Incentives to Invest in Electronic Coordination: Under- or Overinvestment in Equilibrium?

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Abstract

Do firms have proper incentives to invest in electronic coordination? We discuss this question in an oligopoly model with a local firm and a distant competitor that may reduce transport costs by investing in electronic coordination. In a two–stage game with investment in the first stage and price or quantity competition with differentiated products in the second stage we compare profit maximizing investment with (constrained) welfare maximization by a social planer. Depending on market demand, firm conduct and investment costs either over- or underinvestment may result: The firm will overinvest if the negative impact on its competitor exceeds the gain in consumer surplus. This is shown to be especially likely under quantity competition with (almost) homogenous products.

JEL–classification: D43; D61; L13

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

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1 Introduction

Electronic coordination has the potential to reduce search and transport costs. While the effect on search costs has already been discussed in the literature (see e. g. *Bakos, 1997*), the reduction of transport costs is largely neglected. The impact of electronic commerce on transport costs is most obvious for digital or digitalizable products or services: Think of software which can be directly downloaded and therefore must no longer been shipped to the customer or a lokal store. Another example are online bank transactions that allow to do the banking without the necessity to "transport" the customer to the local bank office. But even if products have still to be shipped, like books for example, transport costs in this broader sense may be reduced because a book can now be sent directly to the customer who must no longer drive or walk to a bookstore.[1]

Obtaining the benefits of transport cost reduction by electronic coordination, however, does not come for free: Substantial investment in hardware, software and supporting services (e. g. marketing, logistics) are necessary to sell products or services on an electronic market. In the present paper we analyze whether the investment decision of a firm is likely to be efficient. *Bakos (1997)* already discussed investment incentives of firms that could reduce the search costs of their customers by implementing an electronic market. He argued that investment 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. Our paper differs from *Bakos (1997)* in two ways:

- Assuming that electronic coordination reduces transport costs we consider another investment incentive.
- The investment decision is explicitly modelled as first stage action in a two–stage game and therefore we can derive equilibrium transport costs as a function of parameters like degree of product differentiation, strategic variables in the output market or the initial transport costs of a firm. This enables us to derive explicit statements about efficiency in various situations.

We consider both quantity and price competition. While many markets with physical goods may be appropriately described by an oligopoly model with quantity

[1] Transport costs in this case will only be lowered if the reduced opportunity costs of customers exceed the cost differential due to sending books directly to each customer in a given area instead of sending all books together to a local book store.

strategies (this is the case if setting capacities is the most important strategic decision),[2] this approach is not adequate for digital goods like software or MP3 music: A digital good may be reproduced almost unlimited at very low costs and thus setting capacities (i. e. quantities) is not a strategic issue. Thus it should be kept in mind that only results derived under price competition apply to digital products.

The relative strength of two effects determines whether under- or overinvestment in comparison to the decision of a social planer results in equilibrium: The investing firm does neither consider the positive effect on consumer surplus due to lower equilibrium prices and availability of another type of the differentiated product nor the negative impact on the profits of its competitor due to intensified competition. We obtain the general result that overinvestment is especially likely under quantity competition with (almost) homogenous goods and/or in situations where the optimal investment of the initially disadvantaged firm results in still relatively high, but not prohibitive transport costs.

We proceed as follows: In section 2 we present the two–stage model with a heterogenous good oligopoly in the output stage and derive the second stage equilibria under price and quantity competition for given transport costs. Based on this, section 3 shows for arbitrary investment cost functions how the profit maximizing transport cost reduction differs from the social optimum, i. e. whether the subgame–perfect equilibrium yields over- or underinvestment. In section 4 a specific investment cost function is considered in order to explore in more detail how the initial situation determines the investment decision. Section 5 summarizes and discusses implications for firm strategy and public policy.

2 Model structure and second stage equilibria

The underlying model structure, initially developed in *Morasch/Welzel (2000)*, is as follows: There are two 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; consumers value product differentiation per se and the degree of product differentiation is exogenously given (see

[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.

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.[3]

Thus the decision to invest in electronic coordination can be analyzed in the following two–stage game:

- In the first stage, the firm from the distant region, firm 2, decides about the investment level I that determines the extent to which its transport costs are reduced. The local producer, firm 1, is assumed to be inactive in this stage because it already does not incur any transport cost.[4]
- In the second stage, competition in a differentiated product duopoly with either price or quantity as strategic variables is considered. While transport costs of the local firm are normalized to zero, costs of firm 2 depend on the investment level chosen in stage one.

Let us first consider the second stage of the game for some arbitrary transport costs t. The consumption side is given by an 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 $\alpha = 1$ and firms are assumed to produce with identical and constant average costs normalized

[3]See *Brander/Krugman (1983)* who apply a similar model to analyze reciprocal dumping in an international oligopoly.

