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Diskussionsbeiträge

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Electronic Coordination in Oligopolistic Markets: Impact on Transport Costs and Product Differentiation

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Abstract

Electronic coordination links markets at different locations that have initially been (partially) separated by transport costs. Rising competitive pressure should in turn affect incentives to differentiate products. In this paper investment decisions concerning transport cost reduction and product differentiation are analyzed in a heterogenous product duopoly where firms compete in two spatially separated markets. We show that firms always have non–negative incentives to invest in transport cost reduction, while there exist parameter ranges where product differentiation will actually be reduced after an exogenous reduction of transport cost. We also compare social and privat investment incentives for both price strategies (most likely with digital products) and quantity competition (capacity decisions for physical products). Based on these results we discuss in detail how investment decisions are likely to differ from the efficient solution for each of the two kind of products.

Key words: Electronic markets, Strategic investments, Transport costs, Product differentiation

Durch elektronische Koordination wachsen räumlich getrennte Märkte zusammen, die bislang nur unvollständig ökonomisch integriert waren. Der daraus resultierende verstärkte Wettbewerbsdruck sollte die Anreize der Unternehmen zur Produktdifferenzierung eigentlich erhöhen. Wir analysieren die Interaktion der Investitionsentscheidungen in transportkostensenkende elektronische Koordination und in verstärkte Produktdifferenzierung in einem Duopol mit räumlich getrennten Märkten. Wir zeigen, dass immer ein zumindest schwach positiver Anreiz zur Investition in Transportkostensenkung besteht, während Parameterbereiche existieren in denen die Unternehmen nach einer exogenen Senkung der Transportkosten die Produktdifferenzierung verringern. Des Weiteren vergleichen wir soziale und private Investitionsanreize sowohl bei Preisstrategien (plausibel bei digitalen Gütern) als auch bei Mengenwettbewerb (realistisch als Kapazitätsentscheidung bei physischen Produkten) und diskutieren im Detail, welche Abweichung von der effizienten Entscheidung bei jeder der beiden Produkttypen zu erwarten ist.

Schlagworte: Elektronische Märkte, Strategische Investition, Transportkosten, Produktdifferentierung

JEL–classification: D43, D61, L13

1 Introduction

Markets in different locations that have been at least partially separated by high transport costs may be linked more closely by the possibility of selling products or services via electronic coordination. The point is that distance becomes less important as a determinant of transport and thus total distribution costs. This impact of electronic commerce is most obvious for digital or digitalizable products and services: Think of software which can be directly downloaded and therefore must no longer been shipped to the customer or a local store. However, assuming transport cost reductions may also be reasonable for physical products or for services if a broader definition of transport costs is applied that also includes opportunity costs of customers, which may for example result from the time consuming walk to a local store or bank office. Declining transport costs will affect the incentives of firms to differentiate their products because spatial separation no longer hinders fierce competition. In addition, electronic coordination may yield new ways to differentiate products and thus changes the cost of product differentiation. Think for example of selling notebooks online: While Toshiba as a traditional producers sells a limited number of prespecified notebook types, at Dell's online store the customer can explicitly decide about the combination of components she likes and this customized notebook will be built to order. Considering that usually neither transport cost reductions nor extended product differentiation come for free, the interaction of investment decisions in these two areas must be understood when discussing the impact of electronic coordination in such markets.

The present paper aims at analyzing this interaction in a relatively simple framework that nevertheless highlights the most important stylized facts. We consider two spatially separated duopoly markets, each served by a local firm and, if transport costs are not prohibitive, also by its distant competitor.[1] This means that we do not consider competition between a start-up firm and an incumbent but have in mind a situation where firms have been active, at least in their local market, before the advent of electronic commerce. Think of banks located in different towns, hardware producers in different countries or music labels in Europe vs. the United States. Each of the two firms is assumed to produce a variant of a horizontally differentiated product. For given levels of transport costs and degree of product differentiation firms compete by simultaneously setting prices or quantities, respectively.

We consider both price and quantity strategies mainly because we want to distinguish between two types of products: Physical goods and digital goods. While most markets with physical goods may be appropriately described by an oligopoly model with quantity strategies (this is the case if setting capacities is the most important strategic decision),[2] this approach is not

[1]Extension to an oligopoly with three or more local markets is straightforward as long as transport costs between each pair of local markets are assumed to be identical.

[2]As shown by Kreps/Scheinkman (1983) the Cournot model may be interpreted as the reduced form of a two–stage game where firms decide about capacity at the first stage and set prices in the second stage. See also Güth (1995) who extends the analysis by considering a heterogenous good oligopoly.

adequate for digital goods like software or MP3 music: A digital good may be reproduced almost unlimited at very low marginal costs and thus setting capacities (i. e. quantities) is not likely to be a strategic issue. Digital and physical goods are, however, not only different with respect to strategic variables in the output market: The potential of transport cost reduction is much more limited for physical goods that have still to be shipped to the customer and the necessary investment in logistics should yield much higher investments for a given level of transport cost reduction. It also seems more likely that electronic commerce provides additional potential for product differentiation in the case of digital goods. As will be shown, due to these differences the impact of electronic coordination may be quite distinct for the two types of product

The direct approach to analyzing the problem would be to determine closed form solutions of the two–stage game with simultaneous decisions on investments in both product differentiation and transport cost reduction in the first stage and price or quantity competition in the second stage. However, we decided to use a more indirect way: We first determine derivatives of profit and welfare functions with respect to transport costs and degree of product differentiation. In a second step we apply this information to discuss private investment incentives for all possible initial values of transport costs and product differentiation. Finally we compare private and social incentives by focusing on the differences in the first order conditions of the two problems at the equilibrium values. While we do not obtain explicit solutions, by combining our results with the stylized facts about digital and physical products discussed above, we are able to determine the most likely outcome in any of the two cases. A major advantage of the indirect approach lies in the fact that we need not restrict attention to some specific investment cost functions but must only assume that these functions are sufficiently convex to guarantee interior solutions in the first stage of the game.[3]

Investment incentives in electronic coordination have already been discussed in Bakos (1997) in a model where firms could reduce search costs of their customers by implementing an electronic market. He argued that incentives of all sellers as a group are too low while a single seller might overinvest. However, in his paper a formal analysis of this decision is not performed: He just assumes that firms may capture a certain proportion of the buyers efficiency gain. Another closely related paper is Belleflamme (2001) who explores the so called "productivity paradox" of investment in information technologies (IT). He explores this paradox in a quantity setting oligopoly with a similar demand structure as in our model by considering a lump–sum investment in either production cost reducing or product differentiating IT. While the structure of his model is similar to ours in many respects, his focus is on a completely different question and because he does not consider price strategies and investment is only modeled in lump–sum

[3]Note also that first order conditions in the second stage are to complicated to obtain analytical solutions with the direct approach even for a relatively easy specification with quadratic investment costs (for linear investment costs the problem is not concave). While we carried out some numerical simulations to check whether our arguments based on the indirect approach are correct, relying solely on numerical solutions for some specific cases would have been unsatisfactory.

fashion, his results can not be applied to our specific problem. Finally, papers about product and/or process innovation by BESTER/PETRAKIS (1993), ROSENKRANZ (1996), and quite recently LIN/SAGGI (2002) also analyze investments in cost reduction and/or product differentiation. However, they restrict attention to interior solutions in symmetric situations while we assume higher transport costs for the distant firm (at least initially) and do also discuss corner solutions (e. g. the decision not to invest and to stay out of the distant market).

We proceed as follows: In section 2 we discuss the specification of the output stage and derive second stage equilibria under both price and quantity competition for given levels of transport costs and degree of product differentiation. Based on this, in section 3 we determine derivatives of profits and consumer surplus, discuss marginal and global investment incentives of the firms, and analyze how private equilibria differ from the socially efficient solution. Section 4 concludes by relating the results obtained to the stylized facts about digital and physical goods. This allows us to determine the likely impact of the advent of electronic coordination in different industries and to draw some provisionally policy conclusions.

