\neq i}^{m} r_k^3 - r_i^3\right) + \right.$$

$$+ \frac{3n}{8} r_i^2 (r_{i+1} + r_{i-1}) - \frac{5n}{8} r_i (r_{i+1}^2 + r_{i-1}^2) + \frac{n}{2} r_i \sum_{k=i+1}^{i-1} r_k r_{k+1} -$$

$$\left. - \frac{n}{8} r_{i+1}^2 r_{i+2} - \frac{n}{8} r_{i-1}^2 r_{i-2} - \sum_{k=i+2}^{i-2} n r_k^2 \left(\frac{1}{2} r_i - \frac{1}{8} r_{k+1} - \frac{1}{8} r_{k+1}\right)\right). \tag{4}$$

Inserting the profit functions back into the the pricing formula gives a general formula for the downstream prices dependent on the upstream prices

$$p_j^i = \left(\frac{1}{\sum\limits_{k=1}^{m} r_k(r_k - r_{k+1}) + 2t_u t_d}\right)$$

$$\left[\frac{2t_u t_d^2}{n} + \frac{1}{4}\sum_{k=1}^{m} r_k^3 + \frac{1}{2} r_i^3 + \frac{t_u t_d}{m} \sum_{k=1}^{m} r_k + r_i t_u t_d - \frac{1}{2} r_i \Big(\sum_{k=i+1}^{i-2} r_k r_{k+1}\Big) - \frac{5}{8} r_i^2 (r_{i+1} + r_{i-1}) + \right.$$

$$\left. + \frac{1}{8} r_{i+1}^2 (3r_i + r_{i+2}) + \frac{1}{8} r_{i-1}^2 (3r_i - r_{i-2}) + \frac{1}{4} \sum_{k=i+2}^{i-2} r_k^2 (2r_i - r_{k-1} - r_{k+1})\right]. \tag{5}$$

Having now solved for the downstream prices we proceed to the second stage, where prices are determined on the upstream market.

Upstream market

The profit of an upstream firm i is its price r_i times the quantity that it sells to any of its buyers x_i times the probability that it sells to any of the downstream firms. This can be written as

$$E[P_i](r_i, r_{i-1}, r_{i+1}) = r_i x_i(r_i, r_{-i}) \left(\binom{n}{1} q_i (1-q_i)^{n-1} + 2 \binom{n}{2} q_i^2 (1-q_i)^{n-2} + \right. \tag{6}$$

$$+\cdots+(n-1)\binom{n}{n-1}q_i^{n-1}(1-q_i)+nq_i^n\Bigg)-F_u.$$

The intuition behind this equation is probably easiest to grasp when considering the case $n=2$. In this case there is a probability that no downstream firm buys from upstream firm i which is given by $(1-q_i)^2$. The probability that exactly one firm buys is given by $2q_i(1-q_i)$ and lastly the probability that both downstream firms buy is given by q_i^2. In this last case firm i sells two times x_i. Extending this line of reasoning to the n firm case yields the last term of the right hand side of (6). Rearranging terms gives

$$E[P_i](r_i,r_{i-1},r_{i+1})=r_ix_i(r_i,r_{-i})\left(\sum_{j=1}^{n}\binom{n}{j}jq_i^j(1-q_i)^{n-j}\right)-F_u.$$

We may use a modification of the Binomial Theorem[9] to rewrite the profit function as

$$E[P_i](r_i,r_{i-1},r_{i+1})=r_ix_i(r_i,r_{-i})nq_i\Bigg(q_i+(1-q_i)\Bigg)^{n-1}=r_ix_i(r_i,r_{-i})nq_i-F_u. \quad (7)$$

We now can substitute (3) and (4) in the last equation. Maximizing the profit function for all upstream firms $i\in\{1,...,m\}$ with respect to r_i gives the reaction functions of firm i dependent on r_{i-1} and r_{i+1}. Solving them for the upstream prices gives after cumbersome but routine manipulations the symmetric equilibrium upstream prices. They are remarkably simple and are given by

$$r^\star=\frac{t_ut_dn}{\sum_{j=2}^{m}\frac{t_un^2}{2j(j-1)}+mt_d}=\frac{2t_ut_dmn}{t_un^2(m-1)+2m^2t_d}. \quad (8)$$

The equilibrium upstream prices can now be inserted into the formula for the downstream prices to get

$$p^\star=\frac{t_d\left(mt_d+t_un^2\left(1+\sum_{j=2}^{m}\frac{1}{2j(j-1)}\right)\right)}{n\left(mt_d+t_un^2\left(\sum_{j=2}^{m}\frac{1}{2j(j-1)}\right)\right)}=\frac{t_d(2m^2t_d+t_un^2(3m-1))}{n(2m^2t_d+t_un^2(m-1))}. \quad (9)$$

[9]Recall that the Binomial Theorem says that $\sum_{j=0}^{n}\binom{n}{j}(z)^j(y)^{n-j}=(y+z)^n$.