[4]Note, however, that in the complete model the local firm would decide about investing in electronic coordination to penetrate the distant market.

[5]Similar demand specifications are frequently used in the literature on strategic investments — see e. g. *Bester/Petrakis (1993)* who compare R&D incentives under price vs. quantity competition and *Belleflamme (2001)* who considers investments devoted to product differentiation.

to zero, i. e. we assume $c_1(x_1) = c_2(x_2) = 0$. Given the utility function for $\alpha = 1$, the consumer maximization problem leads to linear inverse demand functions

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

While we are now able to determine the second stage equilibrium under quantity competition, we need demand functions expressing quantity demanded as a function of the two prices to analyze the duopoly with price strategies. Based on the two inverse demand functions a straightforward calculation yields

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

Let total profits be labeled by Π_i and second period profits of firm 2 (without considering the sunk investment in stage one) by π_2. Given that transport costs are zero for the local firm, profit functions under (Cournot-) quantity competition, Π_i^C, are

$$\Pi_1^C(x_1, x_2) = x_1(1 - x_1 - \beta x_2) \tag{4}$$
$$\Pi_2^C(x_1, x_2, t) = x_2(1 - x_2 - \beta x_1) - t x_2 - I(t) \tag{5}$$

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

$$\Pi_1^B(p_1, p_2) = p_1 \left(\frac{1}{1-\beta^2}[(1-\beta) - p_1 + \beta p_2] \right) \tag{6}$$
$$\Pi_2^B(p_1, p_2, t) = (p_2 - t) \left(\frac{1}{1-\beta^2}[(1-\beta) - p_2 + \beta p_1] \right) - I(t). \tag{7}$$

Now second–stage equilibria for given transport costs t of firms 2 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

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

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

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

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

Note that these results are only valid as long as second period profits of firm 2 exceed zero — otherwise firm 2 would not enter the market. 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 prices and quantities into $\pi_2 = \Pi_2 + I(t)$ and solving the resulting equation $\pi_2 = 0$ with respect to t. Second period profits are given by

$$\pi_2^C = \frac{[(2-\beta)-2t]^2}{(4-\beta^2)^2} \tag{16}$$

$$\pi_2^B = \frac{[(1-\beta)(2+\beta)-t(2-\beta^2)]^2}{(1-\beta^2)(4-\beta^2)^2} \tag{17}$$

and thus conditions for transport costs are

$$\bar{t}^C \leq \frac{2-\beta}{2} \tag{18}$$

$$\bar{t}^B \leq \frac{(1-\beta)(2+\beta)}{2-\beta^2}. \tag{19}$$

Based on this information about second stage equilibria, we are able to analyze the investment decision: In section 3 we analyze investment incentives for arbitrary investment cost functions and in section 4 we explore some aspects in greater depth by assuming an explicit quadratic investment cost function.

3 Efficiency of the investment decision

We do now consider the first stage investment decision of firm 2. We assume an arbitrary investment cost function $I(t)$ that is defined for $t \geq 0$ with $I'(t) < 0$ and $I''(t) \geq 0$ — investment in electronic coordination reduces transport costs, however, at a diminishing rate.[6] Firm 2 aims to maximize total profit Π_2. Consider an interior solution t^* to that maximization problem. This implies that a marginal change in investment $I(t^*)$, or more specific in t, would not change total profits of firm 2:

$$\frac{\partial \Pi_2(t^*)}{\partial t} = \frac{\partial \pi_2(t^*)}{\partial t} - \frac{\partial I(t^*)}{\partial t} = 0 \tag{20}$$

This solution must now be compared with a welfare maximizing investment level. For an interior solution $\hat{t}$ the following first order condition with CS indicating consumer surplus must be fulfilled:

$$\frac{\partial \Pi_1(\hat{t})}{\partial t} + \frac{\partial \pi_2(\hat{t})}{\partial t} - \frac{\partial I(\hat{t})}{\partial t} + \frac{\partial CS(\hat{t})}{\partial t} = 0 \tag{21}$$

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 analysis 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.

$$\frac{\partial \Pi_1(t^*)}{\partial t} + \frac{\partial CS(t^*)}{\partial t} = 0. \tag{22}$$

Note that overinvestment relative to the social optimum results if the left hand side of equation (22) 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).