2 Competition in the output stage

As mentioned in introduction, asymmetries with respect to transport costs and the differences between physical and digital products are central to our analysis. To consider these aspects in a relatively simple model, we apply a model structure initially developed in MORASCH/WELZEL (2000) and BANDULET/MORASCH (2001):

- There are two spatially separated markets each served by a local firm with transport costs normalized to zero and, as long as transportation between regions is not prohibitively expensive, also by the firm located in the other market.
- Each firm produces a specific type of a symmetrically differentiated product and consumers value product differentiation per se (see DIXIT/STIGLITZ, 1977 and SPENCE, 1976 for this concept of symmetric product differentiation).
- We assume that firms produce with linear homogeneous cost functions and that arbitrage between the two locations is not feasible. Under these assumptions pricing or output decisions for the two markets are independent and we can restrict attention to one market only when determining the equilibria for the output stage.[4]

[4]See BRANDER/KRUGMAN (1983) who apply a similar model to analyze reciprocal dumping in an international oligopoly. The no–arbitrage condition should be generally fulfilled for physical products (transportation costs even after investment) and also for services (impossibility of reselling). Due to the nature of digital products it may be more difficult to make reselling impossible in this case. However, note that our main results do not depend on the assumption of separated markets — this assumption only helps to derive these results more easily.

At this point we will assume that both transport costs and the degree of product differentiation are exogenously given. The incentives to invest in a reduction of transport costs or a change in the degree of product differentiation will be discussed in the next section.

The consumption side is given by a representative consumer with linear-quadratic utility

$$U(x_1, x_2; x_0) = \alpha(x_1 + x_2) - \frac{1}{2}(x_1^2 + x_2^2 + 2\beta x_1 x_2) + x_0 \tag{1}$$

with x_1 and x_2 indicating the specific types of the differentiated good produced by firm 1 or 2, respectively, and x_0 a numeraire good which is assumed to be produced in another sector of the economy and has been added linearly to ensure that the marginal utility of income is equal to one. The parameter α is a measure of market size while β describes the degree of substitutability between the products of the two firms: If the products are perfect substitutes $\beta = 1$, if they are independent $\beta = 0$.[5] For the ease of computation the market size parameter is normalized to $\alpha = 1$. Given the utility function for $\alpha = 1$, the consumer maximization problem leads to linear inverse demand functions

$$p_i = 1 - x_i - \beta x_j \quad \text{with} \quad j \neq i. \tag{2}$$

Demand functions expressing quantity demanded as a function of the two prices are necessary to analyze the duopoly with price strategies. Based on the two inverse demand functions straightforward calculation yields

$$x_i(p_1, p_2) = \frac{1}{1-\beta^2}[(1-\beta) - p_i + \beta p_j]. \tag{3}$$

On the supply side it is assumed that both firms produce with identical and constant average costs normalized to zero, i. e. we assume $c_1(x_1) = c_2(x_2) = 0$. Transport costs of the local firm 1 are also zero while transport costs from the other location are given by $t \geq 0$. Profits in the output stage under (Cournot-) quantity competition, π_i^C, are

$$\pi_1^C(x_1, x_2) = x_1(1 - x_1 - \beta x_2) \tag{4}$$

$$\pi_2^C(x_1, x_2, t) = x_2(1 - x_2 - \beta x_1) - t x_2 \tag{5}$$

while profits in the case of price strategies (Bertrand–competition), π_i^B, are

$$\pi_1^B(p_1, p_2) = p_1 \left(\frac{1}{1-\beta^2}[(1-\beta) - p_1 + \beta p_2] \right) \tag{6}$$

$$\pi_2^B(p_1, p_2, t) = (p_2 - t) \left(\frac{1}{1-\beta^2}[(1-\beta) - p_2 + \beta p_1] \right) \tag{7}$$

[5] Similar demand specifications are frequently used in the literature on strategic investments — see e. g. Bester/Petrakis (1993) or Lambertini/Rossini (1998).

Now equilibria in the output stage for given transport costs t of firms 2 and given degree of product differentiation β will be determined. This is done by simultaneously solving the first order conditions — in the case of quantity competition with respect to (x_1, x_2) and under price strategies with respect to (p_1, p_2). For Cournot competition output and prices in equilibrium are then given by

$$x_1^C = \frac{(2-\beta)+t\beta}{4-\beta^2} \tag{8}$$

$$p_1^C = \frac{(2-\beta)+t\beta}{4-\beta^2} \tag{9}$$

$$x_2^C = \frac{(2-\beta)-2t}{4-\beta^2} \tag{10}$$

$$p_2^C = \frac{(2-\beta)+t(2-\beta^2)}{4-\beta^2} \tag{11}$$

while price strategies yield

$$x_1^B = \frac{(1-\beta)(2+\beta)+t\beta}{(1-\beta^2)(4-\beta^2)} \tag{12}$$

$$p_1^B = \frac{(1-\beta)(2+\beta)+t\beta}{4-\beta^2} \tag{13}$$

$$x_2^B = \frac{(1-\beta)(2+\beta)-t(2-\beta^2)}{(1-\beta^2)(4-\beta^2)} \tag{14}$$

$$p_2^B = \frac{(1-\beta)(2+\beta)+2t}{4-\beta^2}. \tag{15}$$

A reduction in transport costs reduces prices and quantities of the local firm and thus clearly has a negative impact on this firm's profit. Also, considering that returns per unit of the distant firm is given by $p_2 - t$, a reduction in transport yields higher prices and quantities for the distant firm.

These results are only valid as long as second period profits of firm 2 exceed zero — otherwise the market is only served by the local firm. This restriction is met as long as transport costs do not exceed $\bar{t}^C$ or $\bar{t}^B$, respectively. These limiting values are determined by inserting the equilibrium levels of quantities or prices into the expressions for π_2 (see (5) for quantity competition and (7) for price strategies) and solving the resulting equation $\pi_2 = 0$ with respect to t.

$$\bar{t}^C = \frac{2-\beta}{2} \tag{16}$$

$$\bar{t}^B = \frac{(1-\beta)(2+\beta)}{2-\beta^2}. \tag{17}$$

Note that firm 1 behaves as an unrestricted monopolist under both quantity and price competition if the transport costs exceed $\bar{t}^C$. However, under price competition the distant firm is a potential competitor for $\bar{t}^C > t > \bar{t}^B$ and thus prices set by firm 1 are below the monopoly level. In this case the local firm sets a limit price $p_1^L = (\beta + t - 1)/\beta$ that ensures that $x_2 = 0$ — π_1^L is obtained by substituting $x_2 = 0$ and $p_2 = t$ into the demand function (3) and solving with respect to π_1 (at this limit price firm 2 could only sell a positive output level if p_2 is set smaller than t which in turn yields negative profit).

