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The Liberalization of Rail Transport in the European Union

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“Quite possibly there's nothing as fine as a big freight train starting across country in early summer... That's when you learn that the tragedy of plants is that they have roots.”

– Mark Helprin, *Winter’s Tale* (1983)

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Abstract

This study presents multiple approaches to examine the liberalization of rail transport in the European Union. A legislative review highlights the importance of unbundling infrastructure management and service operations in railway reforms. Furthermore, simultaneous and sequential decision making models specify how market opening minimizes the social deadweight loss and lead to more competitive pricing. Two production frontier models also analyze the effects of vertical disintegration and market opening on network outputs. Results suggest that both vertical unbundling and increasing competitiveness help improve productivity. Lastly, three case studies compare policy implementations across Europe. The United Kingdom, a front runner in railway liberalization, has used franchising to split up British Rail extensively. Germany's integrated model, which keeps the infrastructure manager and the service operator under one umbrella company, has also reached the advanced level. Still, the incumbent Deutsche Bahn has maintained its dominance in long-distance routes. Meanwhile in France, reluctance to replace public ownership in railway companies poses a substantial obstacle for market opening reforms.

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Part I: Introduction

In the 1980s, as railway companies lost ridership and became increasingly dependent on public funding, governments across Europe were under pressure to reform the heavily subsidized national railway networks (Andersson & Hultén, 2009; Szekely, 2009). Rail transport liberalization first took place in Sweden in 1988, when the Transport Policy Act was adopted. Following this legislation, the Swedish government formed Banvekert, the national infrastructure manager, while the incumbent monopoly SJ AB became a service operator, paying infrastructure usage fees to Banvekert (Alexandersson & Hultén, 2008). Moreover, local transport authorities took over SJ AB's ownership of regional routes and were able to offer competitive tendering in these routes. This reform resulted in the first market entrance in 1990, a lower level of public subsidies and a price reduction in the operations of regional lines (Alexandersson & Hultén, 2008; International Labor Organization, 1991). The successful vertical separation between infrastructure management and service operations in Sweden and progresses in increasing competition in several other member states provided the regulatory framework for a EU-wide reform that was aimed to liberalize national railway networks in Europe as they became more integrated (Alexandersson & Hultén, 2008).

Since its initiation in Directive 91/440, the liberalization process of rail transport has been central to European Union competition policy. The European Commission (2008) argued that opening up rail transport market and privatizing existing monopolies helped promote rail networks' efficiency and responsiveness to customers' demand. Alexandersson and Hultén (2008), however, highlighted that privatizing public monopolies like railways was mainly aimed to gain revenues for the public sector or to reduce public subsidies in the future. Like in Sweden's 1988 reform, the foremost step of EU railway liberalization involved vertical separation between infrastructure management and service operations. Implementing Directive 91/440, the European Commission emphasized establishing distinct organization entities to differentiate rail transport operators and infrastructure managers, and required separate accounting systems between these two network levels. Lawmakers considered this separation a vital boost for market competition by providing equal rail capacity allocation, fair infrastructure charging and easy licensing for new rail operators (European Commission, 2008). Directive 91/440 was later followed by three main reform packages and several legislations to deregulate rail markets in multiple aspects. A regulatory review in the next chapter will analyze EU rail liberalization reforms in detail.

My thesis will furthermore provide a theoretical framework to examine rail transport liberalization. Analyses based on antitrust economics and game theory principles were developed to answer several questions such as: Why is a monopolistic market inefficient? How do new entrants improve market conditions? How are market outcomes affected after the market opening? How do the players determine their prices and market shares?

An econometric analysis of railway reforms will also be featured as my thesis's second main focus. Using a production frontier model based on the Cobb-Douglas production function, two regression tests will examine European rail networks' productivity under the impact of increasing market competitiveness and unbundling infrastructure management and service operations. The two tests cover different time frames and geographical span and are expected to provide alternating perspectives of rail liberalization outcomes.