We will now determine the t^* that met $t^* = \hat{t}$ as a function of β: This condition is fulfilled if equation (22) holds for some combination of t^* and β. The derivatives of Π_1 with respect to t for quantity and price competition can easily be determined after inserting equilibrium values x_i^C and p_i^B into Π_i^C and Π_i^B, respectively. When dealing with the external effect on consumers, however, we must keep in mind 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

[6] The investment in transport cost reduction is quite similar to cost reducing R&D (see e. g. *Brander/Spencer, 1983*). However, strategic R&D is usually analyzed in a framework with product market competition in an integrated market and a priori identical firms which yields a simultaneous move game in the R&D stage. Due to these differences a direct application of the results from the R&D literature on the present problem with investment in transport costs is not possible.

we obtain the following formula for consumer surplus (net utility) derived from the consumption of x_1 and x_2:

$$CS = (1 - p_1)x_1 + (1 - p_2)x_2 - \frac{1}{2}(x_1^2 + x_2^2 + 2\beta x_1 x_2) \tag{23}$$

Based on the second stage equilibrium values for x_i and p_i from equations (8) through (11) (for quantity competition) and (12) through (15) (for price strategies) we are now able to write equation (22) as a function of t^* and β:

$$\frac{\partial \Pi_1^C}{\partial t} + \frac{\partial CS^C}{\partial t} = \frac{2\beta(2-\beta) + 2\beta^2 t^*}{(4-\beta^2)^2} - \frac{(1+\beta)(2-\beta)^2 + t^*(3\beta^2 - 4)}{(4-\beta^2)^2} = 0 \tag{24}$$

$$\frac{\partial \Pi_1^B}{\partial t} + \frac{\partial CS^B}{\partial t} = \frac{2\beta(1-\beta)(2+\beta) + 2\beta^2 t^*}{(1-\beta^2)(4-\beta^2)^2} - \frac{(1-\beta)(2+\beta)^2 + t^*(3\beta^2 - 4)}{(1-\beta^2)(4-\beta^2)^2} = 0 \tag{25}$$

Simplifying (24) and (25) yields for both cases the same equation(!):

$$-(1-\beta)(4-\beta^2) + \tilde{t}(4-\beta^2) = 0 \tag{26}$$

So price and quantity competition yield the same function $\tilde{t}(\beta)$ that gives us the values of t^* which are also efficient from a social point of view:

$$\tilde{t}(\beta) = 1 - \beta \tag{27}$$

This implies that firms overinvest in electronic commerce if $t^* > 1 - \beta$ and underinvest if $t^* < 1 - \beta$. Figure 1 shows $\tilde{t}(\beta)$ in $\beta \in [0, 1]$ and displays in addition the restriction that second stage profits of firm 2 must be greater than zero for transport costs t^*.

Before interpreting the results, it should be noted that we assumed t^* to be an interior solution of the profit maximization problem of firm 2. This, however, is only assured if the investment cost function is sufficiently convex. In the next section when we consider an explicit investment cost function we will check whether second order conditions are fulfilled. Keeping this caveat in mind, we may now discuss the results displayed in figure 1:

- As long as products are imperfect substitutes, i. e. $\beta \in]0, 1[$, either under- or overinvestment may happen under price and quantity competition, just depending on the exact value of t^* (which in turn depends on the investment cost function): A t^* close to zero (most likely if investment costs are low) is associated with underinvestment, while overinvestment tends to result if t^* approaches the zero profit restriction. Intuitively overinvestment is likely in situations where firm 2 remains inefficient even after investment while underinvestment happens in situations were transport cost differences between the two firms are small in equilibrium.