We are now able to determine profits and consumer surplus as functions of t and β. Note that in a market with symmetrically differentiated products consumer surplus must be calculated based on the utility function - it is not correct to add up the values for consumer surplus in the market for each specific product (see Vives, 1985). Taking into account that consumers have to pay the market price for each unit of the product we obtain the following formula for consumer surplus (net utility) derived from the consumption of x_1 and x_2:

$$CS = (1 - p_1)x_1 + (1 - p_2)x_2 - \frac{1}{2}(x_1^2 + x_2^2 + 2\beta x_1 x_2) \tag{18}$$

Thus profits and consumer surplus under quantity competition are

$$\pi_1^C = \begin{cases} \frac{[(2-\beta)+t\beta]^2}{(2-\beta)^2(2+\beta)^2} & \text{if} \quad t \leq \frac{2-\beta}{2} \\ \frac{1}{4} & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} \tag{19}$$

$$\pi_2^C = \begin{cases} \frac{[(2-\beta)-2t]^2}{(2-\beta)^2(2+\beta)^2} & \text{if} \quad t \leq \frac{2-\beta}{2} \\ 0 & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} \tag{20}$$

$$CS^C = \begin{cases} \frac{(1+\beta)(1-t)}{(2+\beta)^2} + \frac{(4-3\beta^2)t^2}{2(2-\beta)^2(2+\beta)^2} & \text{if} \quad t \leq \frac{2-\beta}{2} \\ \frac{1}{8} & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} . \tag{21}$$

For price competition we must additionally consider that we have the limit price result in area B:

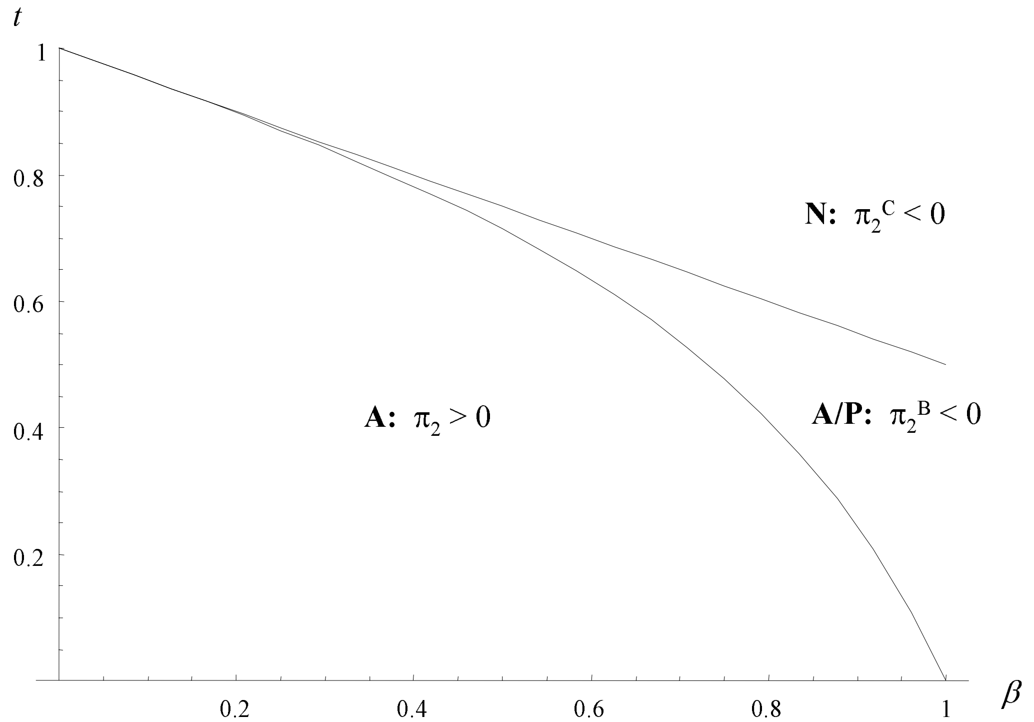
$$\pi_1^B = \begin{cases} \frac{[(1-\beta)(2+\beta)-t\beta]^2}{(1-\beta^2)(4-\beta^2)^2} & \text{if} \quad t \leq \frac{(1-\beta)(2+\beta)}{2-\beta^2} \\ \frac{(1-t)(t+\beta-1)}{\beta^2} & \text{if} \quad \frac{(1-\beta)(2+\beta)}{2-\beta^2} < t \leq \frac{2-\beta}{2} \\ \frac{1}{4} & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} \tag{22}$$

$$\pi_2^B = \begin{cases} \frac{[(1-\beta)(2+\beta)-t(2-\beta^2)]^2}{(1-\beta^2)(4-\beta^2)^2} & \text{if} \quad t \leq \frac{(1-\beta)(2+\beta)}{2-\beta^2} \\ 0 & \text{if} \quad \frac{(1-\beta)(2+\beta)}{2-\beta^2} < t \leq \frac{2-\beta}{2} \\ 0 & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} \tag{23}$$

$$CS^B = \begin{cases} \frac{(1-t)}{(2-\beta)^2(1+\beta)} - \frac{(4-3\beta^2)t^2}{2(1-\beta^2)(4-\beta^2)^2} & \text{if} \quad t \leq \frac{(1-\beta)(2+\beta)}{2-\beta^2} \\ \frac{(1-t)^2}{2\beta^2} & \text{if} \quad \frac{(1-\beta)(2+\beta)}{2-\beta^2} < t \leq \frac{2-\beta}{2} \\ \frac{1}{8} & \text{if} \quad t > \frac{2-\beta}{2} \end{cases} \tag{24}$$

Figure 1 shows the three relevant areas in a (β, t)–diagram: Parameter combinations in area A ("active competitor") yield two active firms in the market for both price and quantity competition. In area A/P the distant firm is active in a quantity setting duopoly while it serves as a potential competitor in the case of price strategies (P stands for "potential competitor"). Finally, in area N ("no competitor") the local firm is an unrestricted monopolist. When we analyze investment incentives, it is important to consider in which area (β, t) is located before and after the investment decision(s).

Figure 1: Areas with and without active distant firms



Source: Mathematica plot based on own calculations

3 Interaction of investment incentives

As already discussed in the introduction, we do not try to determine the equilibrium values of transport costs and degree of product differentiation by solving the two–stage game with simultaneous investment decisions in the pre–output stage, but have instead chosen to use a more indirect approach: We derive our results by inspecting the derivatives of profits and consumer surplus with respect to transport costs and degree of product differentiation (i. e. by considering the marginal returns of the investment) and by comparing at the equilibrium values the first order conditions of the first stage maximization problems of the firms and a social planer, respectively. Assuming sufficiently convex investment costs (to ensure interior solutions) and including information about second stage profit functions, we are able to discuss marginal and global investment incentives for given initial values of t and β. Based on the differences between digital and physical products we can then determine the likely impact of electronic coordination on private investment decisions. In a next step we compare private and social incentives: We start at some private strategies equilibrium and analyze how social incentives depart from private ones at the given equilibrium combination of transport costs and degree of product differentiation. This allows us to determine for all possible equilibrium values of t and β whether a social planer would like to rise or lower investments marginally. By adding information on cross–derivatives, for most cases we can even tell the direction of a discrete step towards the social optimum.

3.1 Derivatives of profits and consumer surplus

In a first step we will now determine the derivatives of profits and consumer surplus with respect to t and β. Let us start by considering the effect of a marginal change in transport costs in the parameter range with a duopoly in the output stage. Values under quantity competition are:

$$\frac{\partial \pi_1^C}{\partial t} = \frac{2\beta(2-\beta)+2\beta^2 t}{(2-\beta)^2(2+\beta)^2} \tag{25}$$

$$\frac{\partial \pi_2^C}{\partial t} = -\frac{4[(2-\beta)-2t]}{(2-\beta)^2(2+\beta)^2} \tag{26}$$

$$\frac{\partial CS^C}{\partial t} = -\frac{(1-t)(4-3\beta^2)+\beta^3}{(2-\beta)^2(2+\beta)^2} \tag{27}$$

As easily can be seen, in the parameter range with interior solutions (areas A and B in figure 1) a marginal reduction of transport costs benefits the distant firm and consumers while it hurts local firms due to intensified competition. The same is true for price competition in the parameter range with an active distant firm (area A in figure 1), however, due to the more complicated formulas for the zero profit constraint this is less visible:

$$\frac{\partial \pi_1^B}{\partial t} = \frac{2\beta(1-\beta)(2+\beta)+2\beta^2 t}{(1-\beta^2)(2-\beta)^2(2+\beta)^2} \tag{28}$$

$$\frac{\partial \pi_2^B}{\partial t} = -\frac{2[(1-\beta)(2+\beta)(2-\beta^2)]-2t[(2-\beta)^2]}{(1-\beta^2)(2-\beta)^2(2+\beta)^2} \tag{29}$$

$$\frac{\partial CS^B}{\partial t} = -\frac{(1-\beta)(2+\beta)^2-t(4-3\beta^2)}{(1-\beta^2)(2-\beta)^2(2+\beta)^2} \tag{30}$$