Having solved for the equilibrium prices in both stages we can now proceed to the first stage and determine the equilibrium number of firms in both markets.

Entry Decision

Inserting the equilibrium prices in the profit functions yields that the expected profit of a downstream firm j is given by $E[\Pi_j] = \frac{t_d}{n^2} - \frac{t_u}{4m} - F_d$ and the expected profit of an upstream firm i is $E[P_i] = \frac{c^\star}{m} - F_u = \frac{2t_u t_d n}{t_u n^2(m-1)+2m^2 t_d} - F_u$. As a consequence, the equilibrium number of firms, $n^\star$ and $m^\star$, are the integers that simultaneously solve the two inequalties[10]

$$\frac{t_d}{(n^\star)^2} - \frac{t_u}{4m^\star} - F_d \geq 0 \tag{10}$$

and

$$\frac{2t_u t_d n^\star}{t_u(n^\star)^2(m^\star - 1) + 2(m^\star)^2 t_d} - F_u \geq 0. \tag{11}$$

The question is if this equilibrium exists and if it is unique. Given our assumptions on F_d and F_u above it is always optimal for at least two firms to enter in each market if there are also two firms in the other market. Thus we can be sure that there will always be an equilibrium in which at least two firms are active in both markets. It remains to show uniqueness of the equilibrium. To this end we first determine the iso-profit-lines of a downstream and an upstream firm, such that profits are equal to zero. For a downstream firm it is given by

$$\frac{\partial n^\star}{\partial m^\star} = \frac{t_u(n^\star)^3}{4t_u(m^\star)^2} > 0, \tag{12}$$

while for an upstream firm it is given by

$$\frac{\partial n^\star}{\partial m^\star} = \frac{n^\star(t_u(n^\star)^2 + 4t_d m^\star)}{(n^\star)^2(m-1) - 2(m^\star)^2 t_d}. \tag{13}$$

The sign of (13) is ambiguous and depends on $n^\star$. If $n^\star \geq \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star - 1)}}$ the right hand side of (13) is negative while it is positive if the reverse holds true. Thus, multi-

[10]In The following we will ignore the integer problem for the sake of exposition

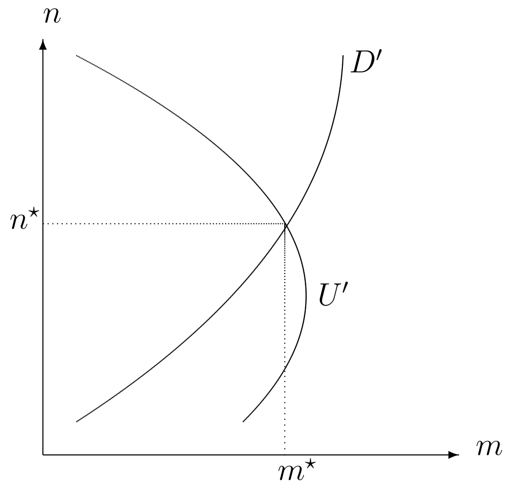

Figure 1: Equilibrium number of firms, $n^\star$ and $m^\star$

ple equilibria can only exist if the two functions cross more than once. But from the above this can happen only if the slope of the iso-profit-line of a downstream firm is steeper than the one of an upstream firm in the region in which the latter increases. But it is easy to show that this can never be the case for $n^\star < \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$. Thus, the equilibrium is unique. Figure 1 displays the equilibrium where D' is the iso-profit-line of a downstream firm and U' the iso-profit-line of an upstream firm.

Thus we have shown the following result.

Proposition 1

In the unique subgame perfect equilibrium of the three stage game the number of entering upstream and downstream firms, $n^\star$ and $m^\star$, is implicitly defined by

$$\frac{t_d}{(n^\star)^2} - \frac{t_u}{4m^\star} = F_d$$

and

$$\frac{2t_u t_d n^\star}{t_u(n^\star)^2(m^\star - 1) + 2(m^\star)^2 t_d} = F_u.$$

Upstream firms charge a price of

$$r^\star = \frac{2t_u t_d m^\star n^\star}{t_u(n^\star)^2(m^\star - 1) + 2(m^\star)^2 t_d},$$

while downstream firms charge a price of

$$p^\star = \frac{t_d(2(m^\star)^2 t_d + t_u(n^\star)^2(3m^\star - 1))}{n^\star(2(m^\star)^2 t_d + t_u(n^\star)^2(m^\star - 1))}.$$

One can observe from the equilibrium prices that the degree of downstream competition enters the equilibrium upstream price in almost the same way as the degree of upstream competition. This shows that downstream competition also confines the upstream prices. On the other hand, the opposite is not true. So even if upstream prices are close to marginal cost downstream prices might be above marginal costs if the degree of competition is low there.