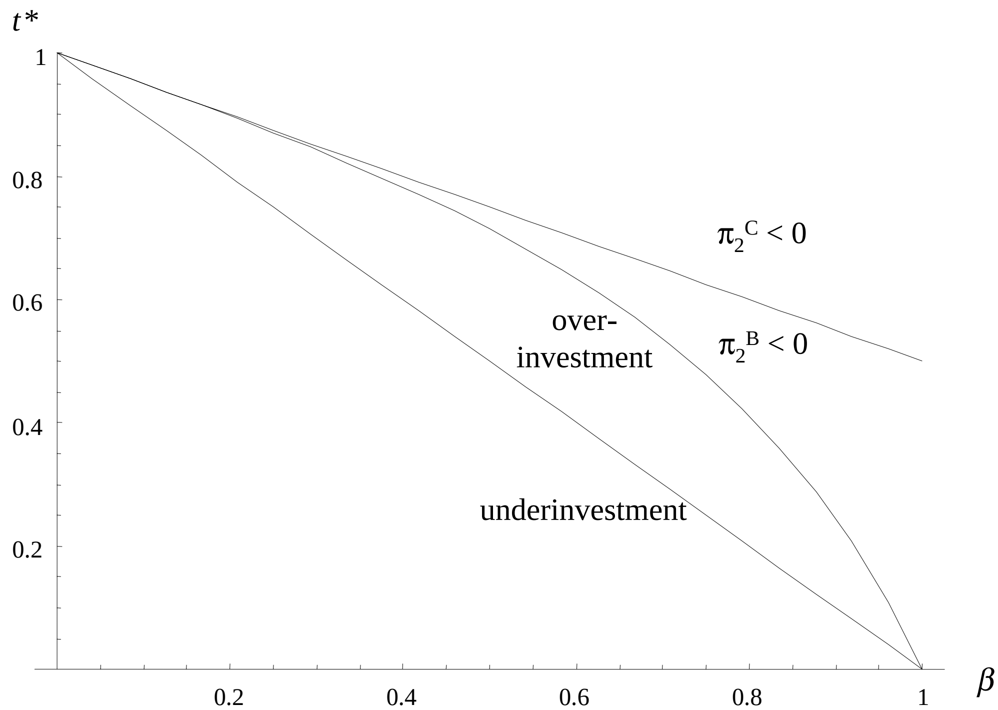

Figure 1: Efficiency of investment as a function of β and t^*

- Homogenous good quantity competition always yields overinvestment (except for efficient investment to the borderline case $t^* = 0$). This may be explained as follows: With homogenous products consumers do not derive additional utility by also consuming the good of the distant firm but only value the price reduction due to intensified competition. In addition the profits of the local firm are reduced more than under product differentiation.

  As expected, a firm has no incentive to invest in the case of homogenous good price competition, while an investment to $t^* = 0$ is welfare improving as long as the investment costs do not exceed the deadweight loss of monopoly pricing.

- While the borderline between over- and underinvestment is identical for both price and quantity competition, overinvestment is less likely with price strategies because more intense competition yields lower second stage profits of firm 2 and thus equilibrium transport costs are more likely to violate the zero profit constraint.

4 A quadratic investment cost function

We do now analyze the game with a quadratic investment cost function. This allows us to discuss how specific details of the investment cost function affect the results, we are able to analyze borderline cases like $t^* = 0$, and we can check whether second order conditions for profit or welfare maximization are actually met.

Because consumer surplus and second period profit functions are all convex in t, a linear investment function would always yield borderline cases, i. e. transport costs are either reduced to zero or no investment results. We therefore consider a quadratic investment cost function $I(t) = (t^0 - t)^2$ which ensures that second order conditions for profit and welfare maximization are always met under quantity competition and also under price strategies as long as products are not very close substitutes. The parameter t^0 may be naturally interpreted as the initial transport costs of firm 2. Assuming digital or digitalizable products the function will be defined on $t \in [0, t^0]$: In this case electronic markets may reduce transport costs to zero, meaning that the local firm has no longer any cost advantage. For physical products that still have to be shipped to the customer, however, it seems more reasonable to assume that transport costs could only be reduced but not eliminated. We therefore also discuss what happens if a lower bound greater zero is introduced for transport costs.

We start by determining first stage profits of firm 2 and welfare as a function of $I(t)$, t and β by assuming that for a given level of transport costs firms will follow second stage equilibrium strategies as derived in (8) through (15).[7]

$$\Pi_2^C = (1 - x_2^C - \beta x_1^C)x_2^C - t x_2^C - (t^0 - t)^2 = \tag{28}$$

$$\left[\frac{1 - t^0(2+\beta)^2}{(2+\beta)^2}\right] - \left[\frac{4 - t^0[2(2-\beta)(2+\beta)^2]}{(2-\beta)(2+\beta)^2}\right] t - \left[\frac{(6-\beta)^2}{(2-\beta)(2+\beta)}\right] t^2$$

$$\Pi_2^B = 1/(1-\beta^2)[(1-\beta) - p_2^B + \beta p_1^B](p_2^B - t) - (t^0 - t)^2 = \tag{29}$$

$$\left[\frac{(1-\beta) - t^0[(1+\beta)(2-\beta)^2]}{(1+\beta)(2-\beta)^2}\right] - \left[\frac{2(2-\beta^2) - t^0[2(1+\beta)(2+\beta)(2-\beta)^2]}{(1+\beta)(2+\beta)(2-\beta)^2}\right] t$$

$$- \left[\frac{12 - 20\beta^2 + 8\beta^4 - \beta^6}{(1+\beta)(1-\beta)(2+\beta)^2(2-\beta)^2}\right] t^2$$

[7] Note that x_i^B refers to the quantities which result in the second stage equilibrium with price strategies — W^B is written based on these quantities because the formula based on equilibrium prices would be much more complicated.

