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STRATEGICAL INTERACTIONS WITHIN TRANSPORT MARKETS

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Abstract

A model of supply and price competition in a differentiated duopoly is introduced in order to analyse strategical interactions between transport companies. By altering the order of moves taken by the operators, conditional on whether the supplies are flexible in the short run or not, and whether there is a leader and a follower, or the operators move simultaneously, four games are analysed. Among other things, the analyses show that if supplies are (in)flexible, the companies' actions can be considered as strategic complements (substitutes) in the case of substitutable services, resulting in a second (first) mover advantage. The results are reversed in the case of complementary services.

INTRODUCTION

The main aim of this paper is to discuss strategical interactions and possible market equilibria in transport markets when the operating transport companies' profits are inter-related. As pointed out in several theoretical and empirical works (see for example Evans, 1988, 1991b and Gwilliam, 1989 analysing deregulation in bus markets or Caves *et al* 1984, Morrison and Winston, 1990, Berry, 1990, Borenstein, 1990, Kumbhakar, 1992 and Baltagi *et al* 1995 studying deregulation in aviation), perfect competitive equilibria are not sustainable in transport markets. Many models describing transport companies' behaviour in deregulated markets have been inspired by the theory of product differentiation and monopolistic competition, see for instance Viton (1981), Dodgson and Katsoulacos (1988), Evans (1990) and Ireland (1991). It is assumed that there exist many transport operators who supply substitutable transport services and that the competition going on between them ("almost") reduces profit to zero. Another type of models which are applied in order to discuss market arrangements in transport markets are inspired by the theory of contestable markets, see Baumol *et al* (1982). Contestability is defined by a situation where there are only one transport company serving the market and this established company's actual actions reflect the threat from potential entrants. This means that the fares and supplies are chosen in a way which would give the potential entrants no possibility to obtain positive profits if they really should enter the markets (see for instance Bailey and Panzar, 1981, Trapani and Olsen, 1982 and Starkie, 1994 in their discussions of market arrangements in aviation.) As commented on by Shepherd (1984) and Evans (1991a), among others, perfect contestability (or "ultra-free" entry), like the assumption that many companies compete in order to be the market operator, is a rather restrictive condition never actually found in the transport markets. If there is a lack of contestability and/or there are a limited number of operating transport companies in the market, one has to search for other equilibria. Hence, based on the criticism of the traditions mentioned above, our study concerning equilibria will be based on a situation where there is a limited number of profit-maximising companies which operate in transport markets which are interrelated in demands, either as substitutes or complements, and where the operators do not face any competition from potential entrants. As far as we know, few attempts have been made to analyse equilibria in transport markets following from a competition between a limited number of operators supplying either substitutes or complements; exceptions for the case of substitutable transport services might be Williams and Abdulaal (1993) and Williams and Martin (1993), which are discussing market arrangements in the bus industry, and Nero (1996) which is analysing duopoly competition in the aviation markets.

In order to analyse the interaction between a limited number of transport operators, we apply a model of quantity and price competition in a differentiated oligopoly inspired by similar models within the general theory of industrial organisation, see for instance the textbooks written by Tirole (1988), Spulber (1989), Hay and Morris (1991), Martin (1993) and Rasmusen (1994). Compared with most of the models of differentiated oligopolies presented in these general textbooks, however, our analysis of strategical interactions focuses on some aspects which appear to be of special interest when studying competition in transport markets. Firstly, in line with what is commonly assumed in models intending to describe a transport operator's behaviour (see for instance Nash, 1978, Jansson, 1979), it is supposed that the transport company makes decisions regarding quantity and quality of supply and the fare level, where both the actual chosen supply and fare influence directly on the travellers' willingness to pay for transport services. Secondly, we will focus on various competitive games where there are differences in the order of moves taken by the transport companies.

THE MODEL

For the sake of simplicity, suppose that it is possible to identify two interrelated transport markets, where each of them are operated by a single transport company. Furthermore, as frequently assumed in theoretical analyses of price and quantity competition in differentiated oligopolies (see for instance Singh and Vives, 1984 and Gal-Or, 1985), we suppose that the transport companies are faced with linear demand functions given by

$$Z_m = Z_m(P_m, P_n) = a_{m0} - a_{mm}P_m + a_{mn}P_n\,, \qquad (1)$$

where P_m can be interpreted as the average users' costs among the consumers (also called generalised costs) by making one trip in market m. The a's are constants, $a_{m0} > 0$, $a_{mm} > 0$ and $a_{mm}a_{nn} - a_{mn}a_{nm} > 0$, $m,n=1,2$, $m...n$. When $\partial Z_m/\partial P_n = a_{mn} > 0$, the transport services supplied in market m and n are (gross) substitutes, while $a_{mn} = 0$ expresses that the services are independent in demand. Finally, if $a_{mn} < 0$, the services in market m and n will be (gross) complements in demand, $m,n = 1,2$, $m \neq n$. If we suppose that the same consumers are involved in the markets and we believe that the income effects of price changes are so low that we can ignore these, it follows from Shephards lemma that $a_{mn} = a_{nm}$. A consumer's costs by making one journey in market m are the sum of the fare paid and the value of the travel time she must spend by making this trip. When ignoring price discriminating behaviour from each of the companies, we can define p_m as the uniform fare level paid by all of the travellers in market m. Furthermore, we let Q_m symbolise the average valuation of the travel time of one journey in market m. It then follows that average users' costs in market m, P_m, are given by

$$P_m = p_m + Q_m,\ m = 1,2. \qquad (2)$$

Additionally, we suppose that the companies can affect the average valuation of the consumers' travel time by changing the quantities and qualities of the services they supply. If the companies increase quantity or quality of the regular services supplied, we assume that the average consumers' valuation of one journey reduces, but at a lower rate as the supply is increased. For the sake of simplicity, we suppose that the different aspects the services supplied, like frequencies, speed and type of conveyance, can be measured by the uniform variable R_m, $m=1,2$. This gives us functions of the type