4 Interplay between Upstream and Downstream Market

4.1 Comparative Statics on Entry Costs and Transportation Costs

In this section we analyze the interplay between upstream and downstream market. We are especially interested in how the number of firms and the degree of competition (expressed via the transportation costs) in one market affects the other market. We start by considering the number of firms. This number is endogenous in our model and is determined by the magnitude of the set-up costs. So we first analyze how $n^\star$ and $m^\star$ change with F_u and F_d.

Proposition 2

(i) The equilibrium numbers of upstream and downstream firms, $n^\star$ and $m^\star$, are decreasing in F_u.

(ii) The equilibrium number of downstream firms, $n^\star$, is decreasing in F_d while the equilibrium number of upstream firms, $m^\star$, is increasing in F_d if $n^\star \geq \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$ while it is decreasing if $n^\star < \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$.

Proof

We start with proving (i). Differentiating (10) with respect to $m^\star$, F_u and taking into account that $n^\star$ might also vary with F_u gives

$$-2\frac{2t_d t_u n^\star(t_u(n^\star)^2+4m^\star t_d)}{(t_u(n^\star)^2(m-1)+2(m^\star)^2t_d)^2}dm^\star - dF_u - \frac{2t_d t_u((t_u(n^\star)^2(m^\star-1)-2(m^\star)^2t_d)^2)}{(t_u(n^\star)^2(m^\star-1)+2(m^\star)^2t_d)^2}\frac{dn^\star}{dF_u}dF_u = 0.$$

Totally differentiating (11) with respect to $n^\star$, F_u and taking into account that $m^\star$ might also vary with F_u yields

$$-2\frac{t_d}{(n^\star)^3}dn^\star + \frac{t_u}{4(m^\star)^2}\frac{dm^\star}{dF_u}dF_u = 0.$$

Solving the last two equations simultaneously for $\frac{dm^\star}{dF_u}$ and $\frac{dn^\star}{dF_u}$ gives

$$\frac{dm^\star}{dF_u} = -\frac{4(m^\star)^2\Big((n^\star)^4t_u^2(m^\star-1)^2+4t_u(m^\star)^2(n^\star)^2t_d(m^\star-1)+4t_d^2(m^\star)^4\Big)}{t_u n^\star\Big(6t_u t_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m\star-1)t_u^2\Big)} < 0$$

and

$$\frac{dn^\star}{dF_u} = -\frac{(n^\star)^2\Big((n^\star)^4t_u^2(m^\star-1)^2+4t_u(m^\star)^2(n^\star)^2t_d(m^\star-1)+4t_d^2(m^\star)^4\Big)}{2t_d\Big(6t_u t_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m\star-1)t_u^2\Big)} < 0,$$

where the last inequality sign follows from the fact that $m^\star > 2$.

Now we turn to case (ii). Proceeding in the same way as above, namely totally differentiating (10) and (11) and solving the resulting equations simultaneously gives

$$\frac{dn^\star}{dF_d} = -\frac{4(n^\star)^3(m^\star)^2\Big(t_u(n^\star)^2+4m^\star t_d\Big)}{6t_u t_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m\star-1)t_u^2} < 0$$

and

$$\frac{dm^\star}{dF_d} = \frac{4(m^\star)^2(n^\star)^2\Big(t_u(n^\star)^2(m^\star-1)-2(m^\star)^2t_d\Big)}{6t_u t_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m\star-1)t_u^2}.$$

It is obvious that $\frac{dm^\star}{dF_d} \geq 0$ if $n^\star \geq \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$ and $\frac{dm^\star}{dF_d} < 0$ if $n^\star < \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$.

q.e.d.

The proposition shows that an increase of the entry costs in the upstream market reduces the number of firms in both markets while the same does not necessarily hold true for an increase in the set-up costs in the downstream market. The first result is very intuitive. If upstream entry costs increase the number of upstream firm decreases in equilibrium. Thus downstream firms in expectation face a larger travel distance to their nearest upstream firm and so face higher costs. This also results in smaller number of downstream firms.