$$W^C = x_1^C + x_2^C - 1/2[(x_1^C)^2 + (x_2^C)^2 + 2\beta x_1^C x_2^C] - t x_2^C - (t^0 - t)^2 = \tag{30}$$

$$\left[\frac{(3+\beta) - t^0(2+\beta)^2}{(2+\beta)^2}\right] - \left[\frac{(3+\beta) - t^0[2(2+\beta)^2]}{(2+\beta)^2}\right] t - \left[\frac{20 - 15\beta^2 + 2\beta^4}{2(2+\beta)^2(2-\beta)^2}\right] t^2$$

$$W^B = x_1^B + x_2^B - 1/2[(x_1^B)^2 + (x_2^B)^2 + 2\beta x_1^B x_2^B] - t x_2^B - (t^0 - t)^2 = \tag{31}$$

$$\left[\frac{(3+2\beta) - t^0[(1+\beta)(2-\beta)^2]}{(1+\beta)(2-\beta)^2}\right] - \left[\frac{(3+2\beta) - t^0[2(1+\beta)(2-\beta)^2]}{(1+\beta)(2-\beta)^2}\right] t$$

$$- \left[\frac{20 - 39\beta^2 + 16\beta^4 - 2\beta^6}{(1+\beta)(1-\beta)(2+\beta)^2(2-\beta)^2}\right] t^2$$

Note that all these functions are quadratic in t and have the form $F = A - Bt - Ct^2$. Thus first order conditions are given by $\partial F/\partial t = -B - 2Ct = 0$ and second order conditions for a maximum are $\partial^2 F/\partial t^2 = -2C < 0$ which is fulfilled as long as $C > 0$. As can easily be seen by direct inspection of (28) through (31) this condition is always met under quantity competition while it fails to hold for β close to one under price competition. The second order conditions for profit and welfare maximization under price competition are met if inequalities (32) and (33) are fulfilled, respectively:

$$12 - 20\beta^2 + 8\beta^4 - \beta^6 > 0 \tag{32}$$

$$\iff \quad \beta^{\Pi_2^B} < \sqrt{\frac{1}{3}\left(8 - \left(46 - 6\sqrt{57}\right)^{1/3} - \frac{22^{2/3}}{\left(23 - 3\sqrt{57}\right)^{1/3}}\right)} \approx 0.932526$$

$$20 - 39\beta^2 + 16\beta^4 - 2\beta^6 > 0 \tag{33}$$

$$\iff \quad \beta^{W^B} < \sqrt{\frac{1}{6}\left(16 - \left(440 - 66\sqrt{42}\right)^{1/3} - \frac{22^{2/3}}{\left(20 - 3\sqrt{42}\right)^{1/3}}\right)} \approx 0.832203$$

It should be kept in mind that subsequent solutions derived for price strategies are thus only valid as long as these restrictions are met. Based on the first order conditions we obtain the following transport costs after investment (which for a given t^0 in turn imply investment costs $I(t^*) = (t^0 - t^*)^2$):

$$t^{C*} = \frac{-2(2-\beta) + t^0[(4-\beta^2)^2]}{(2-\beta^2)(6-\beta^2)} \tag{34}$$

$$t^{B*} = \frac{-(1-\beta)(2-\beta^2)(2+\beta) + t^0[(1-\beta^2)(2-\beta)^2(2+\beta)^2]}{12 - 20\beta^2 + 8\beta^4 - \beta^6} \tag{35}$$

$$\hat{t}^C = \frac{-(3+\beta)(2-\beta)^2 + t^0[2(2-\beta)^2(2+\beta)^2]}{20-15\beta^2+2\beta^4} \tag{36}$$

$$\hat{t}^B = \frac{-(3-2\beta)(1-\beta)(2+\beta)^2 + t^0[2(1-\beta^2)(2-\beta)^2(2+\beta)^2]}{20-39\beta^2+16\beta^4-2\beta^6} \tag{37}$$

Note that equilibrium values of t are negative for t^0 close to zero and thus the constraint $t \geq 0$ binds. On the other hand, for large t^0 the restriction $t \leq t^0$ must be considered.

We will now explicitly derive the solutions for quantity and price strategies and display the results in appropriate figures. Because quantity competition is especially relevant for non-digital goods, we also consider a Cournot model where transport costs can not be eliminated totally.

For quantity competition we must determine the combinations of β and t^0 where the interior solutions t^{C*} and $\hat{t}^C$ coincide as well as the limiting values $t^{C*} = 0$, $t^{C*} = t^0$, $\hat{t}^C = 0$ and $\hat{t}^C = t^0$.

$$t^{C*} = \hat{t}^C \iff t^0 = \frac{16-14\beta-8\beta^2+8\beta^3+\beta^4-\beta^5}{(4-\beta^2)^2} \tag{38}$$

$$t^{C*} = 0 \iff t^0 = \frac{2}{(2-\beta)(2+\beta)^2} \tag{39}$$

$$t^{C*} = t^0 \iff t^0 = \frac{2-\beta}{2} \tag{40}$$

$$\hat{t}^C = 0 \iff t^0 = \frac{3+\beta}{2(2+\beta)^2} \tag{41}$$

$$\hat{t}^C = t^0 \iff t^0 = \frac{(3+\beta)(2-\beta)^2}{12-\beta^2} \tag{42}$$

Using equations (38) through (42) we can display regions with over-, under- and efficient investments in a (β, t^0)–diagram similar to the one used in section 3. Figure 2 also shows the borderline for efficient investment derived in section 3 for the (β, t^*)–diagram to indicate how the areas for over- and underinvestment change if we base them on initial instead of equilibrium transport costs.