The reality of rail reform implementation also varies widely between networks across Europe. The operational structures range from complete separation in the United Kingdom, partial separation in Germany and less separation in France. The outcomes of deregulation are also significantly different between EU member states. The last chapter of this thesis, thus, will compare the reality of railway liberalization in different national networks.

Part II: Legislative Review

In a 2004 study on competition policy in the European Union, Knieps introduced a disaggregated analysis of network sectors to locate the appropriate focus of antitrust regulation. Knieps' findings highlighted that network sectors such as electricity, water supply, air transport and rail transport contained three fundamental levels: network infrastructure, infrastructure management and network services. In rail transport, the base level corresponds to the construction of tracks and other fixed infrastructure, while the intermediate level deals with traffic and infrastructure administration and the top level is rail service operations. The three layers in network sectors can be summarized as follows:

- Base level: Network infrastructure = construction of tracks and other fixed infrastructure
- Intermediate level: Infrastructure management = railway traffic control and track management
- Top level: Network services = rail transport services

In a monopolistic national railway network, all of the three levels are usually controlled by one large-scale corporation that builds tracks and stations, controls rail traffic and runs train services. It should also be noted that entry to the fixed infrastructure level can incur an enormous sunk cost for building tracks, which makes it highly difficult, or even impossible to boost competition. This barrier to entry at the base level is usually referred to as a monopolistic bottleneck: the track owner is the sole upstream supplier of infrastructure access to train service operators. When the track owner also runs train services, they would obviously give prioritized infrastructure access to their own operations. As a result, unbundling this vertical tie between track management and train services is a vital move to increase market competition in network sectors.

The EU Directive 91/440 was the European Union Council's foremost step in its ongoing process of liberalizing the member states' railway markets. This legislation focused on breaking down rail networks' vertical integration by establishing distinct organization entities for train service operations and infrastructure management. With this approach, antitrust lawmakers aimed at boosting market competition by ensuring that "essential functions such as allocation of rail capacity (the 'train paths' that companies need to be able to operate trains on the network), infrastructure charging and licensing must be separated from the operation of transport services and performed in a neutral fashion to give new rail operators fair access to the market" (European Commission, 2008, p. 8).

After most member states unbundled their track managers and service operators at the accounting level, the railway liberalization process continued with two next key regulations in 1995 that focused on licensing and infrastructure allocation. Directive 95/18/EC specified a universal licensing process for new railway undertakings; thanks to this crucial legislative move, a train service operator who successfully obtained a license from one EU member state could freely compete in all other EU markets. On the other hand, Directive 95/19/EC provided the framework for fair allocation and infrastructure capacity charging for railway undertakings. Based on the focus of these two legislations, it could be seen that the initial Directive 91/440, which separated the vertical integration between infrastructure management and service operations, would become largely ineffective without these subsequent reforms.

Coming into effect in 2001, the First Railway Package provided improvement and development from the initial legislations in 1991 and 1995. First of all, Directive 2001/12/EC extended the original Directive 91/440 that focused on breaking down the vertical tie by establishing clearer requirements for the relationship between the state and the infrastructure manager, and between the infrastructure manager and service operators. Besides, Directive 2001/13/EC introduced additional licensing requirements introduced in Directive 95/18/EC by bringing in more safety and service quality criteria. Directive 2001/14/EC furthermore focused on advancing the framework for non-discriminatory allocation and charging of infrastructure in Directive 95/19/EC: it required infrastructure access fees to be set and collected by an independent entity and thus eliminated the potential to manipulate the monopolistic power of infrastructure managers (European Commission, 2010). In addition, according to this European Commission comprehensive study, the First Railway Package also boosted Trans-European rail transport by minimizing delays at borders and setting up a relevant inter-network tariff structure.