The second result deserves more explanation. That the number of downstream firms decreases if the entry costs in the downstream market increase is obvious. But this decrease now has two effects on the profit of an upstream firm. Since there is a smaller number of downstream firms competition in the downstream market is less fierce. Thus a downstream firm's demand would be reduced by a smaller amount if its input supplier would charge a slightly higher price than the input supplier of its neighboring downstream firms. This induces a positive effect on upstream prices and also on upstream profits. On the other hand, if there are less downstream firms there is also a negative effect on upstream prices. The reason is that demand elasticity of an upstream firm increases. With a small number of downstream firms each of these firms has a relatively high market share and so buys a relatively large number of input goods. Thus, if an upstream firm increases its price it runs the risk of losing a buyer with a large demand in contrast to the case with a high number of downstream firms in which demand reduction would be small. This induces downward pressure on upstream prices. The proposition shows that the first effect is dominating if $n^\star$ is large because in this case competition in the downstream market would become fiercer and fiercer if F_d decreases while the demand elasticity effect is small. The opposite is true if $n^\star$ is small. In this case if F_d decreases demand elasticity is reduced by a relatively larger amount compared to the case if $n^\star$ is high.

We now turn to the case of differing degrees of competition. Here we get the following result:

Proposition 3

(i) The equilibrium number of upstream and downstream firms, $n^\star$ and $m^\star$, are both increasing in t_d .

(ii) The equilibrium number of upstream firms $m^\star$ is increasing in t_u while the equilibrium number of downstream firms $n^\star$ is decreasing in t_u.

Proof

The proof proceeds by similar lines as the proof of Proposition 2. First we start with analyzing the effect of t_d. Differentiating (10) with respect to $m^\star$ and t_d gives

$$-2\frac{2t_d t_u n^\star(t_u(n^\star)^2+4m^\star t_d)}{(t_u(n^\star)^2(m-1)+2(m^\star)^2t_d)^2}dm^\star+\frac{2t_u^2(n^\star)^3(m^\star-1)}{(t_u(n^\star)^2(m^\star-1)+2(m^\star)^2t_d)^2}dt_d-$$

$$-\frac{2t_d t_u((t_u(n^\star)^2(m^\star-1)-2(m^\star)^2t_d)^2)}{(t_u(n^\star)^2(m^\star-1)+2(m^\star)^2t_d)^2}\frac{dn^\star}{dt_d}dt_d=0,$$

while differentiating (11) with respect to $n^\star$ and t_d gives

$$-2\frac{t_d}{(n^\star)^3}dn+\frac{1}{(n^\star)^2}dt_d+\frac{t_u}{4(m^\star)^2}\frac{dm^\star}{dt_d}dt_d=0.$$

Solving the last two equations for $\frac{dn^\star}{dt_d}$ and $\frac{dm^\star}{dt_d}$ gives

$$\frac{dn^\star}{dt_d}=\frac{n^\star\Big((n^\star)^4t_u^2(m^\star-1)+4(m^\star)^2t_d(4m^\star t_d+(n^\star)^2t_u)\Big)}{t_d\Big((n^\star)^4t_u^2(m^\star-1)+(m^\star)^2t_d(4m^\star t_d-(n^\star)^2t_u)\Big)}>0$$

and

$$\frac{dm^\star}{dt_d}=\frac{(m^\star)^2\Big(8t_d(m^\star)^2-3t_u(n^\star)^2(m^\star-1)\Big)}{(n^\star)^4t_u^2(m^\star-1)+(m^\star)^2t_d(4m^\star t_d-(n^\star)^2t_u)}.$$

It is easy to show that the right hand side of the last equation is always bigger than zero at the equilibrium values $m^\star$ and $n^\star$ defined by (10) and (11).

Now we turn to the analysis of t_u. Proceeding in the same way as above, namely differentiating (10) and (11) gives

$$\frac{dn^\star}{dt_u}=-\frac{(n^\star)^3m^\star\Big((n^{star})^2t_u+2m^\star t_d\Big)}{6t_ut_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m^\star-1)t_u^2}<0$$

and

$$\frac{dm^\star}{dt_u}=\frac{m^\star\Big((n^\star)^4t_u^2(m^\star-1)+2(m^\star)^2t_d(8m^\star t_d-t_u(n^\star)^2)\Big)}{t_u\Big(6t_ut_d(n^\star)^2(m^\star)^2+32t_d^2(m^\star)^3+(n^\star)^4(m^\star-1)t_u^2\Big)}>0.$$

q.e.d.

This shows that a smaller degree of competition in the downstream market increases the number of firms in both markets. The intuition behind this result is the following. First look at the degree of competition in the downstream market. It is very intuitive that if t_d increases that also the equilibrium number of downstream firms increases. But with an increasing t_d also upstream prices increase as can be seen from (8). The reason is that an upstream firm that charges a higher price does not lose so much demand as with a low t_d. This is because the disadvantage for a downstream firm that buys from this upstream firm is less severe since the degree of competition in the downstream market is smaller. Since this effect holds for all upstream firms, upstream prices and therefore upstream profits are higher and this leads to further entry in the upstream market. This again reinforces entry in the downstream market leading overall to a higher number of firms in both markets.