What can be seen in figure 2?

- If transport costs are relatively low initially, the firm will invest efficiently by reducing transport costs to zero.

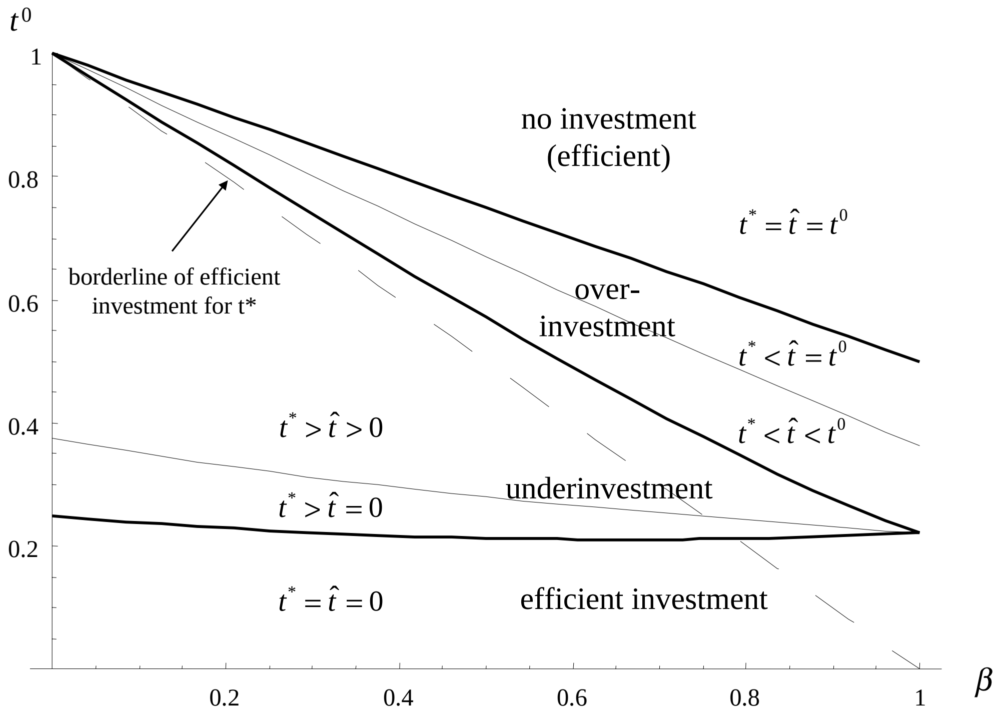

Figure 2: Efficiency of investment for quantity competition with a quadratic investment cost function

- For somewhat higher t^0 and thus also higher investment costs to obtain a certain level of t, it mainly depends on the degree of product differentiation whether over- or underinvestment results: For homogenous goods only overinvestment may happen while underinvestment results with independent products. For an intermediate level of product differentiation, medium levels of t^0 will yield underinvestment while we get overinvestment for t^0 close to the zero profit constraint.

- The firm has no incentive to invest if transport costs are initially so high that the zero profit constraint is violated. The decision of the firm is also socially efficient in this case because entry would reduce welfare: For any level of transport costs the necessary investment level exceeds the welfare increase due to the entry of the firm from the distant regions (for small investment levels the entrant is relatively inefficient which yields only a minor welfare improvement; on the other hand, achieving low transport costs would be very expensive).

How will these results be affected, if physical goods are considered and thus a reduction of transport costs to zero is no longer feasible? If we arbitrarily assume that transport costs could be reduced by no more than 50%, the restrictions $t^* = t^0/2$ and $\hat{t} = t^0/2$ replace the former limiting values $t^* = 0$ and $\hat{t} = 0$:

$$t^{C^*} = \frac{t^0}{2} \quad \Longleftrightarrow \quad t^0 = \frac{4(2-\beta)}{20 - 8\beta^2 + \beta^4} \tag{43}$$

$$\hat{t}^C = \frac{t^0}{2} \quad \Longleftrightarrow \quad t^0 = \frac{2(2-\beta)^2(3+\beta)}{44 - 17\beta^2 + 2\beta^4} \tag{44}$$

Figure 3 shows the results for this alternative formulation.