The Second Railway Package adopted in 2004 was the European Union Council's next step to liberalize the national and international rail transport networks with a focus on upgrading safety and interoperability. Directive 2004/49/EC targeted greater harmonization of safety requirements for new railway undertakings across member states, which in turn, provided European railway companies with greater opportunities to operate internationally, as well as to enter new markets. Interoperability was further enhanced in Directive 2004/50/EC, which developed common requirements for international high speed train services. Moreover, Regulation (EC) 881/2004 founded the European Railway Agency to administrate the common safety principles and boost EU-wide integration of member states' rail networks. On the other hand, Directive 2004/51/EC also opened up the domestic and international cargo markets – an essential step that brought the liberalization process to the next level with a free freight transport market.

In 2007, the European Commission implemented the Third Railway Package that further improved the liberalization process established in the previous legislative approaches. Directive 2007/58/EC allowed free access to the international market of passenger transport, which could be seen as another vital boost in the opening of railway markets. Furthermore, passengers' basic rights were ensured and enhanced at a EU-wide level in Regulation (EC) 1371/2007. Besides, the Third Railway Package also helped increase the interoperability of the Trans-European railway network by developing common licensing for train drivers: license holders could now move much more easily among different EU member states' national networks.

As of January 2013, the European Commission had finished constructing the draft for the Fourth Railway Package (Barrow, 2013); AK Europa reported in March 2013 that the European Parliament was currently debating to improve the proposals. The package would finally open up domestic passenger transport networks, which provided external service operators with full access to infrastructure in all national and regional markets (Barrow, 2013). Liberalizing domestic passenger transport could be considered as one of the final major steps that would maximize the degree of market opening in EU railway legislation. Following this legislation, both domestic and international networks of freight and passenger transport would be fully opened for competition. The International

Railway Journal also suggested transferring rolling stock authorization to the European Railway Agency as an important approach that would reduce the market entry cost and time for new players by twenty percent and save the EU railway industry 500 million euros by 2025 (Barrow, 2013).

Part III: Theoretical Framework

Reasoning based on market competition principles can justify whether opening up rail transport networks across Europe is a worthy process. As such, the following chapter will present theoretical analyses of how eliminating monopoly power and boosting competition make railway markets more efficient and socially desirable.

1. Monopoly

Suppose that a national railway network has a monopoly on a freight transport route and that output equals the amount of goods carried in tons while price is the dollar amount charged for each ton. When the incumbent monopoly firm wants to increase the number of goods transported, it must reduce the price charged for its cargo service to appeal to more customers, which leads to a price decrease in every ton it carries. As this would lead to a decrease of total revenue in the existing amount of goods it was already receiving, assuming that demand is inelastic, the monopoly would have no incentive to do so. As a result, the marginal revenue of a monopoly is less than the price and the marginal revenue curve lies below the demand curve (Figure 1). Just like any neoclassical firm, the monopoly will choose the output level where marginal revenue (MR) equals marginal cost (MC), so the amount of goods the railway company carries is Q_M and the price it charges is P_M.

In contrast, if the freight transport market were perfectly competitive, the firm would still choose an output level where MR equals MC, but the price it would charge, P_C, results in a larger total quantity of goods transported, Q_C, than under monopoly, Q_M. This socially efficient price-quantity combination is reached as the firm's marginal revenue curve is identical to the firm's demand curve in a perfectly competitive market. Moreover, the efficient equilibrium (Q_M, P_M) incurs no deadweight loss, a market condition that is considered efficient and socially desirable.