On the other hand, the smaller the degree of competition in the upstream market the bigger is the number of upstream firms but the smaller is the number of downstream firms. These results are very intuitive. If competition in the upstream market becomes less fierce higher profits can be reaped in the upstream market and so more firms enter. But if t_u increases the cost of a downstream firm increases because the transportation costs increase. This effect is partly offset by the increase in upstream firms that reduces the travel distance. But the direct effect of increased transportation costs always dominates and so fewer downstream firms enter the market.

This shows that the degree of competition in the downstream market affects the number of firms in both markets in the same direction while the opposite holds true for the degree of competition in the upstream market. The reason is that the level of downstream competition crosses over from the downstream market to the upstream market and enters the pricing formula of upstream firms positively. Conversely, the level of upstream competition enters the cost function of downstream firms and so reduces their profits.

4.2 Comparison with the Single Market Model

Economic models very often do only analyze the downstream market, in which the final products are sold to consumers, completely ignoring the upstream market. So it therefore of interest how large the mistake is that one makes when ignoring the upstream market. This is characterized in the next Proposition.

Proposition 4

(i) The magnitude of $\frac{dn^\star}{dt_d}$ is always undervalued when one ignores the upstream market.

(ii) The magnitude of $\frac{dn^\star}{dF_d}$ can either be over- or undervalued when one ignores the upstream market. It is undervalued if $n^\star < \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$ while it is overvalued if $n^\star \geq \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$.

Proof

Considering a standard model of circular competition with symmetric firms and ignoring the upstream market yields the standard formula that all downstream firms charge an equilibrium price of $p^j = c^j + \frac{t_d}{n^\star}$, where c^j are the marginal costs that downstream firm j faces. Thus, each firm receives a demand of $x^j = \frac{1}{n^+}$, where n^+ is the equilibrium number of firms. The equilibrium profit of a downstream firm is given by $\Pi^j = \frac{t_d}{(n^+)^2} - F_d$ and number of firms is given by $\frac{t_d}{(n^+)^2} - F_d = 0$. Thus the change in the equilibrium number of firms when t_d and F_d vary is given by

$$\frac{dn^+}{dt_d} = \frac{n^+}{2t_d} > 0 \tag{14}$$

and

$$\frac{dn^+}{dF_d} = -\frac{(n^+)^3}{2t_d} < 0. \tag{15}$$

To evaluate, if ignoring the upstream market under- or overestimates the magnitude of $\frac{dn^\star}{dt_d}$, we have to start from the same equilibrium number of downstream firms, so $n^\star = n^+ = n$. Now comparing (14) with $\frac{dn^\star}{dt_d}$ reveals that the latter one is bigger if

$$\frac{n\Big(n^4t_u^2(m^\star-1) + 4(m^\star)^2t_d(4m^\star t_d + n^2t_u)\Big)}{t_d\Big(n^4t_u^2(m^\star-1) + (m^\star)^2t_d(4m^\star t_d - n^2t_u)\Big)} > \frac{n}{2t_d}$$

or

$$\frac{n\Big(n^4t_u^2(m^\star-1) + (m^\star)^2t_d(28m^\star t_d + 9n^2t_u)\Big)}{2t_d\Big(n^4t_u^2(m^\star-1) + (m^\star)^2t_d(4m^\star t_d - n^2t_u)\Big)} > 0. \tag{16}$$

Since both the numerator and the denominator are positive this always holds true and so ignoring the upstream market underestimates the magnitude of $\frac{dn^\star}{dt_d}$.

Proceeding in the same way and comparing (15) with $\frac{dn^\star}{dF_d}$ yields that $\frac{dn^\star}{dF_d}$ is of larger magnitude than $\frac{dn^+}{dF_d}$ when starting from the point $n^\star = n^+ = n$ if and only if $n^\star < \sqrt{\frac{2t_d(m^\star)^2}{t_u(m^\star-1)}}$.

q.e.d.

The first result shows that the effects of a changing degree of competition is always underestimated when one ignores the downstream market. The intuition is easy to grasp from Proposition 3. Since the degree of competition in the downstream market also affects upstream prices and profits it changes the number of upstream firms. If downstream competition becomes fiercer this crosses over to the upstream market in which fewer firms enter. This in turn increases the transportation costs for downstream firms and reinforces the effect of a lower entry.

Our second result shows that the effect of varying downstream entry costs can be over- or underestimated when ignoring the downstream market. It is underestimated when we are in the increasing part of the U'-curve in Figure 1 because here the change in $m^\star$ goes in the same direction as the change in $n^\star$ and so reinforces the latter.