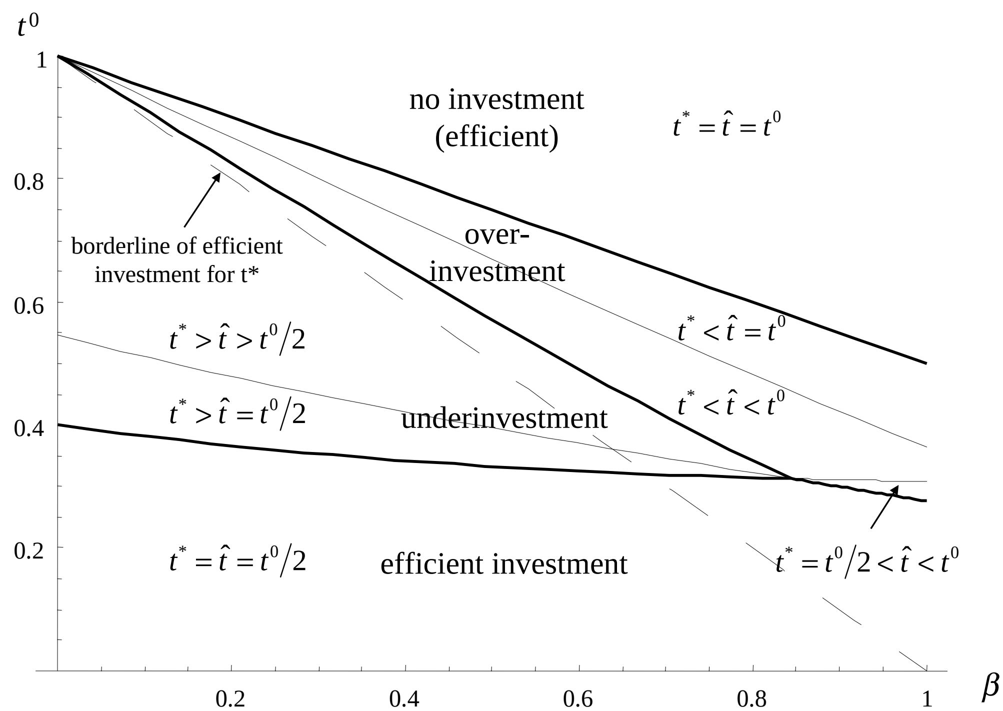

Figure 3: Efficiency of investment for quantity competition with a lower bound $t^0/2$.

By comparing it with figure 2 we observe two main changes:

- The (β, t^0)–area of efficient investment is enlarged since the lower bound restriction has tightened.
- For close substitutes firms may now overinvest in cases where transport costs in equilibrium are reduced as far as possible. How can we explain this difference between the two specifications? A marginal investment to $t^* = 0$ will also

be welfare increasing because the good will now be provided most efficiently (no more transport costs have to be incurred after the investment); therefore overinvestment could not result in this case. However, a marginal investment that reduces transport costs to some lower limit $\underline{t} > 0$ increases the market share of the distant firm and thus more people buy a product where transport costs have to be incurred; because this additional inefficiency is not considered by the investing firm, investment incentives may be excessive from a social point of view.

We now derive results for price strategies. Here we have to bear in mind that second order conditions are not met for all β. Similar to the calculations above, we first determine the combinations of β and t^0 where the interior solutions t^{B^*} and $\hat{t}^B$ coincide and the limiting values $t^{B^*} = 0$, $t^{B^*} = t^0$, $\hat{t}^B = 0$, $\hat{t}^B = t^0$.

$$t^{B*} = \hat{t}^B \quad \Longleftrightarrow \quad t^0 = \frac{16 - 14\beta - 8\beta^2 + 7\beta^3 + \beta^4 - \beta^5}{(4 - \beta^2)^2} \tag{45}$$

$$t^{B*} = 0 \quad \Longleftrightarrow \quad t^0 = \frac{2 - \beta^2}{(2 - \beta)^2(2 + 3\beta + \beta^2)} \tag{46}$$

$$t^{B*} = t^0 \quad \Longleftrightarrow \quad t^0 = \frac{(1 - \beta)(2 + \beta)}{2 - \beta^2} \tag{47}$$

$$\hat{t}^B = 0 \quad \Longleftrightarrow \quad t^0 = \frac{-3 + 2\beta}{2(2 - \beta)^2(1 + \beta)} \tag{48}$$

$$\hat{t}^B = t^0 \quad \Longleftrightarrow \quad t^0 = \frac{(1 - \beta)(3 - 2\beta)(2 + \beta)^2}{12 - 9\beta^2 + 2\beta^4} \tag{49}$$

Now let us consider the case where second order conditions are violated. Here $\hat{t}^B$ and t^{B^*} would minimize welfare and profits, respectively. Since $\partial^2 W^B/\partial t^2$ and $\partial^2 \Pi_2^B/\partial t^2$ are both constant in t, welfare and profit functions are strictly convex under these circumstances. As a consequence, the maximum of Π_2^B and W^B is either given for $t = 0$ or for $t = t^0$. Since marginal investment costs are zero for the first unit and grow slower than second stage profits (according to convexity), investment will be profitable as soon as Π_2^B exceeds zero, and it is socially efficient as long as welfare increases relative to the initial state.