$$Q_m = Q_m(R_m),\ dQ_m/dR_m < 0,\ d^2Q_m/dR_m^2 > 0,\ m=1,2. \qquad (3)$$

Also for the purpose of attaining an easily tractable model, we assume that the costs of producing transport services in both markets are given by the linear functions

$$C_m = C_m(Z_m, R_m) = b_{m0} + b_{m1}Z_m + b_{m2}R_m, \qquad (4)$$

where $b_{mj} > 0$, $m=1,2$ and $j=0,1,2$. Then, by using eqns (1), (2), (3) and (4) it follows that the profit in market m, π_m, is given by:

$$\pi_m = p_mZ_m[p_m+Q_m(R_m), p_n+Q_n(R_n)] - C_m\{Z_m[p_m+Q_m(R_m), p_n+Q_n(R_n)], R_m\} = \qquad (5)$$
$$\pi_m(p_m, p_n, R_m, R_n),\ m,n=1,2,\ m \neq n.$$

By defining profits as in eqn (5) above, implicitly, we have ignored the possibility that the travellers might be rationed.

MARKET EQUILIBRIA

Four different market equilibria are considered. The various competitive situations are defined by differences in the order of moves. Game A below is defined by the situation where the regular services are flexible and can be changed as often as fares and where the companies move simultaneously. This means that case A defines a-one-shot game where all decisions are made at the same time. The equilibrium in game A is found when the two transport operators both can alter their services in the short run, and when none of the companies has any leading market position. Also in case B the regular services are supposed to be flexible in the short run, but one of the companies is supposed to be a leader and therefore be able to choose fare and supply before the other. This defines game B as a two-stage game where the leading company first chooses fare and supply. Then, after the other operator has observed the leader's chosen fare and supply, it adjusts its fare and level of scheduled services. This means that game B characterises the situation of flexibility in supplies and asymmetry regarding the companies' market positions. The competitive equilibrium focused on in case C can also be described as an outcome following from a two-stage game, where the companies at the first stage simultaneously choose supply, and secondly, after being observing the other's move regarding the regular services, they simultaneously choose fares. Hence, we can think of the market arrangement in case C as the outcome in situations where the companies have equal market positions and where the supplies are inflexible in the short run. The competition which we finally study, case D, can be seen as the outcome following from a three stage-game where one of the companies has the ability to choose regular services first. Then, after being observing the leader's chosen level of regular services, the follower makes his decision regarding supply. Finally, after the levels of scheduled services are commonly known, both companies simultaneously choose fares. This means that game D gives the outcome in a situation where the two companies' levels of regular services are inflexible in the short run, and where one of the operators has a leading market position.

The Nash equilibrium in case A is found by assuming that each of the operating companies are maximising profits with regard to its fare and transport supply, given the fare level and the level of transport supply in the other market. From eqn (1), (2), (3), (4) and (5) it follows that the fare levels and the transport supplies must satisfy the following conditions

$$\partial\pi_m /\partial p_m = Z_m + (p_m - b_{m1})(-a_{mm}) = 0 \qquad (6)$$

and

$$\partial\pi_m/\partial R_m = (p_m - b_{m1})(-a_{mm})(dQ_m/dR_m) - b_{m2} = 0\,, \qquad (7)$$

$m=1,2$. The associated second order conditions are here and throughout the analyses supposed to be satisfied, but they are excluded from the presentations. The market equilibrium, defined by eqn (6) and (7), is symbolised by $(p_m^A, p_n^A, R_m^A, R_n^A)$.

Firstly, we notice that if the transport services are independent in demand, i.e. $a_{mn} = a_{nm} = 0$, the monopoly market equilibria are obtained in each of the markets. However, when the demands are interrelated, i.e. $a_{mn} = a_{nm} \neq 0$, the chosen fare and supply in market m would be affected by the choice of fare and supply in market n, $m,n=1,2,\ m\neq n$. From eqn (7) it is seen that a company's marginal profit with respect to its transport services is independent of the other operator's chosen fare and supply, i.e. $(\partial\pi_m /\partial R_m\partial R_n) = (\partial^2\pi_m/\partial R_m\partial p_n) = 0$. Furthermore, it follows that the company's actual choice of regular services is directly dependent on the choice of fare because $(\partial^2\pi_m/\partial R_m\partial p_m) = (-a_{mm})(dQ_m/dR_m) > 0$, and therefore indirectly through eqn (6) also dependent on the other company's chosen fare and supply.

Let us now consider case B where one of the companies has the ability to adjust the fare level and transport supply before the company operating in the other transport market, and where the regular services are flexible in the short run. We regard company m as the leader and company n as the follower. The equilibrium of this game is found by backward induction, i.e. we first look on company n's optimal behaviour for a given strategy choice of company m. This gives us that the follower will adjust its fare and supply such that eqn (6) and (7) are satisfied (interpreted for company n). When company m is going to determine its strategies, it knows company n's reactions on its choices, implicitly given by eqn (6) and (7) above, i.e.