Concerning the first result of the last proposition an interesting exploration is under which conditions the underestimate is especially high. The answer is given in the following Corollary.

Corollary 1

The magnitude of the underestimation of $\frac{dn^\star}{dt_d}$ is increasing in t_u and decreasing in t_d and $m^\star$.

Proof

The magnitude of this underestimation is given by (16). Now differentiating (16) with respect to $m^\star$ yields

$$-\frac{n^3 m^\star t_u\Big(32(m^\star)^3 t_d^2 - 12n^2 m^\star t_u t_d(2m^\star - 3) - 5n^4 t_u^2(m^\star - 2)\Big)}{\Big(n^4 t_u^2(m^\star - 1) + (m^\star)^2 t_d(4m^\star t_d - n^2 t_u)\Big)^2} < 0,$$

while differentiating (16) with respect to t_u yields

$$-\frac{n^3(m^\star)^2\Big(32(m^\star)^3t_d^2-(24n^2m^\star t_u t_d+5n^4t_u^2)(m^\star-1)\Big)}{\Big(n^4t_u^2(m^\star-1)+(m^\star)^2t_d(4m^\star t_d-n^2t_u)\Big)^2}>0.$$

Lastly, differentiating (16) with respect to t_d yields

$$-\frac{n\Big(n^8t_u^4(m^\star-1)+8n^5t_d^3(9n^2+14m^\star t_d)-2n^6(m^\star)^2t_u^3t_d(m^\star-1)-n^4(m^\star)^3t_u^2t_d^2(25m^\star-16)\Big)}{2t_d^2\Big(n^4t_u^2(m^\star-1)+(m^\star)^2t_d(4m^\star t_d-n^2t_u)\Big)^2}<0.$$

The respective inequality signs follow when evaluating the three expressions at the equilibrium values $n^\star$ and $m^\star$.

q.e.d.

The result with respect to m^{star} and t_u is an intuitive one. If competition in the upstream market is low, which means that either m^{star} is small or that t_u is high, the upstream market matters a lot for the competitive conditions in the downstream market. Thus, the mistake that one makes in this case when ignoring the upstream market is big. On the other hand, this mistake is also big when the degree of downstream competition is high which means a small t_d. The reason is that since competition is fierce small changes in the upstream prices can have large effects on the downstream market. To the contrary if t_d is high the mistake of ignoring the upstream market would be small since the equilibrium number of downstream firms is mainly determined by t_d and not by the upstream market conditions.

Summing up this section has shown that there is generally a problem when one only looks at the downstream markets ignoring previous layers in the production chain. Especially the result concerning the degree of downstream competition may provide a warning to policy makers who want to induce fiercer competition in the downstream market. It shows that such a policy can easily lead to overshooting since the effect on entry is usually reinforced via the upstream market.

5 Welfare Analysis

In this section we analyze if the equilibrium number of firms that enter in both markets is socially optimal. It is well known from the papers by Salop (1979) and especially Mankiw and Whinston (1986) that in models of horizontal differentiation too many firms enter because a single firm does not take into account that it steals demand from its rivals. The question if still holds in a market in which the vertical structure is explicitly modelled. A recent paper by Ghosh and Morita (2006) casts doubt on that. In their model firm s produce homogeneous products and compete in quantities in both stages.[11] They show that there might be insufficient entry in the upstream market because an entering firm cannot reap the full gain from entering since a downstream firm also makes some profits. We show that this is no longer true in our model.

The welfare function is given by

$$\min_{n,m} nF_d + mF_u + t_d\Big(2n\int_0^{\frac{1}{2n}} xdx\Big) + t_u n\Big(2m\int_0^{\frac{1}{2m}} xdx\Big) = \tag{17}$$

$$\min_{n,m} nF_d + mF_u + \frac{t_d}{4n} + \frac{nt_u}{4m}$$

Here the first and the second term are the fixed set-up cots while the third and the fourth term are the transportation costs in both markets. Form the first order condition we get that the socially optimal number of firms $\hat{n}$ and $\hat{m}$ are implicitly given by the the following two equations,

$$F_d = \frac{t_d}{4\hat{n}^2} - \frac{t_u}{4\hat{m}} \tag{18}$$

and

$$F_u = \frac{\hat{n}t_u}{4\hat{m}^2}. \tag{19}$$

Recall that the equilibrium number of firm is given by $F_d = \frac{t_d}{(n^\star)^2} - \frac{t_u}{4m^\star}$ and $F_u = \frac{2t_u t_d n^\star}{t_u(n^\star)^2(m^\star-1)+2(m^\star)^2 t_d}$. In the following Proposition we compare the two values.