The strategic variable in the output market also does not affect the outcome for values of t that exceed the zero profit restriction of the distant firm in a quantity setting duopoly: Here derivatives are all zero because marginal changes in t would not affect firm behavior. While this is still true for the distant firm in the limit pricing range under price competition, due to lower prices profits of the local firm are reduced by a fall in transport costs while consumer surplus rises. Derivatives of local firm profits π_1^L, consumer surplus CS^L and welfare W^L in the limit pricing range are given by

$$\frac{\partial \pi_1^L}{\partial t} = \frac{(2-\beta)-2t}{\beta^2} \tag{31}$$

$$\frac{\partial CS^L}{\partial t} = -\frac{1-t}{\beta^2} \tag{32}$$

$$\frac{\partial W^L}{\partial t} = \frac{1-\beta-t}{\beta^2} \tag{33}$$

The derivatives with respect to β are generally somewhat more complicated. However, a close inspection shows that profits of distant firms always rise with a marginal reduction of β, i. e. more differentiated products, and that the effect on consumer surplus is qualitatively different for price and quantity competition, respectively: Under price competition the impact of product differentiation on competition dominates and thus consumers are hurt by a reduction of β; in a quantity setting oligopoly the competition effect is less important than the preferences of consumers for differentiated products und thus reducing β yields higher consumer surplus. Specifically derivatives for quantity competition are given by

$$\frac{\partial \pi_1^C}{\partial \beta} = -\frac{2(2-\beta)^3 + 4t[(2-\beta)(2+\beta)(1-\beta)] + 2t^2[(4+\beta^2)\beta]}{(2-\beta)^3(2+\beta)^3} \tag{34}$$

$$\frac{\partial \pi_2^C}{\partial \beta} = -\frac{2[(2-\beta)-2t][(2-\beta)^2+4\beta t]}{(2-\beta)^3(2+\beta)^3} \tag{35}$$

$$\frac{\partial CS^C}{\partial \beta} = -\frac{(1-t)[(2-\beta)^3\beta] + t^2[(4+3\beta^2)\beta]}{(2-\beta)^3(2+\beta)^3} \tag{36}$$

while derivatives for price competition in area A are

$$\begin{aligned}\frac{\partial \pi_1^B}{\partial \beta} &= \frac{-2[(1-\beta)^2(2+\beta)^3(1-\beta+\beta^2)]}{(2-\beta)^3(2+\beta)^3(1-\beta^2)^2} \\ &\quad + \frac{2t[(1-\beta)^2(2+\beta)(4+2\beta+4\beta^2+3\beta^3)]}{(2-\beta)^3(2+\beta)^3(1-\beta^2)^2} \\ &\quad + \frac{2t^2[(4+\beta^2-2\beta^4)\beta]}{(2-\beta)^3(2+\beta)^3(1-\beta^2)^2}\end{aligned} \tag{37}$$

$$\begin{aligned}\frac{\partial \pi_2^B}{\partial \beta} &= -2[(2+\beta)(1-\beta) - t(2-\beta^2)] \times \\ &\quad \frac{[(1-\beta)(2+\beta)^2(1-\beta+\beta^2) + t((4-2\beta^2+\beta^4)\beta)]}{(2-\beta)^3(2+\beta)^3(1-\beta^2)^2}\end{aligned} \tag{38}$$

$$\frac{\partial CS^B}{\partial \beta} = \frac{3[(1-t)(1-\beta)^2(2+\beta)^3\beta] + 3t^2[(4-5\beta^2+2\beta^4)\beta]}{(2-\beta)^3(2+\beta)^3(1-\beta^2)^2} \tag{39}$$

In the limit pricing range (area B) the situation is different compared to the parameter area close to the zero profit constraint: While firms have still an incentive to make products more homogenous because this enables local firms to set higher limit prices, consumer surplus and thus welfare are now improved by increasing the degree of product differentiation.

$$\frac{\partial \pi_1^L}{\partial \beta} = \frac{(1-t)[(2-\beta)-2t]}{\beta^3} \quad (40)$$

$$\frac{\partial CS^L}{\partial \beta} = -\frac{(1-t)^2}{\beta^3} \quad (41)$$

$$\frac{\partial W^L}{\partial \beta} = \frac{(1-t)(1-\beta-t)}{\beta^3} \quad (42)$$

Based on the information about profit and consumer surplus for given parameter values and on the derivatives with respect to t and β, respectively, we are now able to analyze marginal and global investment incentives of the firms and to compare private and social incentives in private investment equilibria.

3.2 Marginal and global investment incentives

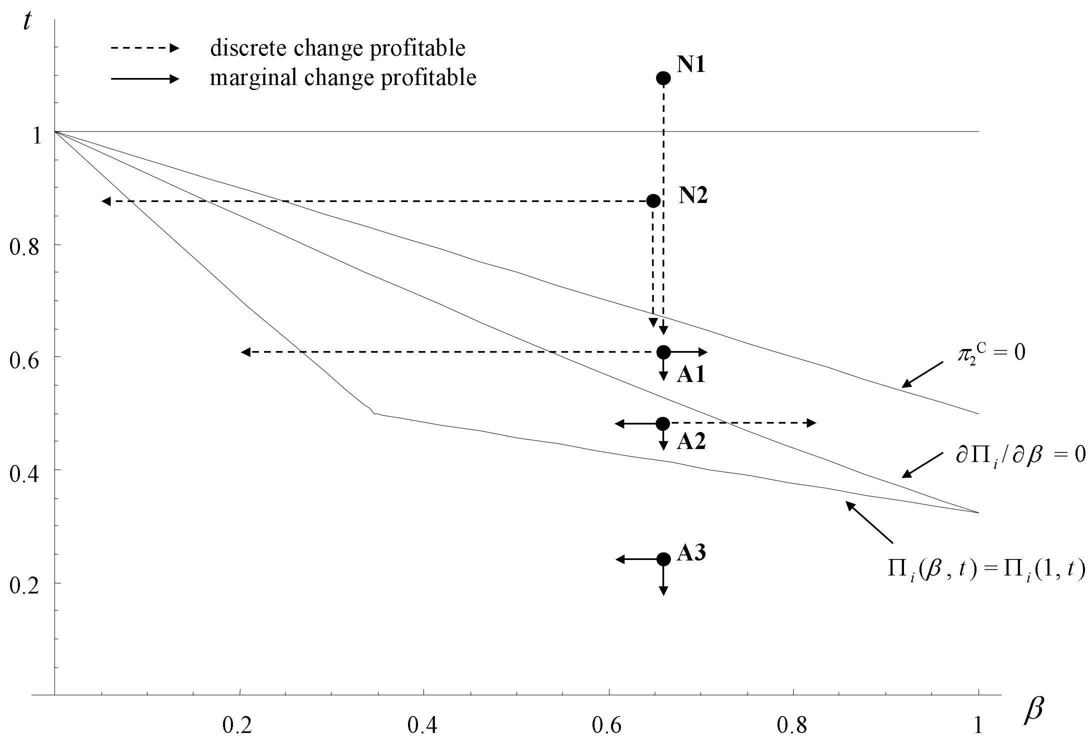
In this section we will develop a graphical representation of marginal and global investment incentives for both transport cost reduction and product differentiation. The figure is based on the effects of changes in t and β on profits in the output stage. However, to discuss investment incentives we must also generally specify the investment cost functions.