$p_n=p_n^{\sim}(p_m,R_m)$ and $R_n=R_n^{\sim}(p_m,R_m)$ where (8)

$\partial p_n^{\sim}/\partial p_m =$

$a_{nm}(p_n-b_{n1})(d^2Q_n/dR_n^2)/a_{nn}[2(p_n-b_{n1})(d^2Q_n/dR_n^2)-(dQ_n/dR_n)^2]\geq(<)0,$
$\partial p_n^{\sim}/\partial R_m = (dQ_m/dR_m)(\partial p_n^{\sim}/\partial p_m)\leq(>)0,$
$\partial R_n^{\sim}/\partial p_m = -(\partial p_n^{\sim}/\partial p_m)[(dQ_n/dR_n)/(p_n-b_{n1})(d^2Q_n/dR_n^2)]\geq(<)0,$
$\partial R_n^{\sim}/\partial R_m = (dQ_m/dR_m)(\partial R_n^{\sim}/\partial p_m)\leq(>)0,$
$\partial P_n^{\sim}/\partial p_m = \partial p_n^{\sim}/\partial p_m + (dQ_n/dR_n)(\partial R_n^{\sim}/\partial p_m) =$
$(\partial p_n^{\sim}/\partial p_m)F_n/[(p_n-b_{n1})(d^2Q_n/dR_n^2)]\geq(<)0$ and
$\partial P_n^{\sim}/\partial R_m = \partial p_n^{\sim}/\partial R_m + (dQ_n/dR_n)(\partial R_n^{\sim}/\partial R_m) =$
$(dQ_m/dR_m)(dP_n^{\sim}/dp_m)\leq(>)0$
as $\partial Z_n/\partial P_m = a_{nm} \geq (<) 0$, where
$\cdot F_n = [(p_n-b_{n1})(d^2Q_n/dR_n^2)-(dQ_n/dR_n)^2] > 0,\ m,n=1,2,\ m\neq n.$

The signs above follow from the assumptions in eqn (1), (2), (3) and (4), and the second order conditions related to company's profit maximum problem. Furthermore, the sign of F_n follows from a concavity assumption related to a consumer welfare function defined on the basis of the market demands in (1). This means that the positive F_n tells us that the consumers' marginal gain of higher levels of regular services in market n becomes lower as the supply increases. Furthermore, from eqn (8) it is seen that the follower (n) will increase (decrease) its fare when the leader (m) increases fare or reduces regular services if the transport supplies are substitutes (complements), i.e. $\partial p_n^{\sim}/\partial p_m \geq (<) 0$ and $\partial p_n^{\sim}/\partial R_m \leq (>) 0$. Moreover, the follower would increase (reduce) his transport services if the market leader increases fare or decreases supply if the companies' supply substitutable (complementary) transport services, i.e. $\partial R_n^{\sim}/\partial p_m \geq (<) 0$ and $\partial R_n^{\sim}/\partial R_m \leq(>) 0$. As commented on above, the follower's transport supply are only indirectly dependent on the leader's choice of fare and supply. This means that in all cases where the follower wants to increase (decrease) his fare, he also wants to increase (decrease) his level of regular services. This leads to two effects on generalised costs in the follower's market where the first one is positive (negative) and the second one in negative (positive). However, the effect which follows from a change in fare level will always dominate the effect following from the change in transport supply. This means that in the case of substitutable (complementary) regular services, a higher fare level or a lower supply in the leader's market will result in higher (lower) generalised costs in the follower's market, i.e. $\partial P_n^{\sim}/\partial p_m \geq (<) 0$ and $\partial P_n^{\sim}/\partial R_m \leq (>) 0$. Compared to a case of simple price competition, for instance characterised by a situation where the companies are unable to choose their levels of transport supplies, or a situation where the supplies have no impact on the users' costs and demands directly, our mixed price and quantity competition model in case A and B gives lower slope values of the reaction functions. By using the expressions in the eqns in (8), it follows that $|\partial P_n^{\sim}/\partial p_m| = |\partial p_n^{\sim}/\partial p_m| G < |\partial p_n^{\sim}/\partial p_m|$, where $0 < G = \{1-[(dQ_n/dR_n)^2/(p_n-b_{n1})(d^2Q_n/dR_n^2)]\} < 1$. This means that the supply competition, which is going on together with the price competition, weakens the strategical interactions between the companies in game A and B. However, as in the simple price competition games, a more "aggressive" strategy chosen by the leading company, either as a lower fare level or a higher level of supply, causes the following company to choose a more (less) "aggressive strategy", resulting in lower (higher) users' costs in its market in the case of substitutable (complementary) transport services. Hence, in the terms of Bulow *et al* (1985), we might say that the interaction in game A and B above is characterised by strategic complements (substitutes) if the services are substitutes (complements). In other words, the reaction functions in game A and B, defined by the generalised costs in the markets, $P_n = P_n^{\sim}(p_m,R_m) = P_n[p_m+Q_m(R_m)] = P_n(P_m)$ are upwards (downwards) sloping in the case of substitutes (complements), i.e. $dP_n/dP_m \geq (<) 0,\ m,n=1,2,\ m\neq n$. The similarity between the strategical interactions focused on above and what is found in the simple price (Bertrand) competition game has led us to use the term modified price competition (MPC) as a description of the mixed price and supply competition in game A and B. Although the supply competition weakens the price competition, the usage of the term MPC illustrates that the price competition dominates in the strategical interactions between the companies. This result is similar to what is found elsewhere. For instance, in a alternating-move infinite-horizon model of homogenous duopoly, where the firms choose prices, Maskin and Tirole (1988b) show that a dynamic price competition gives a "less competitive" outcome than static price-competition. This means that the companies' possibilities to react on the others' moves relax "the degree of price competition".