[11] For a model that is concerned with welfare implications and analyzes price competition in the downstream market but a monopolistic supplier in the upstream market, see Kuhn and Vives (

Proposition 5 The socially optimal number of firms in both markets is smaller than the equilibrium number of firms, $\hat{m} < m^\star$ and $\hat{n} < n^\star$.

Proof

We first show that $\hat{m} < m^\star$. The proof proceeds by way of contradiction. Solving (18) for the socially optimal number of downstream firms dependent on the number of upstream firms gives $\hat{n} = \sqrt{\frac{\hat{m}t_d}{4\hat{m}F_d+t_u}}$. Inserting this in (19) yields

$$F_u = \frac{t_u}{4\hat{m}^2}\sqrt{\frac{\hat{m}t_d}{4\hat{m}F_d + t_u}}.$$

Proceeding in the same way for the equilibrium number of firms reveals that $n^\star$ is given by $n^\star = 2\sqrt{\frac{m^\star t_d}{4m^\star F_d+t_u}}$, and that $m^\star$ is implicitly defined by

$$F_u = \frac{4t_u\sqrt{\frac{m^\star t_d}{4m^\star F_d+t_u}}(4m^\star F_d + t_u)}{m^\star(4t_u(m^\star - 1) + 2t_u m^\star + 8(m^\star)^2 F_d)}.$$

Now suppose that would be $\hat{m} = m^\star = m$. If this is the case the profits of an upstream firm in equilibrium and under social efficiency must be the same,

$$\frac{4t_u\sqrt{\frac{mt_d}{4mF_d+t_u}}(4mF_d + t_u)}{m(4t_u(m-1) + 2t_u m^\star + 8m^2 F_d)} = \frac{t_u}{4m^2}\sqrt{\frac{mt_d}{4mF_d + t_u}}. \tag{20}$$

Routine manipulations of (20) shows that this can only be the case if

$$56m^2F_d + 10mt_u + 4t_u = 0.$$

But since $m \geq 2$ and $F_d, t_u > 0$ this is a contradiction. This shows that the left hand side of (20) is always bigger than the right hand side. As a consequence the equilibrium profit of an upstream firm is always bigger than its profit under social efficiency and so in equilibrium too many upstream firms enter the market.

Now we show that $\hat{n} < n^\star$. Solving (19) for $\hat{m}$ gives $\hat{m} = \frac{1}{2}\sqrt{\frac{\hat{n}t_u}{F_d}}$. Inserting this into (18) reveals that $\hat{n}$ is implicitly defined by

$$F_d = \frac{t_u}{4\hat{n}^2} - \frac{t_u F_u}{2\sqrt{F_u t_u \hat{n}}}.$$

Proceeding in the the same way for the equilibrium number of firms shows that $m^\star$ is given by

$$m^\star = \frac{\sqrt{F_u t_u n^\star (F_u t_u (n^\star)^3 + 8 F_u t_d n^\star + 16 t_d^2)} - F_u t_u (n^\star)^2}{4 F_u t_d}.$$

Thus, $n^\star$ is implicitly defined by

$$F_d = \frac{td}{(n^\star)^2} - \frac{F_u t_d t_u}{\sqrt{F_u t_u n^\star}\sqrt{F_u t_u (n^\star)^3 + 8 F_u t_d n^\star + 16 t_d^2} - F_u t_u (n^\star)^2}.$$

As before suppose that $\hat{n} = n^\star = n$. This could only be true if the profit of a downstream firm in equilibrium and under social efficiency would be the same, namely if

$$\frac{t_u}{4n^2} - \frac{t_u F_u}{2\sqrt{F_u t_u n}} = \frac{td}{(n)^2} - \frac{F_u t_d t_u}{\sqrt{F_u t_u n}\sqrt{F_u t_u n^3 + 8 F_u t_d n + 16 t_d^2} - F_u t_u n^2}. \tag{21}$$

But it is obvious that the first term of the right hand side of (21) is bigger than the first term of the left hand side. Moreover, subtracting the second term of the left hand side from the second term of the right hand side gives

$$\frac{F_u t_d t_u}{\sqrt{F_u t_u n}\sqrt{F_u t_u n^3 + 8 F_u t_d n + 16 t_d^2} - F_u t_u n^2} - \frac{t_u F_u}{2\sqrt{F_u t_u n}} =$$

$$= \frac{F_u t_u \Big(F_u t_u n^2 + 2 t_d \sqrt{F_u t_u n} - \sqrt{F_u t_u n (F_u t_u n^3 + 16 t_d^2 + 8 F_u t_d n)} \Big)}{2\sqrt{F_u t_u n} \Big(\sqrt{F_u t_u n (F_u t_u n^3 + 8 F_u t_d n + 16 t_d^2)} - F_u t_u n^2 \Big)} < 0.$$

As a consequence the left hand side of (21) is always bigger than the right hand side and therefore $\hat{n} < n^\star$.

q.e.d.