- For investments in a reduction of transport costs it seems reasonable to assume a convex investment cost function $I_t(t)$ that is defined in $t \in [0, \bar{t}]$ where $\bar{t}$ represents the initial level of transport costs. Specifically let $I_t(\bar{t}) = 0$, $I_t'(t) < 0$ and $I_t''(t) \geq 0$, i. e. investment in electronic coordination reduces transport costs, however, at a diminishing rate.
- What are realistic features of a cost function for the investment in product differentiation? Following Lin/Saggi (2002), a first possibility would be to presume that an investment by firm i reduces an initial value of product differentiation $\hat{\beta}$ by some value $d_i \in [0, \hat{\beta}/2]$ and that investment costs are given by $I_d(d_i)$ with $I_d' > 0$ and $I_d'' > 0$. By additionally assuming that $I_d'(0) = 0$ and $I_d'(\hat{\beta}/2)$ to be very large, we could guarantee interior solutions for initial values of t and β in parameter ranges where more differentiation increases firm profits. However, for t close to prohibitive levels, increasing product differentiation actually hurts firms. If we realistically consider that products in the initial situation without competition by distant firms are at least somewhat differentiated due to slight differences in firm technologies or consumer preferences (these aspects are not explicitly considered in our model to restrict attention to strategic issues), a modest reduction of transport costs might yield a scenario where firms actually want to make their products more homogenous. In this case it seems most plausible that the necessary changes would also be costly so that a negative level of $d_i \in [-(1-\hat{\beta})/2), 0]$ would yield investment costs

$I_d(d_i)$ with $I'_d < 0$ (contrary to the assumption for rising product differentiation these costs need not be strictly convex).

Based on the information about derivatives of profits we are now able to discuss the likely interaction of the decisions on transport costs and product differentiation. As a general result a marginal reduction of transport costs is always weakly profitable for the distant firm (weakly because it will have no effect if the zero profit constraint of the distant firm is violated) and thus there will be a general tendency to reduce transport costs. Note, however, that industry profits will be reduced if transport costs remain substantial but not prohibitive — firms face a classical prisoners' dilemma in this case. The situation is different when firms decide about product differentiation because an investing firm now considers the impact in the local as well as in the distant market. While differentiating products is beneficial for relatively symmetric firms (i. e. low transport costs), making products more homogenous may raise total profit by reducing or eliminating the market share of an inefficient distant firm (i. e. a firm with relatively high but not prohibitive transport costs).

Figure 2: Private investment incentives: physical goods



Source: Mathematica plot based on own calculations

Figures 2 and 3 show the incentives to reduce transport costs and to change the degree of product differentiation for quantity and price competition, respectively, for all economically relevant combinations of β and t. Arrows indicate the direction of profitable changes: Solid lines refer to profitability on the margin, dashed lines to discrete changes that may be beneficial for some specific investment cost function. Note that the dividing line between N2 and A1 is given by the zero profit condition $\pi_2^C = 0$, the line between A1 and A2 by $\partial\Pi_i/\partial\beta = 0$ (with Π_i as the sum of second stage profits of firm i in both the local and the distant market) and the line between A2 and A3 by the condition $\Pi_i(\beta, t) = \Pi_i(1, t)$ (to the left the sum of profits for some degree of product differentiation β is at least as high as the sum of profits in a homogenous good duopoly). The additional line in figure 3 between P and A1 is defined by $\pi_2^B = 0$ (in P the distant firm is only a potential competitor).

We start by discussing the somewhat less complicated scenario with quantity competition (physical products):

- If the transport cost reduction comes for free, firms would always have an incentive to reduce t to some level below the zero profit constraint for firm 2 (the line that divides the areas N2 and A1). However, in N1 and N2 there is no incentive for a marginal change of t because as long as t is above the zero profit constraint the distant firm will stay out of the market.

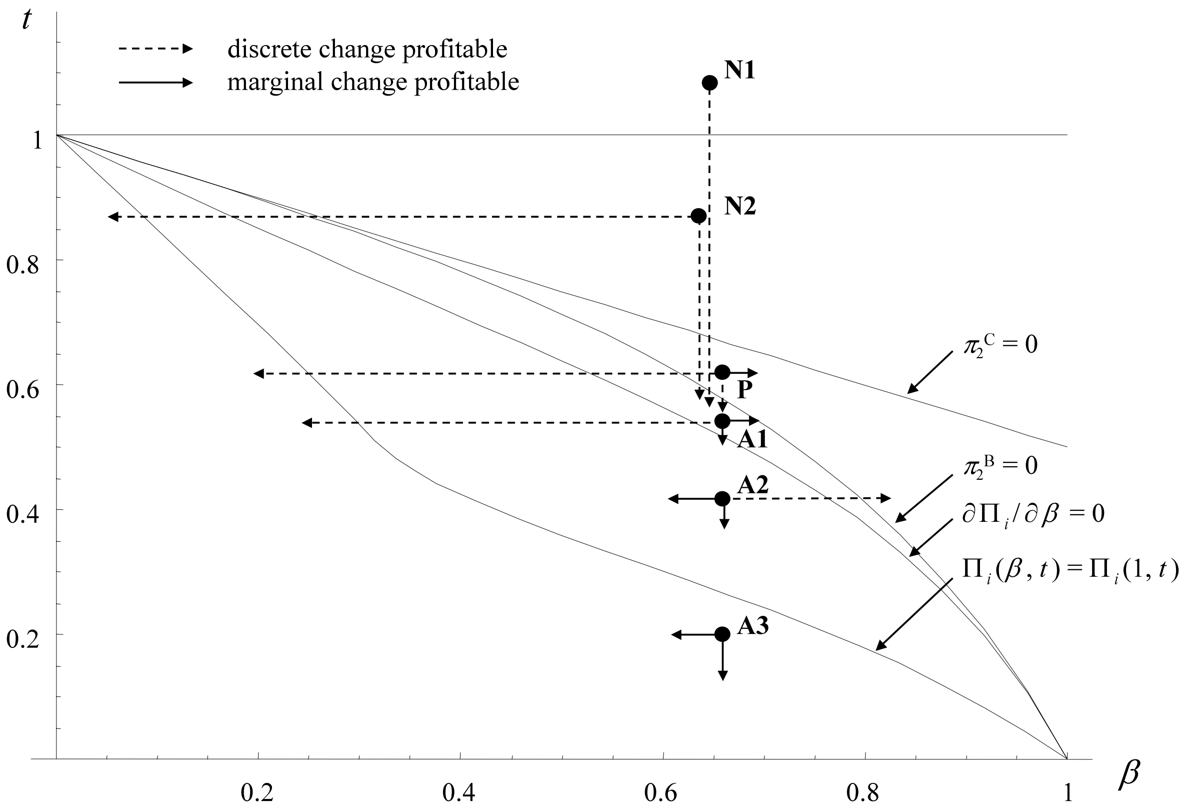
- While in area N1 firms cannot increase their profit by changing β, in zone N2 a costless reduction of β to a value in A3 would raise profits relative to the situation with a monopoly in each local market. The reason is that for β close to zero the markets for the two varieties are almost independent and thus profits of the local firm remain largely unaffected by the entry of the distant competitor. Note, however, that a marginal change of β will not change profits because distant firms do not enter.

- In A1 transport costs are low enough to make entry profitable for the distant firm. However, this decision is inefficient in the sense that total profit of each firm from the local and the distant market together is reduced. Therefore marginally increasing β (making products more homogenous) makes a firm better off by lowering the market share of distant firms or even driving them out of the market. On the other hand, as in N2, a large reduction of β to area A3, i. e. a substantial increase in product differentiation, would yield higher profits than making products more homogenous.

- In A2 and A3 the problem of inefficient entry is less important (it is completely absent for $t = 0$). Therefore a marginal decrease of β raises profits. While decreasing β is globally optimal in A3, depending on the specification of the investment cost function, a discrete change that makes products more homogenous may still be optimal.