By using the eqns in (5) and (8), one can express the leader's profit function by $\pi_m = \pi_m[p_m, p_n^-(p_m,R_m), R_m, R_n^-(p_m,R_m)] = \pi_m^{BL}(p_m,R_m)$. Then it follows that the necessary conditions for maximum profit in market m are given by

$$\partial\pi_m^{BL}/\partial p_m = \partial\pi_m/\partial p_m + (\partial\pi_m/\partial p_n)(\partial p_n^-/\partial p_m) + (\partial\pi_m/\partial R_n)(\partial R_n^- \partial p_m) = Z_m + (p_m - b_{m1})[(-a_{mm}) + a_{mn}(\partial P_n^-/\partial p_m)] = 0, \quad (9)$$

and

$$\partial\pi_m^{BL}/\partial R_m = \partial\pi_m/\partial R_m + (\partial\pi_m/\partial p_n)(\partial p_n^-/\partial R_m) + (\partial\pi_m/\partial R_n)(\partial R_n^-/\partial R_m) = - b_{m2} + (p_m - b_{m1})[(-a_{mm})(dQ_m/dR_m) + a_{mn}(\partial P_n^-/\partial R_m)] = - b_{m2} + (p_m - b_{m1})(dQ_m/dR_m)[a_{mn}(\partial P_n^-/\partial p_m) - a_{mm}] = 0. \quad (10)$$

Eqns (9) and (10), and eqns (6) and (7) interpreted for company n, define the complete L/F Nash-equilibrium in case B where company m has the ability to choose p_m and R_m before company n chooses p_n and R_n. Let $(p_m^{BL}, p_n^{BF}, R_m^{BL}, R_n^{BF})$ denote the values of this leader-follower equilibrium. It follows from eqn (8) that the expression $(p_m - b_{m1})[a_{mn}(\partial P_n^-/\partial p_m)]$ in eqn (9) is positive when $a_{mn} = a_{nm} \neq 0$. By directly comparing eqn (6) and (9), and using the concavity of the profit function, it is seen that this effect leads to a higher fare level in market m in case B compared to case A. Analogously, it follows from eqn (8) that the expression $(p_m - b_{m1})[a_{mn}(dQ_m/dR_m)(\partial P_n^-/\partial p_m)]$ in eqn (10) is negative when $a_{mn} = a_{nm} \neq 0$. By directly comparing eqn (7) and (10), and using the concavity of the profit function, this effect will lead to a lower transport supply in market m in case B than in case A. By a total comparison between the equilibria in case A and B, these direct effects commented on above will dominate. Furthermore, the global comparisons of the equilibria in A and B, and between the outcomes in case B and the situation where the market positions are reversed, i.e. n is the leading company and m is the follower, give us the following results

$$p_m^{BL} \geq p_m^A,\ R_m^{BL} \leq R_m^A,\ P_m^{BL} \geq P_m^A, \quad (11)$$
$$p_n^{BF} \geq (<)\, p_n^A,\ R_n^{BF} \geq (<)\, R_n^A,\ P_n^{BF} \geq (<)\, P_n^A,$$
$$p_m^{BL} \geq p_m^{BF},\ R_m^{BL} \leq R_m^{BF},\ P_m^{BL} \geq P_m^{BF} \text{ as } a_{mn} = a_{nm} \geq (<)\, 0.$$

The first two inequalities in the first line in (11) tells us what is already commented on above; company m chooses a higher fare and a lower level of regular services as a market leader than in the simultaneous case in game A. Both effects lead to higher generalised costs in market m in case B compared to case A ($P_m^{BL} > P_m^A$). Furthermore, as seen by the second line in (11), the size of the fare level and supply in the follower's market n in case B compared to the simultaneous case in A will be conditional on the sign of a_{nm}. In the case of substitutes (complements), the transport company in market n will charge a higher (lower) fare level and a higher (lower) supply than in case A above, i.e. $p_n^{BF} > (<)\, p_n^A$ and $R_n^{BF} > (<)\, R_n^A$. The effect on generalised costs stemming from higher fare dominates the effect stemming from higher supply, which leads to higher (lower) users' costs in market n in the leader-follower case if the services are substitutes (complements), $P_n^{BF} > (<)\, P_n^A$. Hence, from the consumers point of view, the simultaneous Nash-equilibrium in case A will always be better than the leader-follower Nash-equilibrium in case B if the transport services are substitutes because the outcome in case A compared to case B gives lower generalised costs in both markets. In the case of complements, however, the consumers costs where the leader operates, will be higher ($P_m^{BL} > P_m^A$), while the generalised costs will be lower in the other market ($P_n^{BF} < P_n^A$). This gives an ambiguous consumer ranking of the outcomes in the case of complements.

From the third line in (11) it is also seen that a transport operator chooses a higher fare level and a lower transport supply as a leader than as a follower ($p_m^{BL} > p_m^{BF}$ and $R_m^{BL} < R_m^{BF}$), resulting in higher generalised consumers costs in the market ($P_m^{BL} > P_m^{BF}$). Furthermore, by using the results in (11) it follows that

$$\pi_m^A = \pi_m(p_m^A, p_n^A, R_m^A, R_n^A) \leq \pi_m^{BL} = \pi_m(p_m^{BL}, p_n^{BF}, R_m^{BL}, R_n^{BF}) \quad (12)$$
$$\pi_n^A = \pi_n(p_m^A, p_n^A, R_m^A, R_n^A) \leq (>) \pi_n^{BF} = \pi_n(p_m^{BL}, p_n^{BF}, R_m^{BL}, R_n^{BF})$$
$$\pi_m^{BF} = \pi_m(p_m^{BF}, p_n^{BL}, R_m^{BF}, R_n^{BL}) \geq (<) \pi_m^{BL} = \pi_m(p_m^{BL}, p_n^{BF}, R_m^{BL}, R_n^{BF})$$

as $a_{mn} = a_{nm} \geq (<) 0,\ m,n=1,2,\ m \neq n$. The two first lines in (12) tells us that both companies will gain profits by playing game B instead of game A if the services are substitutes. In the case of complements, it is only the leader which receives higher profits in case B compared to case A. From the third line in (12) it is also seen that a company, if game B is played, will prefer being the follower instead of being the leader if the operators supply substitutable transport services. This is by Gal-Or (1985) called a second-mover advantage. However, in the case of complements, it is seen that the leading position is preferred, i.e. there will be a first-mover advantage.

