Specific Investments and Ownership Structures in Railways – An Experimental Analysis

Thomas Ehrmann[♣]
Institute of Strategic Management, Muenster

Karl-Hans Hartwig[♦]
Institute of Transport Economics, Muenster

Torsten Marner[♠]
Institute of Transport Economics, Muenster

Hendrik Schmale
Institute of Strategic Management, Muenster

Contents

[♣] *Institute of Transport Economics, Am Stadtgraben 9, 48143Muenster , Germany Tel.: +49-251-8322990, Fax: +49-251-8328395, E-mail: 10kaha@wiwi.uni-muenster.de*

[♦] *Institute of Strategic Management, Leonardo Campus 18, 48149 Muenster, Germany Tel.: +49-251-8338330, Fax: +49-251-838333, E-mail: ehrmann@ism.uni-muenster.de*

[♣] *Institute of Transport Economics, Am Stadtgraben 9, 48143Muenster , Germany Tel.: +49-251-8322994, Fax: +49-251-8328395, E-mail: torstenmarner@yahoo.de*

[♦] *Institute of Strategic Management, Leonardo Campus 18, 48149 Muenster, Germany Tel.: +49-251-8338336, Fax: +49-251-838333, E-mail: schmale@ism.uni-muenster.de*

Abstract

We analyze the impact of different organizational structures on incentives to invest in railways: vertical integration, vertical separation, and a hybrid form. Economic theory predicts that vertical integration fosters socially optimal investment, whereas, due to potential hold-up problems, both vertical separation and hybrid forms cause severe underinvestment. We test these theoretical predictions in a laboratory experiment and find evidence that, in a vertically integrated environment, the level of investment in rolling stock and in rail infrastructure is roughly socially optimal. The complete absence of a discrepancy in our experimental results between vertical separation and the hybrid organisational structure, contradicting the predictions of model-theory, is surprising and can be attributed to the relatively high investments in the separated model. This contradiction might also be explained by the existence of social preferences.

1.0 Introduction

Since European policy is presently demanding more competition in European railways, vertical relationships in railways are the subject of substantial controversy. Advocates of a vertical separation of infrastructure from transport operation argue that, even if vertically integrated firms are obliged to grant third-party access to railway infrastructure, potential for market foreclosure and discrimination will continue to exist and competition will remain restricted (Nash and Preston, 1994; European Commission, 1996; Link, 2003). Therefore, vertical separation is regarded as the only way to enhance competition within the railway industry. Proponents of vertical integration argue that an institutional separation would reduce economic welfare, because of losses of economies of scope, of lower consumer attractiveness due to coordination failure and of insufficient investment as a result of asset specificity, incomplete contracts and hold-up hazards (Cantos, 2001;Pfund, 2003; Pittman, 2007).

There is a large body of *theoretical* research that supports these positions, highlighting the drawbacks and inefficiencies of vertical separation, as well as the advantages and disadvantages arising from vertical integration solutions. This abundance of theoretical research contrasts with the low number of recent *empirical* studies, even though a very substantial number of institutional settings for the railway sector have been established worldwide in the meantime (that is Gomez-Ibanez, 2004; Cantos and Campos, 2005; Nash, 2006). According to Nash and Rivera-Trujillo (2007) the lack of empirical evidence is due to the fact that most of these settings are not comparable, in particular due to the short time horizon of reform experiences. Sufficiently large data bases necessary for analytical research are available only for a few of the relevant variables. Most previous studies on vertical separation test for economies of scope (Preston, 1996; Growitsch and Wetzel, 2009) and analyze the implications on competition and on efficiency and productivity growth (Nash and Preston, 1994; Bitzan, 2003; Friebel et al., 2003; Driessen et al., 2006; Sanchez et al., 2008).

Up to now, there is only one empirical study on asset specificity, incomplete contracts, hold ups and investment behaviour in different institutional settings of rail industry by Merkert, Nash and Smith (2008). From the perspective of the New Institutional Economics, the authors analyze the impact of the governance structures of British, German and Swedish railways on competition and on the transaction costs of different interactions between infrastructure managers and train operators. The data have been collected by reviewing policy documents and contracts from seven pre-specified transaction areas and interviews with infrastructure managers, senior managers from train operators, regulators and industry associations. The results show that, although asset specificity and incomplete contracts do exist, the frequency, uncertainty and complexity of coordination and contractual interactions are perceived as more relevant than investment hold-up or lock-in issues (p. 27). All in all, the authors conclude that vertical separation turns out to be the "clearest approach in terms of non-discrimination" and viable at reasonable cost, in "terms of transaction cost economics" (p. 40).

In order to determine whether a separate railway organization would reduce or even eliminate the incentive to invest on one or even both sides (the infrastructure provider and the transport operator), so that underinvestment may occur, raising costs and diminishing welfare in the long run, we adopt an experimental approach. Based on the seminal work of Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995) on specific investments and the structure of vertical relationships, we model investment behaviour in various institutional arrangements in railways, hypothesize corresponding investment levels and test these hypotheses through experimental research. Such research provides an alternative framework to systematically designing varying institutional settings and analysing the resultant incentive structures and their impact on economic behaviour (Roth, 1995). In our case, the approach sheds some empirical light, from another perspective, on an important aspect of restructuring the European railway industry, an issue has so far been discussed by means of more or less qualitative arguments in case studies. The fundamental question is whether the investment incentives associated with a separate institutional arrangement can cause a long-term investment problem and welfare losses.

The structure of this paper is as follows. In Section 2, we generally describe the hold-up problem and show the relevance of specific investments, opportunistic behavior and incomplete contracts in railways. In Section 3, our model of investment behavior in different organizational structures is introduced, so that the expected investment levels can be hypothesized. Section 4 contains the experimental design. In Section 5, the experimental results with respect to investment incentives are presented. In Section 6, the results are discussed, before we close with a summary and some future perspectives.