This result shows that the well-known intuition that too many firm enter because of the business stealing effect is confirmed even if one considers explicitly the vertical relationships in a market. It also points out that the recent result of Ghosh and Morita (2006) is not a general one and does not hold for any kind of model about successive oligopolies. The mode of competition (prices or quantities) and the exact structure of vertical relationships is equally important for the result.

6 Conclusion

In this paper we have provided a model of successive vertical oligopolies that allows for endogenous entry and varying degrees of competition in the upstream and in the downstream market stage. We have shown that there exists a unique equilibrium two tier market structure. Furthermore, we have shown that upstream and downstream markets affect each other asymmetrically and that the overall market outcome is dominated by the competitive conditions on the downstream market. Finally, we found that the consequences of varying degrees of competition on firm entry in the downstream market are underestimated when one ignores the upstream market. The more different the competitive environment in upstream and downstream market, the larger is this underestimation effect.

In the light of these results, an interesting question to ask is how production processes evolve, i.e. what determines which market is upstream, which is downstream. While in most manufacturing processes there seems to be a natural order of production stages this does not necessarily predetermine who is buying inputs from whom. The results of our paper suggest that this organizational issues matter for the overall market outcome.

Throughout the paper we have restricted attention to analyzing the two tier market structure of an upstream and a downstream market. In principle, the model could be extended to a multi-layer market structure. There is no reason to expect that the results would change dramatically if one allowed for more stages of production.

A natural extension of the model would be to allow for vertical mergers. Along the lines of the present paper, interesting questions to ask would be how the endogenous two tier market structure evolves if vertical mergers are allowed. Furthermore, it would be interesting to investigate to what extent the welfare implications of vertical mergers depend on the upstream and the downstream market conditions. Given the asymmetric nature of firm competition in case of vertical mergers, such an analysis becomes considerably more intricate and must be left for future research.

References

- M. Abiru, B. Nahata, S. Raychaudhuri, and M. Waterson (1998): "Equilibrium Structure in Vertical Oligopoly,"*Journal of Economic Behavior and Organization* , 72, 463-480.

- P. Aghion and M. Schankerman (2004): "On the Welfare Effects and Political Economy of Competition-Enhancing Policies,"*Economic Journal* , 114, 800-834.

- P. Belleflamme and E. Toulemonde (2003): "Product Differentiation in Vertical Successive Oligopolies "*Canadian Journal of Economics* , 36, 523-545.

- Y. Chen (2001): "On Vertical Mergers and their Competitive Effects,"*RAND Journal of Economics*, 32 , 667-685.

- J.J. Gabszewicz, and J.-F. Thisse (1986): "Spatial Competition and the Location of Firms,"in: *Location Theory*, ed.: R. Arnott, London: Harwood Academic Press.

- G. Gaudet and N. van Long (1996): "Vertical Integration, Foreclosure, and Profit in the Presence of Double Marginalization,"*Journal of Economics and Management Strategy*, 5 , 409-432.

- A. Ghosh and H. Morita (2006): "Free Entry and Social Efficiency under Vertical Oligopoly,"*RAND Journal of Economics*, forthcoming.

- M.K. Greenhut and H. Ohta (1979): "Vertical Integration in Successive Oligopolies,"*American Economic Review*, 69, 137-141.

- O. Hart and J. Tirole (1990): "Vertical Integration and Market Foreclosure,"*Brookings Papers on Economic Activity: Microeconomics*, 205-276.

- K.-U. Kuhn and X. Vives (1999): "Excess Entry, Vertical Integration, and Welfare,"*RAND Journal of Economics*, 30, 575-603.

- N.G. Mankiw and M.D. Whinston (1986): "Free Entry and Social Efficiency,"*RAND Journal of Economics*, 17, 48-58.

- J.A. Ordover, G Saloner, and S.C. Salop (1990): “Equilibrium Vertical Foreclosure,”*American Economic Review*, 17, 48-58.

- P. Rey and J. Tirole (2006): “A Primer on Foreclosure,”forthcoming in: *Handbook of Industrial Organization, Vol. 3*, eds.: M. Armstrong and R.H. Porter, North Holland, Amsterdam.

- M.A. Salinger (1988): “Vertical Merger and Market Foreclosure,”*Quarterly Journal of Economics*, 103, 345-356.

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

- C. Syverson (2004): “Market Structure and Productivity: A Concrete Example,”*Journal of Political Economy*, 112, 1181-1222.