Let us now look on case C where the regular services are inflexible in the short run, while fares are flexible. Furthermore, no company has any leader position in the market. In this two-stage game, the transport operators are supposed to choose transport supplies simultaneously at the first stage. Then, after being observing each others chosen supplies, the transport operators simultaneously determine their fares. In order to find the Nash-equilibrium of this game, we follow the traditional procedure of backward induction, which means that the solution can be found by studying the strategy choices in two sub-games. First there is a supply or quantity competition, secondly the companies adjust fares. The solution of the second sub-game is given by eqn (6) which implicitly define the fares as functions of R_m and R_n, i.e.

$$p_m = p_m^*(R_m, R_n) \text{ where} \quad (13)$$
$$\partial p_m^*/\partial R_m = -(dQ_m/R_m)[(2a_{mm}a_{nn} - a_{mn}a_{nm})/(4a_{mm}a_{nn} - a_{mn}a_{nm})] > 0$$
and
$$\partial p_m^*/\partial R_n = (dQ_n/dR_n)a_{mn}a_{nn}/(4a_{mm}a_{nn} - a_{mn}a_{nm}) \leq (>) 0 \text{ if } a_{mn} \geq (<) 0,\ m,n=1,2,\ m \neq n.$$

This means that a partial increase in the ex ante chosen supply in a market will be followed by a higher fare level to the travellers *ex post* in the same market ($\partial p_m^*/\partial R_m > 0$). Furthermore, a higher level of regular services chosen *ex ante* in one market will lead to a reduction in the fare for a substitutable service ($\partial p_m^*/\partial R_n < 0$), and lead to an increase in the fare for a complementary service ($\partial p_m^*/\partial R_n > 0$). By using the eqns in (3) and (13), we see that $\partial P_m^*/\partial R_m = \partial p_m^*/\partial R_m + (dQ_m/dR_m) = (dQ_m/dR_m)2a_{mm}a_{nn}/(4a_{mm}a_{nn} - a_{mn}a_{nm}) < 0,\ m=1,2$. This means that an exogenous increase in *ex ante* chosen supply in a market will result in a reduction *ex post* in the average users' costs in the particular market. The reduction of generalised costs in the market follows because the consumers' average valuation of the travel time per trip decreases as a consequence of higher *ex ante* supply ($dQ_m/dR_m < 0$), and this effect will dominate the positive effect caused by a higher fare level. Furthermore, a higher level of transport supply *ex ante* in one market will reduce (increase) the generalised costs in the other market in the case of substitutable (complementary) transport services, i.e. $\partial P_n^*/\partial R_m = \partial p_n^*/\partial R_m \leq (>) 0$. It then follows from eqn (1) and (13) that a higher level of regular services supplied *ex ante* in one market will increase the number of travellers *ex post* in the same market, even though the fare level increases in the particular market and the generalised costs are influenced in a way which weakens the effect of increased supply, i.e. $dZ_m/dR_m = -a_{mm}(\partial P_m^*/\partial R_m) + a_{mn}(\partial P_n^*/\partial R_m) = -a_{mm}(dQ_m/R_m)[(2a_{mm}a_{nn} - a_{mn}a_{nm})/(4a_{mm}a_{nn} - a_{mn}a_{nm})] > 0,\ m,n=1,2,\ m \neq n$. Moreover, eqn (13) inserted in eqn (5) gives the profit functions for the transport companies

$$\pi_m = \pi_m(p_m^*(R_m, R_n), p_n^*(R_m, R_n), R_m, R_n) = \pi_m^C(R_m, R_n). \quad (14)$$

Then, the solution of the first sub-game in case C is found by maximising $\pi_m^C(R_m, R_n)$ w.r.t. R_m, $m,n=1,2,\ m...n$. This means that the Nash-equilibrium of the competitive game C must satisfy, in addition to the conditions given in eqn (6), the following equations

$$\partial \pi_m^C/\partial R_m = \partial \pi_m/\partial R_m + (\partial \pi_m/\partial p_n)(\partial p_n^*/\partial R_m) = \quad (15)$$
$$[a_{mn}(\partial p_n^*/\partial R_m) - a_{mm}(dQ_m/dR_m)](p_m - b_{m1}) - b_{m2} = 0,\quad m,n=1,2,\ m \neq n..$$

Let us denote this equilibrium related to case C by $(p_m^C, p_n^C, R_m^C, R_n^C)$. From eqn (13) it follows that the expression $a_{mn}(\partial p_n^* / \partial R_m)$ in eqn (15) is negative when $a_{mn} = a_{nm} \neq 0$, $m,n=1,2$, $m \neq n$. By a directly comparison between eqn (7) and (15), it is seen that this effect leads to lower transport supplies in both markets in case C compared to case A. In order to see why, suppose one of the companies in case C assesses to increase the level of the regular services in the market. Unlike the game in case A, the operator knows that the other company will response on this higher choice of regular services when its determining the fare level in the second stage of the game. From eqn (13) it is seen that a company supplying substitutable routes chooses a lower fare and an operator supplying complementary transport services reacts by increasing fares *ex post* as a consequence of a higher level of regular services. In both cases the reactions would reduce demand in the first company's market, resulting in lower profits. Hence, knowing this response, the transport operator will choose to supply less regular services than in a situation where such reactions from other companies are absent, i.e. in case A ($R_m^C < R_m^A$).