2.0 Specific Investments, Incomplete Contracts and Underinvestment in Railways: Theory and Previous Research

According to modern institutional economics, a vertical separation of infrastructure from operations in network industries is an inferior form of organization, if investments are specific and contracts incomplete (Williamson, 1975 and 1985; Klein et al., 1978; Crocker and Masten, 1991). Because specific investments yield significantly lower values or lower gains from trade, when employed in a transaction other than originally intended (Joskow, 2003), the investor bears the risk of being exploited by an opportunistic transaction partner, who will appropriate the difference between the value of the investment in its first and second-best use (quasi-rent) in an ex-post bargaining process. If the investor anticipates the risk of a hold-up and if contractual arrangements to avert hold-ups are hindered by incomplete contracts, he will not undertake the investment at all. In network industries, underinvestment may occur on either side of the transaction. The vertical integration of infrastructure and operations could constitute an institutional setting which prevents disincentives to invest.

Previous research on the rail industry had indeed identified asset specificity in the network infrastructure as well as in the rolling stock. Primary arguments are the strong technical interdependency of both of the input factors and the fact that investments not only require significant financial resources, but most often are completely irreversible (that is Rothengatter, 2001; Gomez-Ibanez, 2004; Cantos and Campos, 2005; Pittman, 2005). Various empirical studies have attempted to document and estimate asset specificity. Yvrande-Billon (2004) estimated a high level of specificity, measured by the impossibility of re-deployment of the rolling stock of British railways. According to Affuso and Newbery (2002), up to 82 per cent of each asset of the transport companies in Great Britain are specific. Ferreira (1997), Crozet (2004), Bouf et al. (2005), von Hirschhausen and Siegmann (2004) and Merkert et al. (2008) detected asset specificities of different kinds (physical specificity, site specificity, dedicated specificity and temporal specificity) and different levels of relevance down-stream on the infrastructure level as well as up-stream on the operational level of rolling stock.

Common examples of asset specificity in the railway context are investments in high-speed rail lines and in modern signal and safety technology, such as the European Train Control System (ETCS) which allows for higher capacities and higher operating densities, due to the economization of permanent signalling equipment through the direct transmission of propulsion command via GSM (de Rus and Nombela, 2007; International Union of Railways, 2003). Investment in high-speed rail tracks and ETCS-infrastructure is enormously cost-intensive for infrastructure companies and requires simultaneous investments in rolling stock by a transport operator who pays for and uses the track for a period sufficient for an amortization of the infrastructure investment. As Pittman (2007) points out, “a track operator can make certain investments to improve efficiency and performance, but the realization of these benefits depends significantly on actions taken by the train operator”. If the technological demand for transport operation exhibits a lower level than high-speed rail and ETCS, it is impossible to maintain an appropriate price for track usage (Nash, 2005). The value of the investments will decrease. This is correspondingly true vice versa, if the transport operator invests in high-speed trains or implements ETCS in rolling stock without corresponding investments from the infrastructure operator, as in the case of Virgin Rail, a British transport company (Pfund, 2003).

In order to avoid the hazards of “downgrading” the infrastructure and rolling stock, investments have to be coordinated very exactly, so as to produce the final output of transportation and to improve quality in terms of timesaving and safer transport. With separate environments for rail infrastructure and transport operation, efficient coordination fails to take place, because of disincentives to invest on both sides as a result of hold-up risks and incomplete contracts. Since investment behaviour is neither fully observable nor enforceable by law “subject to shirking and opportunism, the investments on both sides may not be made and economic welfare will suffer as a result” (Pittman, 2007). A potentially superior institutional solution could take the form of vertical integration, which is proved empirically by the experiment described in the present paper.

3.0 Theoretical Model

In order to test the hypothesis that vertical integration is the superior form of organization in the railway industry with respect to asset specificities, we use the standard models of Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995). Theory states that incentives to invest depend on ownership structure. Because ownership structures in European railways are established politically in conformity with EU guidelines (European Commission 1991 and 2001), we develop three different scenarios with exogenously predetermined ownership structures:

(1) vertical separation

(2) vertical integration

(3) hybrid form of organization.

Ownership rights affect the incentive structure in determining the extent to which an investor can claim a generated surplus and thereby recover at least his initial investment costs. Hence, ownership creates the incentive to invest. We assume that investments are embodied in physical capital such as rolling stock and rail infrastructure, rather than in human capital. From this, it follows that the value of the investment is not bound to the investor, but solely to the respective asset.[1] Furthermore, ownership of an asset assigns the right to make an investment, as well as the ability to transfer this right, since making the investment is assumed not to be specific to a particular individual.

Investment decision rights are allocated to the transport operator (F_1) and the infrastructure operator (F_2), together producing the final good of railway transport by a combination of the two specific assets of rolling stock (a_1) and rail infrastructure (a_2). In fact, the transport operator uses the track to produce transport activities. Depending on the ownership structure, both actors can either be completely autonomous firms or departments within one integrated

[1] If the investments were embodied in human capital, rather than in physical capital, an acquisition of the complementary asset, that is vertical integration, would not enable the new owner to generate a full surplus, because part of the investment's value would be tied to the former owner himself. Thus, in the case of integration, the acquiring firm would still have to negotiate with the former owner, in order to obtain full access to the investment, although it already controls the physical asset.

firm. The gross surplus derived from the transport activity (*S*) depends on specific investments in rolling stock (i_1) and in the rail infrastructure (i_2): $S(i_1,i_2)$. Investments increase the productivity of the assets and are made in period $t = 1$, in which investment costs $c(i_1)$ and $c(i_2)$ accrue to the investing party. Although in $t = 1$, it is clear that specific investments are required to produce the final good of transportation, uncertainty prevails as to the precise asset configuration. This is due to the fact that, particularly in the context of railways, the production of the final good is highly complex and therefore, the costs of defining a comprehensive contract over the exact uses of a_1 and a_2 are assumed to be prohibitively high. This uncertainty also means that ex-ante contracting involving the division of the surplus from cooperation, is not feasible. Hence, the allocation of gross surplus cannot take place until investment is sunk and uncertainty is resolved in the next period, $t = 2$. Figure 3.1. summarises this chronology of action.