The picture for price strategies (digital goods) looks quite similar. In fact areas N1 and N2 are unchanged while for A2 and A3 only the exact course of the borderlines is altered. The main qualitative variation is the area between N2 and A2, which in contrast to the situation under quantity competition is now divided into P and A1. The small zone A1 yields the same result as the respective area under quantity competition. However, in P there is only potential competition and thus the local firm would not benefit from a marginal reduction of transport costs.

Figure 3: Private investment incentives: digital goods



Source: Mathematica plot based on own calculations

Let us now interpret the results in light of the differences between physical and digital products. The situation for given values of t and β is quite similar for both kind of products, despite for relatively homogenous goods and intermediate transport costs (the area with potential competition in the case of price strategies). However, it can be argued that for digital products equilibria after investments in electronic coordination are likely to result in low levels of transport costs and substantial product differentiation, while relatively high transport costs and less differentiation is the most probable outcome under quantity competition (physical products): Electronic coordination might reduce transport costs of digital goods and services substantially or even to zero at modest investment levels and might also provide additional possibilities to differentiate such products. For physical products the necessary investment in logistics makes transport cost reductions more costly and even after substantial investment there will remain transport cost disadvantages for distant firms; also competition in markets with (almost) homogenous goods is much less pronounced under quantity competition and the impact of electronic commerce on options to differentiate products should be more limited for physical goods. Equilibria with digital goods are therefore most likely in zone A3 with low transport costs and a substantial degree of product differentiation. For physical goods, however, equilibria could very well be in areas N2, A1 or A2 with prohibitive or almost prohibitive transport costs and a relatively low degree of product differentiation. Here it is possible that firms might either decide not to invest in transport cost reducing electronic coordination (in N2) or to react on a reduction of transport costs by making products more homogenous (in A1 and A2).

3.3 Private vs. social investment incentives in equilibrium

After having discussed the private investment incentives, which enabled us to predict the impact of electronic commerce in markets with digital and physical products, respectively, we will now deal with the question how private equilibria are likely to differ from the social optimum: Will there be underinvestment because firms do not get all the benefits caused by their investment or will the firms overinvest because negative impacts on other firms or consumers are not taken into consideration?

To highlight the basic idea of our approach, we start by analyzing the easiest case — investment in transport cost reduction for an exogenously given level of product differentiation. Additional considerations for investment in product differentiation and simultaneous decisions on both forms of investment will be discussed below. Analyzing the social efficiency of investments in transport cost reduction is less complicated for two reasons: (i) Looking at the derivatives of profits and consumer surplus, it can easily be seen that an investment always raises profits of the investing firm and consumer surplus while it reduces profits of the local firm. (ii) Because pricing and output decisions in the two markets are independent for a given degree of product differentiation, we can restrict attention to one market and in the investment stage only the distant firm is an active player. As shown in BANDULET/MORASCH (2001) the problem can thus be analyzed as follows: Let t^* be an interior solution of the maximization problem of firm 2. Then a marginal change of t^* would not affect total profits of firm 2 (i. e. profits net of investment costs):

$$\frac{\partial \pi_2(t^*)}{\partial t} - \frac{\partial I_t(t^*)}{\partial t} = 0 \tag{43}$$

Accordingly for an interior solution $\hat{t}$ of the welfare maximization problem, the following first order condition must be fulfilled:

$$\frac{\partial \pi_1(\hat{t})}{\partial t} + \frac{\partial \pi_2(\hat{t})}{\partial t} - \frac{\partial I_t(\hat{t})}{\partial t} + \frac{\partial CS(\hat{t})}{\partial t} = 0 \tag{44}$$

The investment decision by firm 2 is socially efficient, i. e. $t^* = \hat{t}$, if the external effects on profits of the local firm and on consumers just cancel out (see Farrell/Shapiro, 1990 for applying a similar concept of external effects to merger policy): The marginal loss of consumer surplus by raising t must equalize the according marginal gain of profits by firm 1.

$$\frac{\partial \pi_1(t^*)}{\partial t} + \frac{\partial CS(t^*)}{\partial t} = 0. \tag{45}$$

Note that overinvestment relative to the social optimum results if the left hand side of equation (45) exceeds zero (a reduction of investment would raise t which in turn would induce a positive external effect), while underinvestment coincides with the sum of partial derivatives being below zero (a transport cost reducing investment, i. e. a reduction of t, would then reduce the negative external effect). Inserting the formulas of the derivatives from section 3.1 into (45) and solving for t^*, we can determine the parameter combinations of t and β with under- or overinvestment, respectively. As shown in Bandulet/Morasch (2001) the borderline with efficient investment is given by $t^* = 1 - \beta$ for both price and quantity competition. Overinvestment will result for higher transport costs in equilibrium (up to the zero profit constraint of the distant firm), while we get underinvestment when equilibrium transport costs are below this borderline but higher than zero.

The analysis becomes generally more complicated for investment in product differentiation and simultaneous decisions on both forms of investment. The main reason is that markets are no longer independent and we have to consider the strategic interaction of private investment decisions. Let us first consider the determination of the degree of product differentiation for a given level of transport costs. Here the firms non–cooperatively decide about investment levels $I_d(d_i)$ in a simultaneous move game, while a social planer determines β by choosing an combination (d_1, d_2) that maximizes welfare. With π_i^j as profits in market j of a firm that is located in market i first order conditions for the private strategies equilibrium may be written as

$$\frac{\partial \pi_1^1}{\partial d_1} + \frac{\partial \pi_1^2}{\partial d_1} - \frac{\partial I_d}{\partial d_1} = 0 \tag{46}$$

$$\frac{\partial \pi_2^1}{\partial d_2} + \frac{\partial \pi_2^2}{\partial d_2} - \frac{\partial I_d}{\partial d_2} = 0. \tag{47}$$

First order conditions for the maximization problem of a social planer generally differ from (46) and (47) because he additionally considers the impact of a change in d_i (and thus β) on consumer surplus and on the profits of firm j and because he will decide on the cost minimizing mix of (d_1, d_2) to achieve some level of β. Therefore, at first sight, the procedure applied for the determination of the level of transport cost reductions does not seem to work here. However, because investment cost functions I_d are assumed to be convex and identical for both firms, the cost minimizing way to obtain a given level of β calls for $d_1 = d_2$. Thus investment levels in a social optimum must be the same at both firms. On the other hand, as firms are symmetric when considering the complete model with both markets together, we also know that in a economically sensible private strategies equilibrium d_1 must equal d_2. Therefore some degree of product differentiation β will be achieved by the same investment level $d = d_1 = d_2$ under both private and social investment decisions. Similar to the determination of transport cost reductions, we can thus derive *one* first order condition for each case based on derivatives with respect to β. This is done by first substituting d for d_1 and d_2, respectively, and then multiplying the first order conditions by $d\,d/d\,\beta$. With $\Pi_i = \pi_i^i + \pi_i^j$ as gross profits of firm i in both markets together and CS as consumer surplus in any of the two markets we obtain

$$\frac{\partial \Pi_i}{\partial \beta} - \frac{\partial I_d}{\partial \beta} = 0 \tag{48}$$

$$\frac{\partial \Pi_i}{\partial \beta} + \frac{\partial \Pi_j}{\partial \beta} + 2\frac{\partial CS}{\partial \beta} - \frac{\partial I_d}{\partial \beta} = 0. \tag{49}$$

as first order conditions under private strategies and social optimization, respectively. Noting that $\Pi_i = \Pi_j$ in equilibrium due to symmetry, a borderline in (β, t)–space with efficient private investment in product differentiation isdefined by the solution of the following equation:

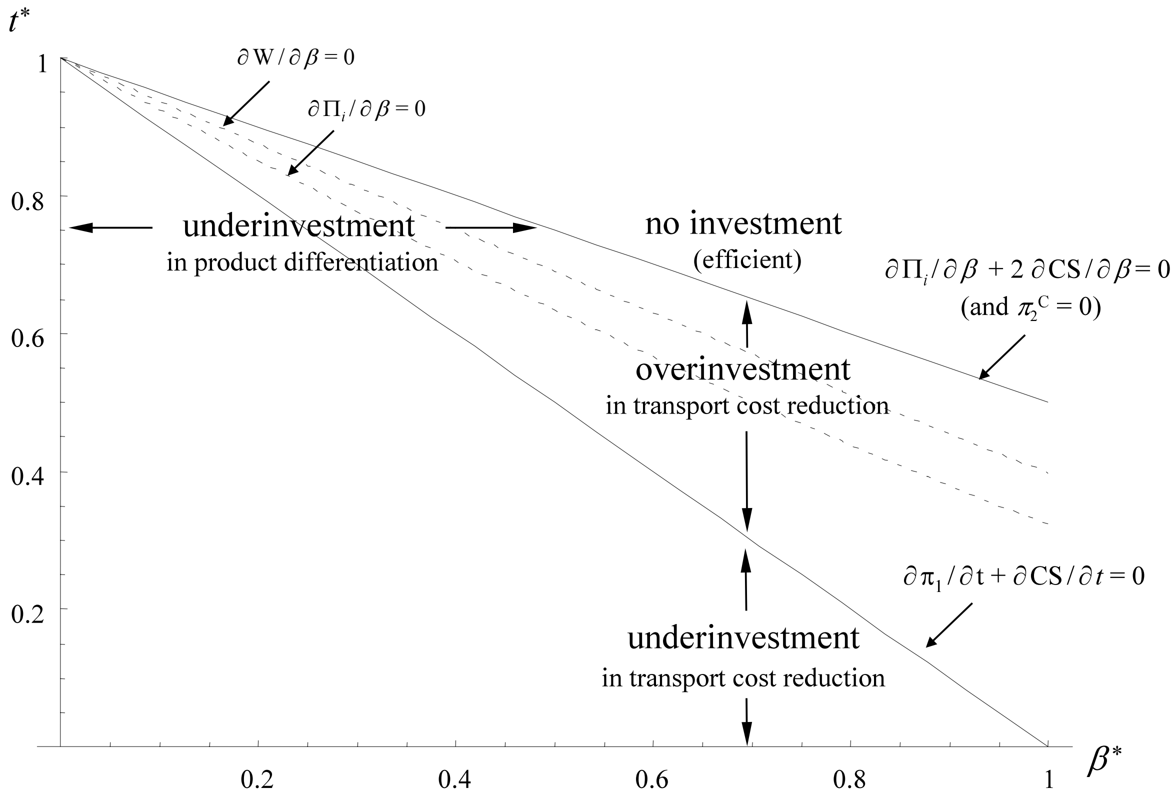
$$\frac{\partial \Pi_i(\beta^*)}{\partial \beta} + 2\frac{\partial CS(\beta^*)}{\partial \beta} = 0. \tag{50}$$

Under quantity strategies the solution of (50) with respect to t coincides with the zero profit constraint for the distant firm. We consequently observe always underinvestment in product differentiation in the parameter space with interior solutions. The underlying reason is that more product differentiation not only benefits the other firm but also consumers (the positive effect of higher gross utility with more differentiated products dominates the negative impact of higher prices due to reduced competition). The situation is different with price strategies because here the price effect of less differentiation is very pronounced if goods are already close substitutes (with homogenous goods and zero transport costs price would equal marginal cost). Therefore we observe overinvestment in product differentiation for low lelvels of product differentiation. If, however, products are substantially differentiated in equilibrium we might get the underinvestment result as in the case of price competition. The borderline that results under price competition is defined by a quite complicate expression without any direct economic interpretation and we will therefore not display this expression but only present the resulting borderline in figure 5.

When discussing simultaneous decisions on both investment in transport cost reduction and product differentiation, we could directly apply the results derived above if we restrict attention to marginal changes of investment levels. However, because we want to compare two different equilibria we actually must deal with discrete changes. Here we face the following problem: Suppose that we have underinvestment in both transport cost reduction and product differentiation. We can only be sure that investment in product differentiation in the social optimum is indeed higher as in the private strategies equilibrium if lower transport costs do not reduce the incentive to invest in product differentiation. To deal with this problem, we must determine the cross–partial–derivatives of profits and welfare with respect to t and β. Based on the results obtained in section 3.1 this is a straightforward exercise. Fortunately these cross–derivatives are unambiguously positive in the parameter range with interior solutions for both price and quantity strategies, meaning that a transport cost reduction always increases the incentives to invest in product differentiation and vice versa.

We are now able to display our results in two figures for quantity and price competition, respectively. Note that we have t^* and β^* on the axes in figure 4 and 5, indicating that we are now dealing with equilibrium values after investment. The solid lines refer to the borderlines between over- and underinvestment while the dashed lines indicate the incentives of firms and the social planer to reduce or increase the degree of product differentiation.

Figure 4: Private vs. social investment incentives: physical goods



Source: Mathematica plot based on own calculations

Let us start with figure 4 which deals with the situation quantity competition (physical goods). In the area above the zero profit constraint the private decision not to invest is also socially efficient because below this borderline we have overinvestment in transport cost reduction and the social planer has a marginal incentive to reduce product differentiation. For a given degree of product differentiation the private strategies equilibrium yields overinvestment in transport cost reduction for equilibrium levels of transport costs close to the zero profit constraint and/or relatively homogenous products, while the firms underinvest if transport costs are nearly zero and/or products are quite differentiated. Because for a given level of transport costs equilibrium investment in product differentiation is too low from a social point of view for all parameter combinations with interior solutions, the latter result still holds in the case of simultaneous determination of both t and β.

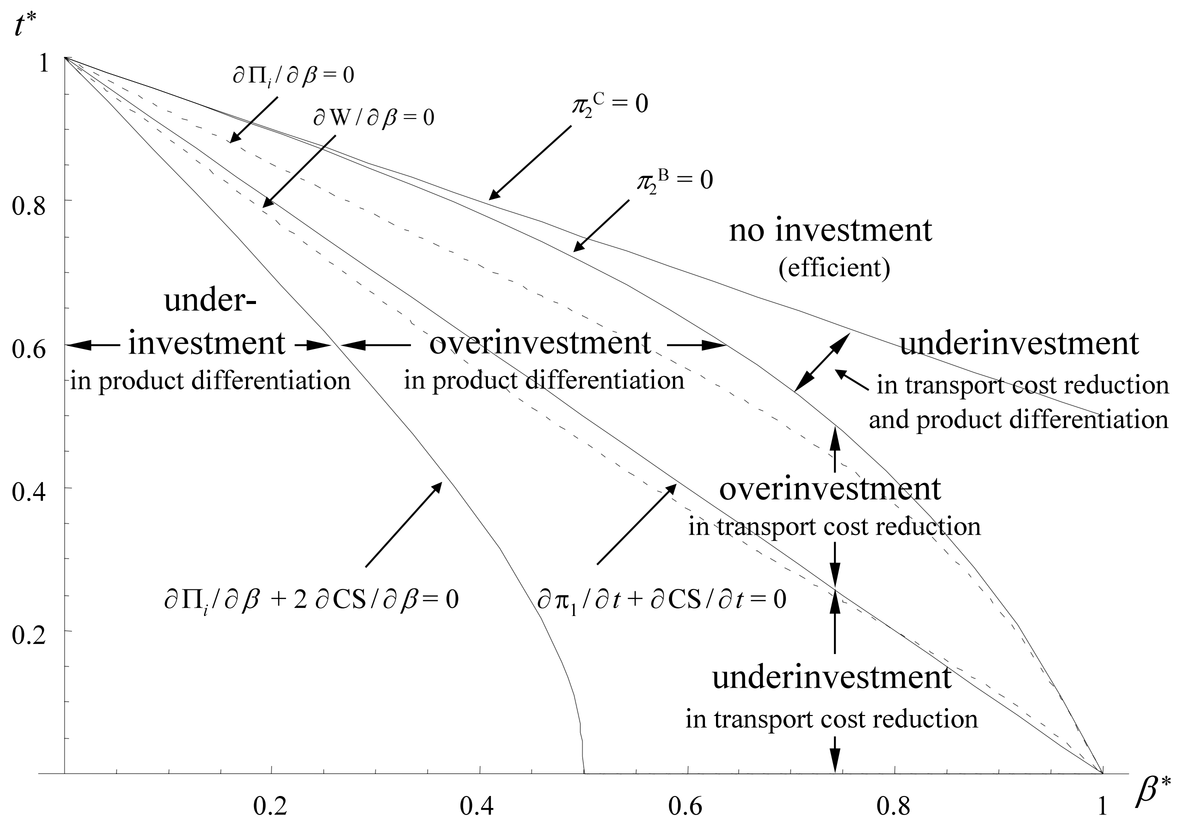
The situation is different in the area above the borderline for efficient private investment in transport cost reduction. Here we can only rule out that the social planer would both invest less in product differentiation and more in transport cost reduction. All other combinations are possible: For example higher transport costs in the social optimum make investment in product differentiation less attractive which represents a countervailing force to the higher investment incentive of the social planer for a given level of transport costs. Therefore a social optimum with lower transport costs and both more or less homogenous goods is possible. The same kind of reasoning can be put forward by starting with a higher degree of product differentiation and showing that transport costs may then be either lower or higher in the social optimum.