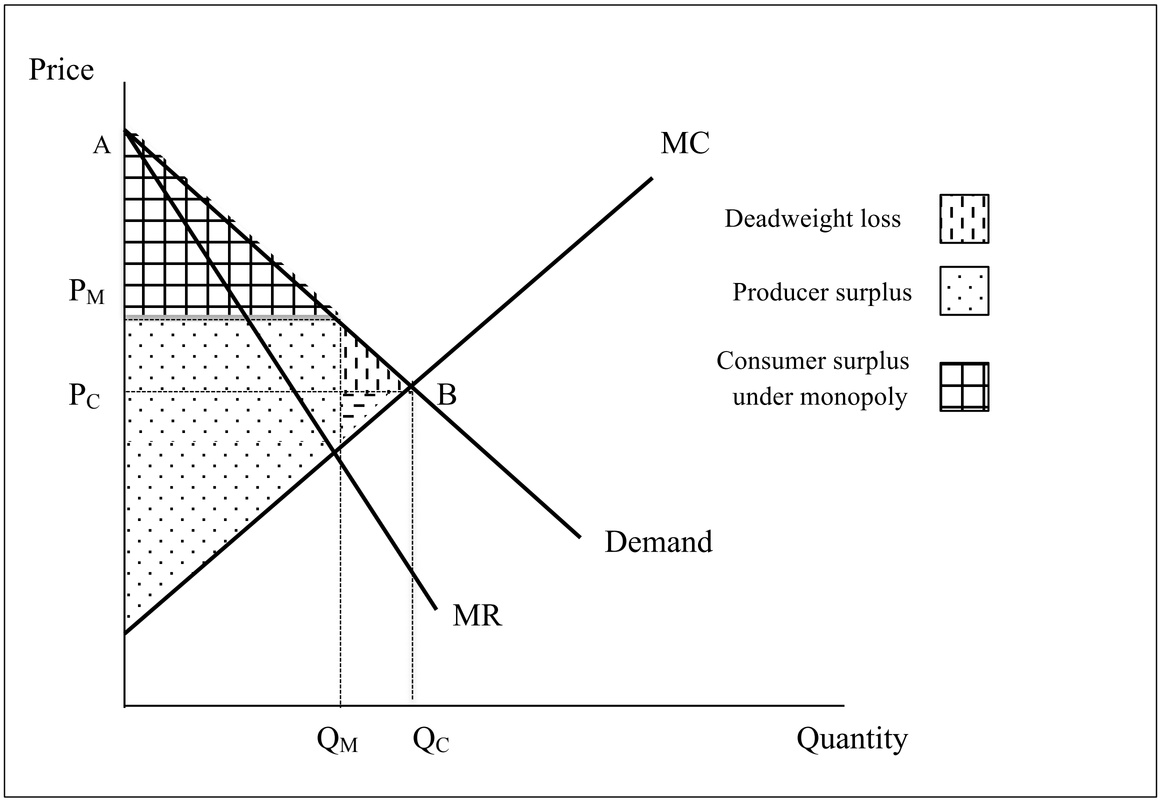

Figure 1: Market conditions under monopoly and competition

In a perfectly competitive market, consumer surplus is the area of triangle ABP_C in Figure 1. Under monopoly, the consumer surplus is shrunk to the gridded triangle area, while the monopoly's profit (or producer surplus) is represented by the dotted rectangle above line BP_C, which is the difference between monopolistic price and competitive price, times the number of goods transported. The area of the vertically dashed triangle is called the deadweight loss, which indicates a social cost of economic inefficiency. As a result of this, the government seeks to limit and regulate markets with monopoly power to maximize efficiency and to reduce the social cost from deadweight loss.

2. Price competition

After the liberalization reforms, each rail transport market in Europe can be referred to as an oligopoly, as there are now a small number of service providers. Popular oligopoly analyses include the Cournot model – a quantity approach, and the Bertrand model – a price approach (Judd, 1996). The Cournot model assumes that oligopolists set output and the market price will adjust to match quantity. On the other hand, in the Betrand model, oligopolists determine the price determinants and consumers choose output levels contingent on the set market price. A 1999 study by Preston, Wheland and Wardman highlighted that demand in transport markets, including rail transport, was inelastic, as there is a set number of riders and a set number of goods carried in every route. When a specific railway market has a new entrant, demand will not rise drastically and both the incumbent and the newcomer have to determine their price strategy to meet the existing demand. Given this nature of the railway industry, we can conclude that the Bertrand model is more appropriate for the analysis of rail transport oligopolies.