Insert Figure 3.1. about here

We assume that in the case considered here, the gross surplus from production $S(i_1,i_2)$ is defined as $S(i_1,i_2) = 20(i_1 + i_2)$. Investment costs $c(i_1)$ and $c(i_2)$ are defined as $c(i_1) = 15i_1$ and $c(i_2) = 15i_2$. Investments can be chosen from the interval $i_1, i_2 \in \{1,2,...,10\}$.

3.1 Vertical separation

In the case of vertical separation, one of the pure forms of privatization alternatives, the transport operator F_1 and the infrastructure operator F_2 are completely autonomous firms.

Each possesses one productive asset, that is, F_1 owns and controls a_1 and F_2 owns and controls a_2, so that the transport operator contributes to the provision of transport by making the rolling stock available, while the infrastructure operator contributes to the production of the final good of transportation, by providing the rail infrastructure. Consequently, both actors independently and simultaneously choose investments in $t = 1$. After uncertainty is resolved in $t = 2$, they bargain over the infrastructure charge and type, determining the division of the resultant gross surplus $S(i_1,i_2)$. Finally, when the actors reach agreement and trade occurs, ex-post pay pay-offs are realized for the transport operator (Π_1) and the infrastructure operator (Π_2), given by the following equations:

$$\Pi_1 = \begin{cases} b \cdot S(i_1, i_2) - c(i_1) & \text{contractual agreement,} \\ -c(i_1) & \text{non-agreement.} \end{cases} \tag{3.1}$$

$$\Pi_2 = \begin{cases} (1-b) \cdot S(i_1, i_2) - c(i_2) & \text{contractual agreement,} \\ -c(i_2) & \text{non-agreement.} \end{cases} \tag{3.2}$$

b denotes the transport operator's negotiated share of the surplus, $(1 - b)$ the infrastructure operator's share in the case of agreement. However, it is important to note that a surplus is generated only if both actors agree to trade. Otherwise, the production of the final good is impeded, since both actors withdraw their asset from the production process. Since investments are sunk, each has to bear his individual investment costs.

In our model, bargaining follows a Rubinstein alternating-offer structure with a maximum of ten bargaining rounds (Rubinstein, 1982) and a multiple-pie finite-horizon bargaining setting (Sloof, 2004).[2] In each bargaining round, one round-pie is negotiated between the two players. The size of each round-pie is 1/10 $S(i_1,i_2)$. Both actors alternate in making offers with respect to the division of the ten round-pies, with the first offer being randomly assigned to one of the

[2] In the interest of simplification, we disregard any other discounting effects. This guarantees the implementation of an exactly symmetrical Nash bargaining solution (Nash, 1950). Any further discounting would have caused a first-mover advantage for the subject with the right of first offer. Here, backward induction predicts a sub-game perfect equilibrium with an equal share in the first bargaining round.

players. Actors are allowed to respond to offers in three different ways. Firstly, they can accept the offer and the round-pie of the current bargaining round, with all remaining round-pies being divided according to the agreement. Secondly, the responder can reject the offer and terminate negotiations. In this case, the current and all remaining round-pies are irrevocably lost and, consequently, both players receive nothing. Thirdly, the player can reject and submit a counter offer instead. Bargaining then proceeds to the next round and the current round-pie is lost, this in turn reflecting the cost of negotiation. Finally, b and (1-b) are determined by bargaining.

We assume that the gains from trade are divided according to the Nash bargaining solution, that is, a 50/50 division of the surplus (Nash, 1950), so that investments result from the optimization of equations (3.3) and (3.4):

$$\Pi_1 = \frac{1}{2} \cdot S(i_1, i_2) - c(i_1), \tag{3.3}$$

$$\Pi_2 = \frac{1}{2} \cdot S(i_1, i_2) - c(i_2).^3 \tag{3.4}$$

Since $S(i_1, i_2) > c(i_1) + c(i_2)$ does apply, in a first-best world, where coordination between the two parties is feasible, F_1 as well as F_2 would have an incentive to invest the maximum amount of $i_{1,2}=i^{max}$. In the absence of hold-up threats, the parties could redistribute any increase in value by means of ex ante lump-sum transfers.

However, $1/2 \cdot (\delta S / \delta i_1) < \delta c_1$ and $1/2 \cdot (\delta S / \delta i_2) < \delta c_2$ imply that individually, in an incomplete contracting world with rational and self-interested actors, investment entails strictly negative net pay-offs. This results from the fact that any increase in value, $\delta S / \delta i$, must be shared equally with the other partner, whereas increasing investment costs are incurred on one's own. Consequently, the marginal costs of investment exceed the marginal

[3] This is true for $\delta S / \delta i > 0$ and $\delta^2 S / \delta^2 i = 0$. For the sake of simplicity, investment costs are assumed to be linear, so that $\delta c / \delta i > 0$ and $\delta^2 c / \delta^2 i = 0$.

benefits. Both the transport operator and the infrastructure operator will invest the minimum of $i_1 = i_2 = i^{min}$, both anticipating opportunistic behaviour in the form of a hold-up by the other party.[4] Given the abovementioned parameterization, $\Pi_1 = 10i_2 - 5i_1$ and $\Pi_2 = 10i_1 - 5i_2$ describe the individual optimisation problems. Hence, for the transport operator, the choice of $i_1 = i_{min} = 1$ is optimal and for the infrastructure operator, it is optimal to choose $i_2 = i_{min} = 1$. This situation resembles a prisoners' dilemma and results in bilateral underinvestment. The prisoners' dilemma is documented by Figure 3.2. and depicts the profits accruing to the players at three different levels of investment (1, 5, 10). Combination $(i_1, i_2) = (1; 1)$ is a Nash equilibrium with a resulting overall profit of $\prod_1+\prod_2=5+5=10$, which is inferior to individually unstable investments of 10, generating an overall profit of $\prod_1+\prod_2=50+50=100$.