When looking at figure 5 for price competition, we notice two main differences: (i) Because consumer surplus increases in β, there are now parameter ranges with overinvestment in product differentiation. We thus have an additional borderline that indicates combination of β and t where private and social incentives coincide; also the borderline for no private investment incentives lies now above the respective line for the social planer. (ii) We must specifically consider the area between the zero profit constraints of the distant firm for quantity and price strategies, respectively, where the distant firm serves as a potential competitor of the local monopolist.

Considering investment in transport costs for a given degree of product differentiation, results are exactly the same as under quantity competition except for the area between the two zero profit constraints where we get underinvestment. In this area the distant firm has no incentive for a marginal investment because it would stay out of the market even after investment. Therefore we obtain a private investment equilibrium in this parameter range with zero investment. However, there exists a social incentive to invest because the limit price of the local firm would be reduced and thus welfare (the sum of producer and consumer surplus) would increase.

The outcomes for investment in product differentiation are quite similar: For given transport costs underinvestment is assured for relatively low values of β^* and t^* while overinvestment results in the rest of the area with interior solutions. In the limit pricing range there is underinvestment because more product differentiation would make the distant firm a more “dangerous” potential competitor which reduces the monopoly power of the local firm. Finally, above the zero profit constraint for quantity competition the private decision not to invest is again efficient.

Figure 5: Private vs. social investment incentives: digital goods



Source: Mathematica plot based on own calculations

What can be said if both investment levels are determined simultaneously? The results from above are robust in the two underinvestment regions (to the lower left and under limit pricing), in the lens with overinvestment in transport cost reduction and product differentiation (between the zero profit constraint and the borderline for investment in transport cost reduction) and also in the "no investment" range. Only in the triangle like area between the borderlines with efficient investment in β and t, respectively, a definite result can not be obtained: We can only state that it is not possible for both transport costs to be higher and products to be more differentiated in the social optimum (all other combinations of under- and overinvestment can happen).

We can now discuss the probable outcome for the two different kind of products. (i) Due to the specific characteristics of physical products, it is most likely that equilibria are in the upper right area of figure 4 with either the efficient decision not to invest or overinvestment in transport cost reduction for a given level of product differentiation. In the latter case, however, for a given level of transport costs firms underinvest in product differentiation (as they do in the whole area with interior solutions) and the result is therefor unclear if both t and β are determined simultaneously. (ii) The situation is different for digital goods (price competition— see figure 5): Here equilibria tend to be in the area with underinvestment in transport cost reduction or efficient investment to zero transport costs. If a high degree of product differentiation is feasible at relatively low costs, underinvestment in both product differentiation and transport cost reduction will result if firms decide on both investments simultaneously. As in the case with physical products we do not obtain a definite result if products remain more homogenous in equilibrium, because now firms overinvest in product differentiation for a given level of transport costs.

4 Conclusion

Electronic coordination enables firms to reduce transport costs to distant markets and offers new opportunities to differentiate products. In the present paper we applied a spatial heterogenous good duopoly model with either price or quantity strategies (i) to discuss marginal and global incentives of firms to invest in transport cost reduction or product differentiation and (ii) to analyze how private and social investment incentives differ. We also argued that the appropriate model structure and the likely effects are different for physical and digital products, respectively: Competition in markets with physical products may be best analyzed in a quantity setting oligopoly because capacities are likely to be important; also substantial transport cost disadvantages for the distant firm will remain even after investing in electronic commerce. On the other hand, a model with price competition is more appropriate for digital products and here transport costs near zero are quite probable after investment. By combining the results obtained in the formal analysis with the specific characteristics of physical and digital products, respectively, we are able to predict the likely outcomes in any of the two cases and to discuss potential implications for public policy.

Because a reduction of transport costs increases competitive pressure, one would generally expect that firms will consequently have an incentive to rise the degree of product differentiation to counteract this effect. However we obtained the surprising outcome that product differentiation may actually be decreased if initially prohibitive transport costs are reduced somewhat below the zero profit constraint of the distant firm. What is the intuition behind this result? By making products more homogenous the market share of the distant competitor is diminished and this firm may even be driven out of the market. While it is evident that this gives the local firm an incentive to reduce the degree of product differentiation, it is not yet sufficient to explain why a firm that also acts in a distant market has such an incentive. Here we need the additional argument that relatively high transport costs yield low profit margins in the distant market and thus the positive effect in the local market dominates the negative impact in the distant one. Note that if transport costs go down further, we obtain the expected outcome with incentives to increase product differentiation.

How likely is it that products become actually more homogenous and what can be said about the social efficiency under private investment?

- As mentioned above, for physical products it is probable that equilibrium transport costs (i. e. after investment) are still substantial or even prohibitive. While we did not show explicitly that firms could reach an equilibrium with both lower transport costs and more homogeneous goods when they simultaneously decide about both investment levels, one can at least easily imagine situations where an exogenous reduction of transportation costs (e. g. lower network prices due to technological progress in the network industry) triggers a reduction of product differentiation. Concerning the comparison of social and private investment incentives, the private decision not to invest is also socially efficient. On the other hand, a definitive conclusion is not possible for transport costs between the zero profit constraint and the borderline with efficient investment in transport cost reduction: For a given degree of product differentiation private investment exceeds the socially optimal one and for given transport costs we observe underinvestment in product differentiation; if, however, firms simultaneously decide about both investments, the only thing we definitely know about the social optimum is that there will not be both lower transport costs and more homogeneous products.
- For digital products quite low or even zero transport costs are the most likely outcome in a private strategies equilibrium and in this case firms have a great incentive to increase the degree of product differentiation. From a social point of view, underinvestment in both transport cost reduction and product differentiation results if products are substantially differentiated in the private strategies equilibrium. Otherwise we have overinvestment in product differentiation and if firms invest simultaneous we can thus only rule out that a social planer chooses both lower investment in transport costs and higher investment in product differentiation. It should be noted that outcomes in the limit pricing range seem only probable if there is almost no potential for product differentiation.

Given that results are highly sensitive and that for both kinds of products we do not obtain definitive outcomes in the most likely situations, it seems most sensible to call for a "hands off" policy in this area. It should, however, be noted that we assumed that the decisions of the firms are made non–cooperatively. However, especially when considering the investment in transport cost reduction, firms will have an incentive to collude which would definitely result in underinvestment relative to the social optimal level. Insofar competition policy should be reluctant to allow cooperation in this pre–competitive area.

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