Furthermore, remembering that the fare levels in case A and C are implicitly given eqn (6) and that $\partial p_m^* / \partial R_m > 0$, it follows that the equilibrium fare levels will be lower in a game C compared to game A, i.e. $p_m^C < p_m^A$. However, the users' costs within the transport markets will be higher in case C than in case A. This means that the reductions in fares by moving from case A to B will be more than offset by the negative effects the higher levels of supplies have on the generalised costs, i.e. $\partial P_m^* / \partial R_m < 0$. This means that from the travellers' point of view, simultaneous moves of fares and regular services are preferred even though it results in higher fare levels on the routes. In short, the global comparison between the market arrangements in case A and C, has led to the following results

$$R_m^C \leq R_m^A, \; p_m^C \leq p_m^A, \; P_m^C \geq P_m^A, \tag{16}$$

where the equalities hold when $a_{mn} = a_{nm} = 0$, $m,n=1,2$, $m \neq n$. It is also interesting to know which kind of game, A or C, is preferred by the companies. Using the results in (16), it is found that

$$\pi_m^C = \pi_m(p_m^C, p_n^C, R_m^C, R_n^C) \geq (<) \pi_m^A, \tag{17}$$

as $a_{mn} = a_{nm} \geq (<) \; 0$, $m,n=1,2$, $m \neq n$. This means that in the case of substitutes (complements), both companies would prefer case C (case A). The results in (17) is seen by the following reasoning: Let us first consider the situation where the transport services supplied are complements and that the transport companies originally play the MPC game in case A. Then, let us suppose that company m, instead of choosing p_m^A and R_m^A, chooses p_m^C and R_m^C. This would reduce his profits because the originally values p_m^A and R_m^A maximised the profits for company n's chosen values p_n^A and R_n^A. Furthermore, if company n, instead of choosing p_n^A and R_n^A, actually chooses p_n^C and R_n^C, this results in higher generalised costs in market n, i.e. $P_n^C > P_n^A$, which leads to a fall in the demand for company m's routes and its profits will be additionally reduced. This indicates that $\pi_m^A > \pi_m^C$ in the case of complements. The reasoning follows the same lines in the case of substitutes. Suppose now that the companies originally play game C. If company m chooses R_m^A instead of R_m^C, its profits will be reduced because the value R_m^A maximises profits for company n's choice R_n^C. Furthermore, if company n chooses a higher level of regular services instead of R_n^C, for instance $R_m^A > R_m^C$, the demand in company m's market reduces, leading to an additionally fall in company m's profits. This tells us that $\pi_m^A < \pi_m^C$ in the case of substitutable regular services.

Generally, it is seen that the possibility to react on each others choices of regular services in the second stage of the game (by determining fares) in case C, relaxes the "degree of competition" between substitutable transport services compared to case A. In the case of complementary transport services, however, the higher levels of supplies, resulting in lower generalised costs in case A compared to case C, induce higher demands and profits in game A than in game C. The results in (17) are in accordance with conclusions drawn in Singh and Vives (1984) and Cheng (1985). In a heterogeneous duopoly, where the market structure is given by linear demand and cost functions, they find, by comparing the simultaneous equilibria following from simple price (or

Betrand) competition and simple quantity (or Cournot) competition, that the consumers always will prefer price competition to quantity competition, and that the firms will prefer quantity (price) competition in the case of substitutes (complements). We have seen that this result also holds for the one-shot MPC game in case A compared to the two stage quantity-price competition game in case C.

Game D is characterised a company being able to determinate his level of supply first and inflexible regular services in the short run. First transport operator m chooses his level of regular services. Then company n, after being observing company m's supply level, determinate his supply, and, finally, when supplies are known, the companies simultaneously choose their fare levels. In order to find the Nash-equilibrium of game D, we first look into the companies' behaviour in the third stage in the game. At this stage the transport operators simultaneously determinate their fare levels, and the optimal behaviour must satisfy the conditions given in eqn (6). The optimal choice in second stage, where the following transport operator determines his transport supply, is described by equation (15), interpreted for company n. Implicitly, eqn (15) defines the level of regular services chosen by company n as function of the supply determinate by company m, i.e.

$$R_n=R_n^*(R_m). \qquad (18)$$

From eqn (15) it follows that $dR_n^*/dR_m = H/J \leq (>)\ 0$ where $H=-(dQ_n/dR_n)(dQ_m/dR_m)a_{mm}a_{nm} \leq (>) 0$ and $J=(4a_{mm}a_{nn}-a_{mn}a_{nm})(d^2Q_n/dR_n2)(p_n-b_{n1})-(2a_{mm}a_{nn}-a_{mn}a_{nm})(dQ_n/dR_n)^2>0$ as $a_{mn} = a_{nm} \geq (<)\ 0$, $m,n=1,2,\ m \neq n$.

It is seen from eqn (18) that if the leader (transport company m) increases his supply, the follower (company n) will reduce (increase) his level of regular services in the case of substitutes (complements). In the terms of Bulow *et al* (1985), the transport supplies are strategic substitutes (complements) in the case of substitutable (complementary) transport services. Alternatively, one could say that case D leads to downwards (upwards) sloping reaction function in the case of substitutes (complements). In any case, this is the opposite conclusion of what was seen in the leader-follower model in case B, where the responses in generalised costs gave us strategical complements in the case of substitutable transport services (or upwards sloping reaction functions defined on the users' costs) and strategical substitutes (or downwards sloping reaction functions defined on the generalised costs) in the case of complementary regular services. The games in case C and D, which are characterised by a quantity competition in the first round and a price competition in a second round, are in fact giving similar strategical interactions as in simple one-shot quantity (Cournot) competition games. This means that the supply competition in the first stage of the game dominates the price competition in the second stage. Our findings are in accordance with Kreps and Scheinkman (1983) which search for equilibrium in a two stage game, where the firms, producing homogenous products, in the first round compete in quantities and in the second round compete in prices. They show that the Cournot outcome (under some circumstances) is the equilibrium of the game. The dominance of the quantity competition in the first stage of game C and D has led us to use the term modified quantity competition (MQC) as a description of the strategical interactions going on in these games.