Insert Figure 3.2. about here

3.2 Vertical integration

In the model of vertical integration, one fully integrated railway company owns the rights of control over the net infrastructure and the rolling stock, as well as the investment rights. Therefore, there is no hold-up hazard and the investor can fully internalise revenue derived

[4] Only after their own investment is sunk, do the agents learn of the other party's investment. In this respect, other constellations are also possible. Nöldeke and Schmidt (1998) and Smirnov and Wait (2004) concentrate, for example, on the problem of underinvestment in the case of sequential investments. In the railway context, existing monitoring and contract-enforcement problems imply that the application of simultaneous investments is advisable.

from his investments. The integrated firm's investment incentives, therefore, are expressed in the optimising the following equation:[5]

$$\Pi_2 = S(i_1, i_2) - c(i_1) - c(i_2). \qquad (3.5)$$

Accordingly, the model predicts maximal investment levels for the integrated case: $i_1 = i_2 = i^{max}$. Given the abovementioned parameterization, $\Pi_2 = 5(i_1 + i_2)$ is true, investments in rolling stock and in transport operation reach their maximum levels: $i_1 = i_2 = i_{max} = 10$, and thus, $i_1 + i_2 = 20$.

In the separate structure, the need to recover investment costs implies an incentive to fully utilize the enhanced productivity of assets. This holds, because any quality loss due to a reduction in effort would be counterproductive, given one's own prior investment decision.[6] However, in an integrated arrangement, this is not true for all production steps, taking into account that the transport division cannot make investment decisions and does not have to bear any investment costs. Given individual self-interest and rational behaviour, the result is shirking by the transport division, in order to minimize the disutility of work (Alchian and Demsetz, 1972). Although shirking reduces the efficiency of those parts of the production process involving the transport operator's effort and decreases the marginal benefits of investment, shirking does not affect investment incentives, because marginal benefits still significantly exceed marginal cost.

---

[5] Equation (3.5) denotes the integrated firms' ex-post pay-off in the case of Type 2 integration (see Hart, 1995, p.35), that is, F_2 integrates F_1 and thus, becomes the sole owner of the entire set of assets, a_1 and a_2. Alternatively, we could have considered the case of Type 1 integration. Given the symmetry of parameterization, this would not have any effect on the theoretical predictions regarding investment incentives. Therefore, we content ourselves with the analysis of one case.

[6] Taking this aspect into consideration further strengthens the consistency of our experimental investigation, since this aspect implies interaction between F_1 and F_2, although F_2 is the sole owner of the assets and makes the investment decisions.

3.3 Hybrid model

Considering the ownership-structure continuum, which is bounded by full integration on one side and full separation on the other, there are obviously several alternative hybrid organizational designs (Ferreira, 1997). Below, we model a structure which partly separates the rights to control the assets from those of making an investment. Accordingly, the final good of rail transportation is produced by a company which is subdivided into two divisions: the transport operator and the dominant infrastructure operator. The rights of control over rolling stock a_1 and rail infrastructure a_2 are assigned to the dominant infrastructure operator F_2.[7] Thus, analogously to the integrated case, this model also allows a full internalization of investments revenue. Nevertheless, this model differs in terms of investment-rights allocation. In particular, the dominating infrastructure operator transfers the responsibility and right to invest in the rolling stock to the dominated transport operator and pays remuneration w to F_1, after receiving the complete gross surplus from the investments. Hence, in the first step, the transport operator decides on investment i_1 and in the second step, he receives the compensation.

$$\Pi_1 = w - c(i_1), \tag{3.6}$$

$$\Pi_2 = S(i_1, i_2) - c(i_2) - w. \tag{3.7}$$

Because the infrastructure operator possesses all control rights and, therefore, full residual claimant status, his incentive is to invest the maximum amount $i_2 = i^{max}$. His marginal benefits from investment exceed the marginal costs. The transport operator only decides to invest $i_1 = i^{min}$ in anticipation of rational and self-interested behaviour from the infrastructure operator, which implies the minimum compensation $w = w^{min} = 15$.[8]

---

[7] To ensure consistency with regard to the integration model, we obviously consider Type 2 integration here as well.

[8] Note that F_1 must invest at least the minimum of $i_1 = 1$.

Given the above parameterization, $\Pi_1 = w - 15i_1$ and $\Pi_2 = 20i_1 + 5i_2 - w$ are true. In equilibrium, the transport operator invests an amount of $i_1 = i_{min} = 1$ and the infrastructure operator an amount of $i_2 = i_{max} = 10$. As a result, unilateral underinvestment occurs and the model of hybrid organisation is therefore inferior to the integrated model but, in terms of investment incentives, superior when compared to the separated model. Table 3.1. summarises the standard theoretical predictions of investment behaviour and bargaining outcomes, given our parameterization.

Insert Table 3.1. about here

4.0 Experimental Design

The experimental investigation consisted of six treatments, both multi- and single-period games for each of the three models. The computer-based experiments were carried out at the Department of Economic Studies, Muenster University, Germany, in 2006. 256 respondents were recruited from a homogenous group of students studying economics at an advanced level. For each treatment, the subject group was divided into two subgroups, half being assigned the role of transport operator (F_1) and the other the role of infrastructure operator (F_2). Subjects kept their role throughout the experiment. They were paid according to performance and earned, on average, €12.50 per hour.

The multi-period treatment consisted of 12 rounds, during which each of the respondents were randomly and anonymously matched pair-wise. Instructions were handed out and read to all subjects.[9] Thus, all had identical information about the rules and structure of the game. In order to ensure that any player knew the consequences of his decisions, we provided a simulation device. The simulator enabled the calculation of outcomes of investment and bargaining decisions throughout the game. The subjects were also informed about the matching procedure. Hence, reputational effects should be minimized. Furthermore, the subgroups were located in separate rooms and communication within the subgroup was strictly forbidden. This ensured that no player could forecast his current partner's decisions on the basis of past behaviour.