$$\Pi_2^B|_{t=0} = 0 \quad \Longleftrightarrow \quad t^0 = \frac{(1 - \beta)(2 + \beta)}{\sqrt{1 - \beta^2}(4 - \beta^2)} \tag{50}$$

$$W^B|_{t=0} = W^B|_{t=t^0} \quad \Longleftrightarrow \quad t^0 = \frac{2(2 + \beta)^2(3 - 5\beta + 2\beta^2)}{44 - 57\beta^2 + 20\beta^4 - 2\beta^6} \tag{51}$$

Using equations (45) through (51), figure 4 displays regions with over-, under- and efficient investments in a (β, t^0)–diagram. As can be seen, results are not qualitatively different to that under quantity competition as long as products are sufficiently differentiated. For very close substitutes, however, investment is only likely if investment costs are quite low (in these cases it is usually also socially efficient).

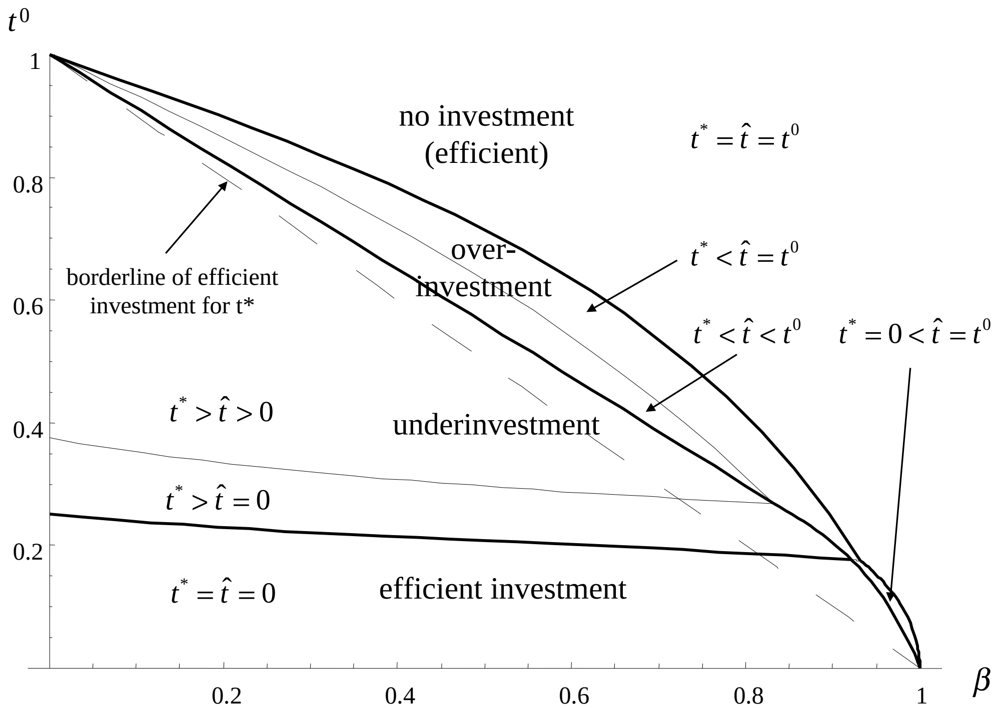

Figure 4: Efficiency of investment for price competition with a quadratic investment cost function

5 Conclusion

As has been shown, both underinvestment or overinvestment relative to the welfare maximizing strategy may result in equilibrium: The outcome depends on the degree of product differentiation, the competitive strategy (price or quantity competition) and the investment cost function. Overinvestment is most likely under quantity competition with a low degree of product differentiation, while underinvestment results if products are substantially differentiated and the initial transport costs are considerably below the zero profit level of transport costs for the distant firm.

If we take into account that each firm will face a similar investment problem with respect to its distant market, we see that firms are in a prisoners dilemma: Joint profits would rise if a firm reduces its investment in electronic coordination relative to equilibrium investment levels. However, because each firm could improve its position by deviating from the lower jointly optimal investment, competitors will overinvest in electronic markets from the industry perspective as long as they are not able to effectively coordinate their strategies.

From a public policy point of view the first lesson is that anti trust authorities should have a close look on efforts of firms in an industry to jointly develop electronic markets — underinvestment due to cartellization is quite likely in this case. What can be said if it is assured that firm strategies are set non–cooperatively? As has been shown a deviation from the social optimum is still likely. However, firms may either under- or overinvestment and given the sensitivity of the results to factors like market demand, firm conduct and investment costs, and the information disadvantage of public authorities with respect to these factors, it seems most reasonable not intervene in this investment decision.

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