In order to deduce the Nash-equilibrium in case D, eqn (18) is inserted in eqn (14) giving us the profit function for the leading company m

$$\pi_m = \pi_m^C[R_m, R_n^*(R_m)] = \pi_m^{DL}(R_m). \qquad (19)$$

In the first stage of this competitive game, the leader maximises eqn (19) with regard to R_m. This gives us the following first order condition

$$d\pi_m^{DL}/dR_m = \partial\pi_m^C/\partial R_m + (\partial\pi_m^C/\partial R_n)(dR_n^*/dR_m) = \qquad (20)$$

$$\partial\pi_m/\partial R_m + (\partial\pi_m/\partial p_n)(\partial p_n^*/\partial R_m) + (\partial\pi_m^C/\partial R_n)(dR_n^*/dR_m) = 0$$

where $\partial\pi_m^C/\partial R_n = (\partial\pi_m/\partial p_n)(\partial p_n^*/\partial R_n) + (\partial\pi_m/\partial R_n) =$
$[2a_{mm}a_{nn}(p_m-b_{m1})a_{mn}(dQ_n/dR_n)]/(4a_{mm}a_{nn}-a_{mn}a_{nm}) \leq (>)\ 0$ as $a_{mn} \geq (<)\ 0,\ m,n=1,2,\ m \neq n$.

Firstly, it should be noticed that the expression $(\partial\pi_m^C/\partial R_n)(dR_n^*/dR_m) \geq 0$, where equality holds when the demands are independent, i.e. $a_{mn} = a_{nm} = 0$. Let us denote the equilibrium of case D by $(p_m^{DL}, p_n^{DF}, R_m^{DL}, R_n^{DF})$. By comparing the conditions in eqn (6), (16) (interpreted for the following company n) and (20), defining the equilibrium in game D to the conditions in eqn (6) and (16), giving the equilibrium in game C, and by comparing company m's strategy choice in the case where company m is a leader to the case where it is a follower, it is seen that

$$R_m^{DL} \geq R_m^C,\ p_m^{DL} \geq p_m^C,\ P_m^{DL} \leq P_m^C \qquad (21)$$
$$R_n^{DF} \leq (>)\, R_n^C,\ p_n^{DF} \leq (>)\, p_n^C,\ P_n^{DF} \geq (<)\, P_n^C$$
$$R_m^{DL} \geq R_m^{DF},\ p_m^{DL} \geq p_m^{DF},\ P_m^{DL} \leq P_m^{DF} \text{ as } a_{mn} = a_{nm} \geq (<)\, 0,\quad m,n=1,2,\ m \neq n.$$

In the case of substitutes, game D gives higher transport supply in the leader's market (m) than in case C and lower transport services in the follower's market (n) compared to case C. This means that the fares will be respectively higher and lower. The regular services influence on the consumers' costs will dominate the effect following from the changes in fare levels, which gives lower generalised costs in market m and higher generalised costs in market n in case D compared with case C. However, it the services are complements, the effects by moving from case C to case D will be exactly the opposite in market n operated by the follower. Moreover, it is seen from (21) that a company which moves from a follower position to the leading position will choose to increase transport services and fares, where the dominating effect on generalised costs would stem from the increased transport supply. This results in lower generalised costs in the market if the company becomes the leader instead of the follower.

Furthermore, by using the results in (21), it follows that

$$\pi_m^C \leq \pi_m^{DL} = \pi_m(p_m^{DL}, p_n^{DF}, R_m^{DL}, R_n^{DF}) \qquad (22)$$
$$\pi_n^C \geq (<) \pi_n^{DF} = \pi_n(p_m^{DL}, p_n^{DF}, R_m^{DL}, R_n^{DF})$$
$$\pi_m^{DF} = \pi_m(p_m^{DF}, p_n^{DF}, R_m^{DF}, R_n^{DL}) \leq (>) \pi_m^{DL} = \pi_m(p_m^{DL}, p_n^{DF}, R_m^{DL}, R_n^{DF})$$
as $a_{mn} = a_{nm} \geq (<)\, 0,\ m,n=1,2,\ m \neq n$.

The first line above tells us that company m would gain profits by playing game D as a leader compared to case C where the market power where symmetric distributed. Whether also the follower would prefer playing game D to game C, is dependent on whether the follower supplies substitutable or complementary regular services. If the transport supplies are substitutes, it is seen from the second line in (22) that the company m, being the follower, will prefer the symmetry case in C to the leader-follower equilibrium in case D. In the case of complements, however, the following company would rather prefer game D to game C. From the third line in (22), it is also seen that a company in the case of substitutes has a first mover advantage, while there is a second mover advantage in the case of complements. This is exactly the opposite conclusion of what was seen by comparing the results from game A and B in the case of MPC in (12) above. The reasoning behind this conclusion is simple. By being the leader in MQC, the transport company chooses a relatively high level of regular services in his market. A high level of regular services will reduce the demand and the profitability in a substitutable transport market. This is in accordance with the models of Fudenberg and Tirole (1983) and Maskin and Tirole (1987) and (1988a,b), which in different ways illustrate that the leader gains profits by making a relative high investment in the case where it face competition from a firm supplying perfectly substitutable service. However, the demand and profitability will be increased in a complementary market by the choice of a high level of regular service from the leader. A company being the leader instead of the follower in the case of substitutes, means a possibility for the operator to increase the profitability in his own market by choosing an aggressive strategy in the first stage of the game. In the case of complementary services, however, being the leader compared to the case of being the follower means that the company bears relative high costs in choosing a high level of regular services instead of waiting and let the other company determinate a high level of supply which would affect his demand positively.