Each round involved two stages, an investment and a bargaining stage. This applies to the single-period scenarios as well as to the multi-period scenarios.[10] The single-period games involved a single play of the two-stage game. At the investment stage, the subjects were requested to simultaneously choose their investment levels. However, as described above, the right to invest depends on the ownership structure. In the separated case and the hybrid case, both players – the one assigned the role of infrastructure operator and the counterpart – were provided with the right to invest in one of the assets. However, in the integrated case, the infrastructure operator had the right to invest in both assets, the rolling stock and the infrastructure. At the bargaining stage, the impact of the considered ownership structures on the nature of the game was greater than at the first stage. In the integrated and hybrid cases, stage two consisted of the choice of compensation level by the infrastructure player. At stage two of the separation scenario, the players were asked to allocate the surplus generated in stage one by the abovementioned bargaining process.

[9] The detailed instructions are available from the authors upon request.

[10] For simplicity, we will call the second stage the *bargaining stage* throughout the remainder of the paper, even though, in the integrated case and the hybrid case, the second stage is more likely to resemble a dictator game rather than a bargaining game.

In each of the considered treatments, the subjects were informed about the chosen investment levels before proceeding to the bargaining stage. At the end of stage two of each treatment, payments were made according to the bargaining results and, finally, investment costs were incurred by the investors. In the multi-period games, both players subsequently moved to the next game period and were again randomly matched with a partner. In the single-period games, the experiment finished at this point and the subjects were paid according to their performance.

5.0 Experimental Results

In the multi-period treatments 44 subjects participated in the separated case, 44 in the hybrid case and 42 in the integrated case. With respect to investment behaviour, the first result from the experiment is as follows:

> *Result 1.* Average investment levels are maximized in the integration model. Integration induces levels of investments close to the social optimum.

The average total investment in rolling stock and rail infrastructure amounted to 14.70 in the separated case, 13.65 in the hybrid case, and 19.56 in the integration case. The experimental results thus evidently support the theoretical prediction with respect to the vertical integration model. In more than 92 per cent of the cases (466 out of 504), the respondents chose the efficient investment level $i^{max} = 10$.

Insert Table 5.1. about here

A pair-wise comparison of the investments, conducted by means of the Mann-Whitney-U-Test, indicates the superiority of the integrated model ($p < .01$). Table (5.1.) shows the results from three non-parametric tests, examining total investments for rounds 1-12.

> *Result 2.* The hybrid case does not provide higher investment incentives than the separated model. Both the separation and the hybrid cases cause underinvestment with respect to the social optimum, but exceed theoretical predictions from the models.

A comparison of theoretical predictions with the investment results from the experiment reveals that, in the separation case as well as in the hybrid case, investments clearly exceed the equilibrium results of the models (separation case: 14,70 > 2, hybrid case: 13,56 > 11). The complete absence of any difference in our experimental results between vertical separation and the hybrid organisational structure, contradicting the predictions of model-theory, is surprising and can largely be attributed to the relatively high investments in the separated model. However, investment in the separation case exceeded that of the hybrid case by roughly 1.05 (p = .002). This result was driven partly by the final three rounds. A detailed examination of total investment indicates that in 9 of 12 rounds, average total investments do not differ significantly from each other. Figure 5.1. further reveals a parallel development of total investment in the hybrid and separation cases in rounds 1 to 7. Whereas, from round 8 onwards, investment in the separation case even increases, investment in the hybrid case decreases simultaneously.[11]

Insert Figure 5.1. about here

In the single-period treatments, 42 subjects participated in the separated case, 44 in the hybrid case and 42 in the integration case. An examination of investments in the single-period treatments yields similar findings to those reported for the multi-period treatments (Fig. 5.2.). Although the results seem to match the rank order of theoretical predictions more closely, investments do not differ significantly between the separation (12.75) and hybrid cases (14.32). Average investments in rolling stock and rail infrastructure of the integration case (19.71) remain significantly superior and close to the social optimum. Yet, it is noticeable that investments in the first round of the multi-period games – 11.27 in the hybrid case, 11.18 in the separated case, and 18.33 in the integrated case – do not reach comparable levels. Thus, to some extent, the subjects may have relied on learning-by-doing in the multi-period treatments; this in turn indicates some kind of randomness in early-round decisions.

Insert Figure 5.2. about here

6.0 Discussion and Further Results

The results of our experimental analysis largely confirm the theoretical predictions of investment behaviour in different institutional arrangements in the railway sector. In a world

[11] This growing discrepancy might originate from some form of last-period effect, as the test participants were asked to take part in at least 8 rounds. Last-period effects result in uncooperative player behavior in the final rounds of repeated games, because misbehavior cannot be sanctioned. However, since subjects were randomly matched with other partners in each round, direct sanctioning was not feasible anyway. Nonetheless, F_1s might have used underinvestment as a collective sanctioning device, this in fact losing credibility with an increasing probability of termination.

of incomplete contracts and asset specificity, with respect to specific investments, full vertical integration is the superior organizational solution. The amounts invested by our respondents were closer to the social optimal values than the amounts invested in a hybrid or separated structure. However, while investments in the integration scenario almost reach the predicted value and investments in the hybrid scenario differ by 23 per cent, investments in the separation case substantially exceed the predicted levels.

The existence of social preferences may explain this apparent contradiction.[12] In contrast to the utility functions of rational and self-interested actors, the utility functions of actors exhibiting social preferences also comprise the utility of the exchange partner. One potential outcome might be that actors do not consider investments as sunk at the time of negotiation, but expect the net benefits from investment to reflect the contribution of each player to the gross surplus, that is to investment cost (Homans, 1961; Selten, 1978). An investigation of the bargaining outcomes indicates that, in fact, a significant proportion of repsondents does index the bargaining behaviour to prior investments. In order to test whether equity theory can contribute to the explanation of observed investment behaviour, we estimate the following simple equation: $b = \alpha + \beta[i_1 /(i_1 + i_2)]$ with F_1's share b as the dependent variable and his relative contribution to the total surplus as the independent variable.[13]

Insert Table 6.1. about here

----

[12] For a brief overview of the different types of social preferences such as conditional cooperation, reciprocity, inequity aversion and the like, see Rabin, 1993; Bolton and Ockenfels, 2000; Fehr and Fischbacher, 2002.