Assume the following Bertrand game in a passenger rail route with 2 players: Firm A, the incumbent and Firm B, the entrant. In order to find the best price strategy, newcomer Firm B must consider both its own price and the existing monopoly Firm A's price to determine the demand for its rail transport service. Furthermore, assume that services offered by both firms are identical and that train riders' choice is a function of price. Initially, riders have no time preference of train services (time slot allocation will be discussed further in the next section). If the newcomer Firm B sets its price higher than that of the incumbent, no one will buy Firm B's tickets. On the other hand, if Firm B sets its price lower than Firm A's price, no one will buy Firm A's tickets. If Firm B selects a price equal to the incumbent's price, both firms will have an equal number of riders. The discontinuous demand function for Firm B's output can be expressed as follows:

$q_B = 0$ if $p_B > p_A$

$q_B = (a - bp_2)/2$ if $p_B = p_A$

$q_B = a - bp_2$ if $p_B < p_A$

(From the Bertrand demand function: P = A – BQ, the demand function is rewritten as: Q = a – bP where a = A/B and b = 1/B.)

From this function, we can determine Firm B's profit, as a function of p_A and p_B:

$\pi_B (p_A,p_B) = 0$ if $p_B > p_A$

$\pi_B (p_A,p_B) = (p_B - c)(a - bp_B)/2$ if $p_B = p_A$

$\pi_B (p_A,p_B) = (p_B - c)(a - bp_B)$ if $p_B < p_A$

where c is the cost of producing one unit, in this case, the cost of providing train service for one ticket.

We now seek the price p_B that maximizes Firm B's profit in response to different choices of p_A. If Firm A sets its fare above the pure monopoly price, Firm B's best response is to set its fare at the monopoly price and earn the monopoly profit. If Firm A sets a price under its marginal cost c (which means Firm A will lose money by operating its train service), Firm B's best response is to set a higher price. In this case, Firm B has no riders and sells no tickets. However, if Firm B sets its price lower than p_A, and hence, lower than its marginal cost c, it will gain negative profit. The most likely case, however, is when the incumbent sets its price above the marginal cost but below or equal to the monopoly price. If Firm B sets its fare equal to that of Firm A's fare, both firms will share an equal number of riders. However, if Firm B sets its fare slightly lower than Firm A's fare, it will cover the whole market while its profit margin per ticket is only lowered by a very small amount.

We also expect a similar response from Firm A in response to any given choice of p_B, as this game is symmetric. Suppose that when Firm B enters the market, it sets its fare slightly below Firm A's fare. Then, Firm B will cover the entire market and Firm A will have no riders. However, Firm A's managers know that if it lowers its price slightly below Firm B's price, it will cover the entire market again and leave Firm B with no riders. Simply put, in this game, both firms know that their best response is to set the price slightly lower than the rival's price. As a result, the only possible Nash equilibrium is the equal price settings at the marginal cost ($p_A = c$, $p_B = c$). At this level, neither of the firms wants to lower its fare further as negative profit will occur. Interestingly, the price set equal at the marginal cost is also the same under perfect competition. This outcome exemplifies the Bertrand Paradox, since there are only 2 firms with monopoly power selling an identical product, but these firms are mimicking a perfectly competitive result.

This certainly is an important result that highlights the ability of market opening reforms to boost price competition and eliminate market power of incumbent railway monopolies.

The Bertrand analysis above is carried out under the assumption that both firms are equal players in this oligopolistic passenger rail market and that riders have no preference of one service over the other. However, in reality, the incumbent certainly has dominant market power, given its established ridership and a more extensive network that makes it easier for connections. As a result, the newcomer has to consider various methods to avoid competing directly with the existing monopoly. The following section will discuss in detail the decision making process that the entrant goes through.