It is also interesting to compare the outcomes in game A and D. The price competition in both games is similar, i.e. the companies choose fares for any levels of supply such that eqn (6) holds. The supply adjustments are in game A defined by eqn (7), while eqn (16) and (20) define respectively the follower's and the leader's choice of regular services in case D. As seen in the comparison above between game A and C, the difference in company n marginal profit with respect to supply in eqn (7) and (16) leads to a lower supply in the follower's market in case D than in case A. Furthermore, regarding the difference between eqn (7) and (20), it can be shown that $(\partial\pi_m/\partial p_n)(\partial p_n^*/\partial R_m) + (\partial\pi_m^C/\partial R_n)(dR_n^*/dR_m) = (\partial\pi_m/\partial p_n)a_{nm}a_{nm}(dQ_m/dR_m)F_n/J \leq 0$, which also leads company m to choose a lower level of regular services in case D compared to case A. Hence, by doing a global comparison of the equilibrium in case D, defined by the conditions in eqn (6), (16) and (20) and the equilibrium in case A, given by the conditions in eqn (6) and (7), it is seen that

$$R_m^{DL} \leq R_m^A,\ p_m^{DL} \leq p_m^A,\ P_m^{DL} \geq P_m^A, \qquad (23)$$
$$R_n^{DF} \leq R_n^A,\ p_n^{DF} \leq p_n^A,\ P_n^{DF} \geq P_n^A.$$

Furthermore, by using the results in eqn (22), this leads to

$$\pi_m^{DL} \geq (<)\pi_m^A \text{ and } \pi_n^{DF} \geq (<)\pi_n^A \qquad (24)$$

as $a_{mn} = a_{nm} \geq (<)\ 0,\ m,n=1,2,\ m \neq n$.

The movement from game A to game D means that transport supplies become inflexible in the short run and that company m obtains the possibility to determinate the level of regular services first. The first change will reduce transport supplies in both markets, while the second effect will increase supplies in both markets if the services supplied are complements. In the case of substitutes, however, the follower will supply less regular services. As seen in (23), the first effects dominate, and these reductions in supplies will more than off-set the effects followed by lower fare levels, resulting in higher users' costs in both markets in case D compared to case A.

CONCLUSIONS

We have seen that the travellers, who are supposed to be concerned only about the generalised costs in the markets, prefer that the two transport operators supplying substitutable routes compete in the way described in game A, i.e. that none of the companies have any leading market position and that regular services are flexible in the short run. This game gives the lowest generalised costs in both markets compared to the other competitive games in our analyses. Furthermore, it is seen that game A also is the game which gives the companies the lowest profits. In the case of flexible regular services in the short run, both companies would rather prefer playing game B where one of them becomes a market leader. However, they will both prefer to behave as a follower rather than being the leader. In the case of inflexible regular services, i.e. MQC games, however, the consumers which usually travel by routes supplied by one of the companies, would prefer that the company which operates these routes can behave as a leader. But the travellers which most commonly use the services supplied by the other company, would disagree because they will face higher generalised costs in the follower's market than in case C. They would rather prefer that the operator which supplies the routes they travel by, could become the leader. We also see that in the MQC games there exists a first mover advantage which means that the transport operators prefer being the leader compared to being playing a game with equal market positions or being in the follower's position. However, it is not seen whether the travellers or the companies would prefer the outcomes following from game B to C or prefer the generalised costs and profits in B to D. Regarding the companies possible rankings, it is most likely that a company would prefer being the leader of game D (giving the operator a first mover advantage) than being the leader in game B (which means a first mover disadvantage). By using an analogous reasoning, it also seems evident that a company would rather want to play game C than playing game B as a leader. However, it is an open question whether a company would prefer being the leader in game D compared to being the follower in game B, and whether a company will prefer the outcome in game C to the profits stemming from being the follower in game B. Generally, answers to these questions are conditional on the size of the first mover advantage in game D, the second mover advantage in game B and the profit gains by playing MQC games instead of MPC games. Even in our simplified model structure, with linear demands and costs, the answers will be ambiguous.

In the case of complementary services, it is seen that the travellers which only use the services supplied the one company, will prefer that this company behave as a follower rather than a leader. The consumers who travels by routes supplied by both companies, however, will face lower generalised costs in the follower's market and higher generalised costs in the leader's. Furthermore, it is seen that the consumers will prefer game A, where the transport services are flexible, to the MQC games in case C and D. If the services are inflexible, all travellers will prefer the leader-follower equilibrium in case D to the competition with equal market positions in game C. In the case of MPC, a company will prefer being able to determinate fare and supply before the other company compared to being playing the simultaneous game in A or being the follower in game B. Furthermore, it is seen that the profit outcomes for both companies by playing game A is higher than the profits following from the MQC games in C and D. However, if the services are inflexible in the short run, both companies will gain profits by playing the leader-follower game in D compared to being playing game C. In the case of MQC, however, a company will prefer being a follower rather than being the leader.

Even though several aspects are left out from the analyses, the model framework presented here must be considered as the first attempt in order to discuss possible equilibria in transport markets by making use of the differentiated duopoly models found in the general theory of industrial organisation. The purpose has been to adjust the general framework to a structure often found in transport markets. As commented on in the introduction, models inspired by the theories of product differentiation and contestability have been dominating the discussion of equilibria in transport markets. However, it seems obvious that in situations where the number of actual and potential transport operators are limited, strategical interactions like those focused on in our analyses at least must be considered as a complementary description of possible market arrangements in transport markets.

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