[13] Since our parameterization is linear, the individual contribution to gross surplus can be represented by the estimation of the influence of F_2's portion of costs on his obtained share. This must, and in fact does, yield equivalent results. We content ourselves with estimating F_1's share.

Table (6.1.) displays the results of our estimations.[14] Basic OLS regressions with one independent variable, reacts very sensitively to outlying observations (Hackett, 1993). Therefore, we also applied a robust estimation technique to test the robustness of the estimation (Hamilton, 1991). Both estimations strongly support the notion that the individual contribution to gross surplus exerts a substantial influence on the outcome of bargaining. Hence, social preferences seem to influence investment incentives and might explain the observation of higher investment levels than those predicted theoretically.

A further result of our experiment suggests that equal power due to shared ownership, as in the separation model, leads to efficiency losses, because of negotiation costs. In the sub-game perfect equilibrium, negotiations are successful and immediate, with bargaining terminating after the first round with breakdowns generally not being observed. This conclusion is based on the assumption of a homogenous group of actors. It follows that, since the sample becomes more heterogeneous, this result can no longer be retained, since rational actors might be disciplined by those with social preferences. Specifically, it may become rational to deviate from the theoretical prediction when confronted with potential and unexpected negotiation breakdowns by fair actors. Accordingly, in 24.6 per cent of cases, bargaining proceeds beyond round one. This causes efficiency losses of 25.7 per cent. In particular, total investments in all rounds amounted to 3.881, which corresponds to a net joint surplus of 19.405. A profit of only 14.417 could yet be realized, due to agreement delays and negotiation breakdowns (Joskow, 2003).[15]

---

[14] We also obtained positive coefficients for the single period game. However, the results were not significant.

[15] It is worth noting that our bargaining procedure places considerable emphasis on negotiation costs. Refusals immediately result in substantial losses. In reality, simple refusals are not expected to be that costly. Nevertheless, our results show that actors indeed use their bargaining power in order to enforce their interests, although they know how expensive this might be. See Hart and Moore (1988), Maskin and Moore (1999), who document the relevance of renegotiations in bargaining situations.

7.0 Conclusions

The present research paper constitutes an initial contribution to the empirical analysis of organizational structures and investment incentives in the railway sector. In general, our experimental results seem to indicate that, in a world of incomplete contracts, a vertical separation of railways as well as hybrid forms might cause deficits in innovation, quality and safety, due to underinvestment in relation-specific assets. Although the levels of investments in the separation and the hybrid scenario exceeded the theoretical predictions, they failed to match the social optimum.

One of the main objectives of the European railways is the re-vitalization of rail traffic, which involves strengthening railway competitiveness in an intermodal comparison. The system's high technical and organizational complexity impedes or at least limits the potential for complete contracts which cover every conceivable aspect of the transaction. In order to determine which organizational structure is most appropriate for macroeconomic purposes, it is of paramount importance to consider the numerous effects of these various structures. Not only are incentives to invest relevant, but also aspects such as additional synergy effects, economies of scope, competition, subsidies, privatization revenues or the marketability of the railway industry. However, the problems that occurred in Great Britain after the railway restructuring process indicate that, particularly in this sector, considering the incentives to invest in innovation, quality and safety may be a particularly important aspect, and one that has so far been underrated

Our analysis shows that individual profit-maximizing behaviour may lead to suboptimal decisions from a macroeconomic perspective, which in turn could constrain the competitive capabilities of European railways. Our results are also of particular importance for the design of hybrid models. The case considered here involves the separation of the right to decide on investments and the right to control the respective asset within the production process. From this, it follows that the investing party did not have any sanctioning potential after the investment had been undertaken, which may explain the comparatively low investments in rolling stock. However, this constellation constitutes only one possible alternative to designing a hybrid organizational form. Consequently, other design options, which could potentially combine the advantages of the pure organizational forms more effectively, should be taken into account. In order to determine definitively which organizational structure is macro-economically superior, further quantitative-oriented research is required, especially to investigate the industrial-economic effects. However, it is advisable firstly to analyze the full impact of different organizational structures before making policy decisions.

References

Affuso, L. and Newbery, D., (2002). Investment, Reprocurement and Franchise Contract Length in the British Railway Industry. Discussion Paper No. 2619, Centre for Economic Policy Research.

Alchian, A.A. and Demsetz, H., (1972). Production, Information Costs, and Economic Organization. *American Economic Review*, 63, pp. 777-95.

Bitzan, J.D., (2003). Railroad Costs and Competition: The Implications of Introducing Competition to Railroad Networks. *Journal of Transport Economics and Policy*, 37, pp. 201-25.

Bolton, G. and Ockenfels, A., (2000). A Theory of Equity, Reciprocity and Competition. *American Economic Review*, 90, pp. 166-93.

Bouf, D., Crozet, Y. and Leveque, J., (2005). Vertical separation, disputes resolution and competition in railway industry. *9th International Conference on Competition and Ownership in Land Transport* (Thredbo 9), Lisbon, September 2005.

Cantos, P., (2001). Vertical Relationships for the European Railway Industry. *Transport Policy*, 8, pp. 77-83.

Cantos, P. and Campos, J., (2005). Recent changes in the global rail industry: facing the challenge of increased flexibility. *European Transport*, 29, pp. 1-21.

Crocker, K.J. and Masten, S.E., (1991). Pretia Ex Machina? Prices and Process in Long-Term Contracts. *Journal of Law and Economics*, 34, pp. 69-99.

Crozet, Y., (2004). European Railway Infrastructure: Towards a Conversion of Infrastructure Charging? *International Journal of Transport Management*, 2(1), pp. 5-15.

Driessen, G., Lijesen, M. and Mulder, M. (2006). The Impact of Competition on Productive Efficiency in European Railways, *CPB Discussion Paper,* 71.

European Commission (1991): Council Directive 91/440/EEC of 29 July 1991 on the development of the Community's railways.

European Commission (1996): A Strategy for Revitalising the Community's Railways. White Paper. COM (96) 421 final, 30 July 1996.

European Commission (2001): Directive 2001/12/EC of the European Parliament and of the Council of 26 February (2001) amending Council Directive 91/440/EEC on the development of the Community's railways.

Fehr, E., and Fischbacher, U., (2002). Why social preferences matter – The impact of non-selfish motives on competition, cooperation and incentives. *The Economic Journal,* 112, C1-C33.

Ferreira, L., (1997). Rail Track Infrastructure Ownership: Investment and Operational Issues. *Transportation*, 24(2), pp. 183-200.

Friebel, G., M. Ivaldi, and C. Vibes (2003): 'Railway (de)regulation: a European efficiency comparison', IDEI report no. 3 on passenger rail transport, University of Toulouse.

Gomez-Ibanez, J. (2004). Railway Reforms: An Overview of the Options. Available at: http://www.hks.harvard.edu/taubmancenter/pdfs/working_papers/gomezibanez_04_railway.pdf [Accessed 16 May 2008].

Grossman S. and Hart, O., (1986). The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy*, 94, pp. 691-719.

Growitsch, C. and Wetzel, H., (2009). Testing for Economics of Scope in European Railways: An Efficiency Analysis. *Journal of Transport Economics and Policy*, 43, pp. 1-24.

Hackett, S.C., (1993). Incomplete Contracting: A Laboratory Experimental Analysis. *Economic Inquiry*, 31, pp. 274-97.

Hamilton, L.C., (1991). *Regression with Graphics: A Second Course in Applied Statistics*. Pacific Grove, CA: Brooks/Cole.

Hart, O., (1995). *Firms, Contracts and Financial Structure*. Oxford: Clarendon Press.

Hart O., and J. Moore (1988): 'Incomplete contracts and renegotiation', *Econometrica*, 56, 755-85.

Hart, O. and Moore, J., (1990). Property Rights and the Nature of the Firm. *Journal of Political Economy*, 98, pp. 1119-158.

Hirschhausen C. von and Siegmann, J., (2004). *SYNETRA: Synergien zwischen Bahnnetz- und -transport, Praxis, Probleme, Potentiale*. Survey on behalf of the Bundesministerium für Bildung und Forschung, Berlin.

Homans, G.C., (1961). *Social Behavior: Its Elementary Forms*. New York: Harcourt, Brace and World.

International Union of Railways (UIC), (2003). Implementing the European Train Control System ETCS – Opportunities for European Rail Corridors. *UIC ERTMS Conference*, Leipzig, 10-11 December 2003.

Joskow, P.L., (2003). Vertical Integration. In Menard, C. and Shirley, M.M., eds. *Handbook of New Institutional Economics*. Dordrecht: Springer.

Klein, B., Crawford, R. and Alchian, A., (1978). Vertical integration, Appropriable Rents, and the Competitive Contracting Process. *Journal of Law and Economics*, 21, pp. 297-326.

Link, H., (2003). Rail infrastructure charging and on-track competition in Germany – nine years later. *European Transport Conference,* Strasbourg.

Maskin, E.S., and J. Moore (1999): 'Implementation and Renegotiation', *Review of Economic Studies*, 66, 1, 39-56.

Merkert, R., Nash, C.A. and Smith, A.S.J. (2008). Looking beyond separation – A comparative analysis of British, German and Swedish railways from a new institutional perspective, *European Transport Conference*, Leiden.

Nash, C.A., (2005). Rail Infrastructure Charges in Europe. *Journal of Transport Economics and Policy*, 39, pp. 259-78.

Nash, C.A., (2006). Europe: Alternative Models for Restructuring. In Gomez-Ibanez, J.A., and de Rus, G., ed. *Competition in the Railway Industry: An International Comparative Analysis*. Northampton, MA: Edward Elgar.

Nash, C.A. and Preston, J.M., (1994). Competition in rail transport: a new opportunity for railways. Working Paper 397, Institute for Transport Studies, University of Leeds.

Nash, C.A. and Rivera-Trujillo, C., (2007). Rail Reform in Europe: Issues and Research Needs. In Rietveld, P. and Stough, R.R., ed. *Institutions and Sustainable Transport: Regulatory Reforms in Advanced Economies*. Cheltenham, UK and Northampton, MA, USA, pp. 111-41.

Nash, J.F., (1950). The bargaining problem. *Econometrica*, 18, pp. 155-62.

Nöldeke G. and Schmidt, K.M., (1998). Sequential Investments and Options to Own. *RAND Journal of Economics*, 29, pp. 633-53.

Pfund, C., (2003). The Separation of Infrastructure and Operations Constitutes a Fundamental Mistake. *Public Transport International*, 3/2003, pp. 32-33.

Pittman, R.W., (2005). Structural Separation to Create Competition? The Case of Freight Railways. *Review of Network Economics*, 4(3), pp. 181-96.

Pittman, R.W., (2007). Make or buy on the Russian railway? Coase, Williamson, and Tsar Nicholas II. *Economic Change and Restructuring*, 40(3), pp. 207-21.

Preston, K., (1996). The Economics of British Rail Privatisation: An Assessment. *Transport Reviews,* 16(1)

Rabin, M., (1993). Incorporating Fairness into Game Theory and Economics. *American Economic Review*, 83, pp. 1281-302.

Roth, A.E., (1995). Introduction to Experimental Economics. In Kagel, J.H. and Roth, A.E. eds. *Handbook of Experimental Economics*. Princeton, NJ: University Press Princeton, pp. 3-109.

Rothengatter, W., (2001). How good is first best? Marginal Cost and other Pricing Principles for User Charging in Transport. Working Paper, University of Karlsruhe.

Rubinstein, A., (1982). Perfect Equilibrium in a Bargaining Model. *Econometrica*, 50, pp. 97-109.

Rus, G. de, and Nombela, G., (2007). Is Investment in High Speed Rail Socially Profitable? *Journal of Transport Economics and Policy*, 41, pp. 3-23.

Sanchez, P.C., Monsalvez, J.M.P. and Martinez, L.S., (2008). Vertical and Horizontal Separation in the European Railway Sector: Effects on Productivity, *Documentos de Trabajo,* Fundacion BBVA, 12.

Selten, R., (1978). The equity principle in economic behaviour. In Gottinger, H. and Leinfellner, W., ed. *Decision Theory and Social Ethics, Issues in Social Choice*. Dordrecht: Reidel, pp. 289-301.

Sloof, R., (2004). Finite Horizon Bargaining with Outside Options and Threat Points. *Theory and Decision*, 57, pp. 109-42.

Smirnov, V., and Wait, A., (2004). Hold-up and sequential specific investments. *RAND Journal of Economics*, 35, pp. 386-400.

Williamson, O.E. (1975): *Markets and Hierarchies: Analysis and Antitrust Implications*, New York.

Williamson, O.E., (1985). *The Economic Institutions of Capitalism*. New York: Free Press.

Yvrande-Billon, A., (2004). Franchising Public Services: An Analysis of the Duration of Passenger Rail Franchises in Great Britain. In Cliquet, G., Hendrickse, G., Tuunanen, M. and Windsperger, J., eds. *Economics and Management of Networks*. Springer, pp. 174-91.

FIGURES AND TABLES

Figure 3.1. Chronology of action

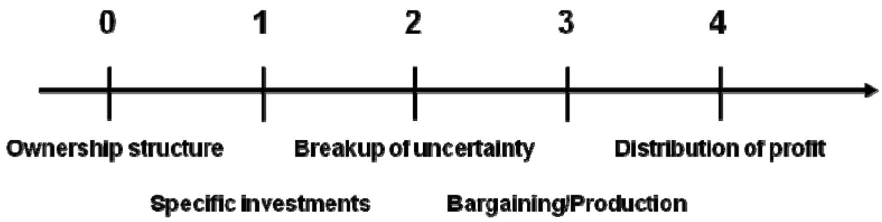

Figure 3.2. Vertical separation and Prisoners' dilemma

i_1 ; i_2	**1**	**5**	**10**
1	5 ; 5	45 ; -15	95 ; -40
5	-15 ; 45	25 ; 25	75 ; 0
10	-40 ; 95	0 ; 75	50 ; 50

Table 3.1. Summary of Hypotheses

	Vertical Separation	Vertical Integration	Hybrid Model
Stage 1			
i_1	1	10	1
i_2	1	10	10
$i_{12} = i_1 + i_2$	2	20	11
Stage 2			
b	0,5		
w			15
No. of rounds	1	1*	1*

Asterisks indicate that the number of bargaining rounds is fixed due to the setup of treatments.

Table 5.1. Investment Incentives, Two Sample, Non-Parametric Pair wise Tests

	Average Investment Levels			Mann-Whitney-U-Test					
	Integration	Hybrid	Separation	Int. and Sep.		Int. and Hyb.		Hyb. and Sep.	
Variable	Case	Case	Case	Z	p > Z	Z	p > Z	Z	p > Z
i_1	9.78	4.39*	7.51	-11.08	.000	-17.45	.000	-10.20	.000
i_2	9.79	9.26*	7.19	-11.39	.000	-4.64	.000	-8.19	.000
i_1+i_2	19.65	13.65	14.70	-14.87	.000	-17.41	.000	-3.14	.002

Asterisks indicate significant differences (<1%) within the same column, that is differences in investments between F_1 and F_2 in the respective treatment.

Figure 5.1. Average Total Investments

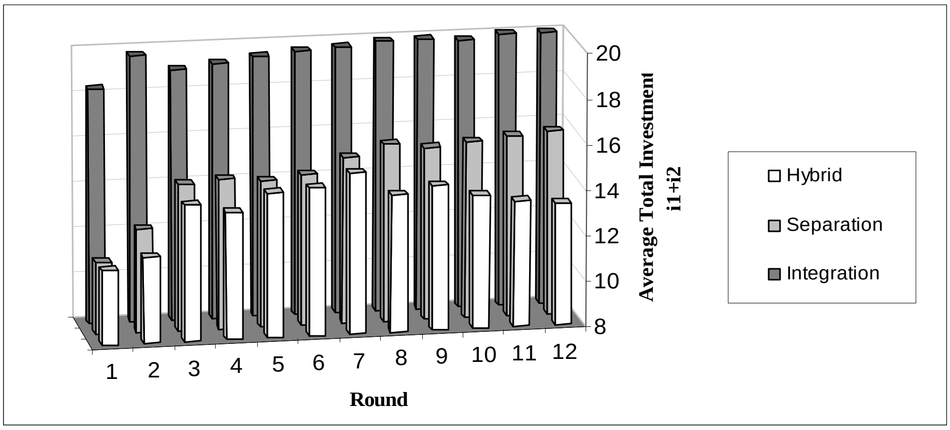

Figure 5.2. Total Investments, Single-Period Treatments

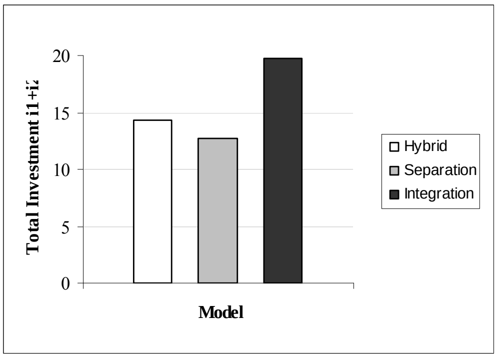

Table 6.1. Estimation Results F_1, Separated Model

	OLS	IRLS Robust Regression
i1/(i1+i2)	0.566***	0.777***
	(0.071)	(0.001)
Constant	0.205***	0.110***
	(0.356)	(0.005)
N	264	264
F(1, 262)	63.880***	8954.460***
R^2	0.439	0.439

Dependent variable: F1's share of surplus b. Robust standard errors in parentheses. Significance levels: *** $p < 0.001$; ** $p < 0.01$.