3. Game theory models

Ruiz-Rúa and Palacín (2012) summarized the decision making process of a new railway undertaking in the following diagram:

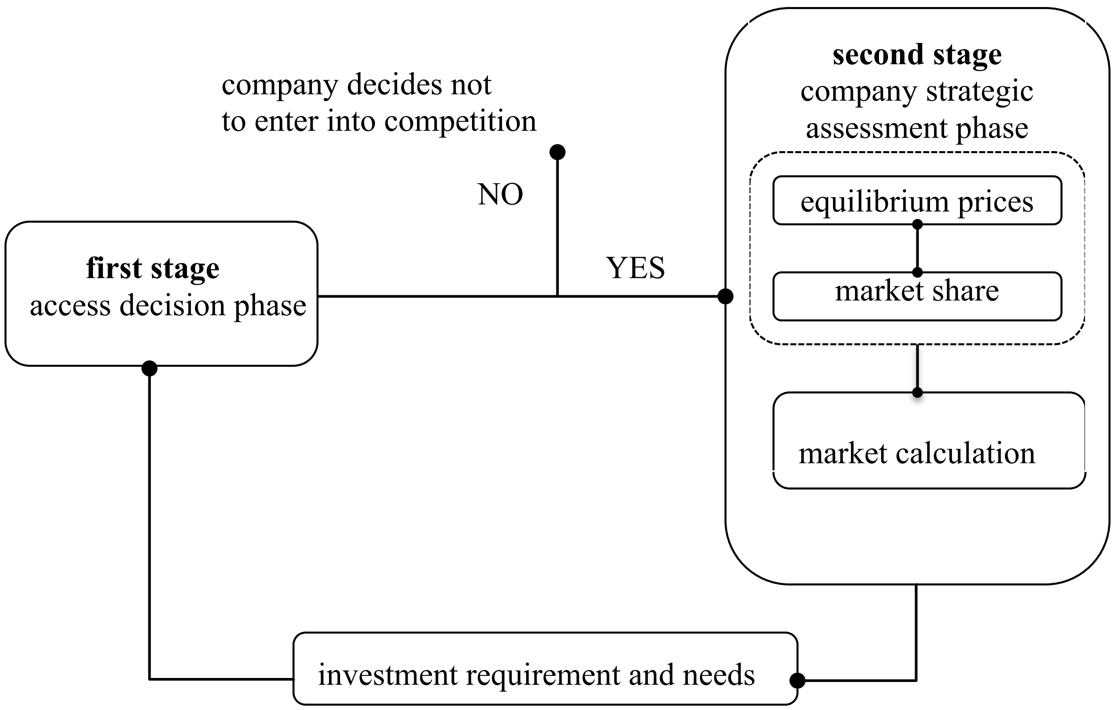

Figure 2: "Competition Strategic Plan" (Ruiz-Rúa & Palacín, 2012)

According to this strategy model, in the first stage, the newcomer decides whether or not they should enter into competition, using available information pertaining existing ridership, profit margins and regulations. In the next stage, the newcomer becomes a market player and assesses operation strategies such as how much they should charge and the market share they should cover. Price decisions are also crucial to the profitability of service operations, as discussed in the Bertrand analysis. After evaluating their profits based on the price and market share strategies, the new entrant will determine the investment requirements and come back to the first decision phase of whether they should stay in the market.

Two of the most important market strategies that new railway undertakings have to determine are time slot allocation and price determination. Scheduling strategies allow the new player to avoid direct competition with the incumbent and cover the empty time slots with higher growth potential. On the other hand, price setting decisions can significantly affect the newcomer's gain in ridership, which determines their ability to stay in the market. The following analysis will provide a deeper insight into these two game theoretical strategies.

a. Time slot allocation

Consider the following game based on Pepall and Richards and Norman's hypothetical example for air transport competition (2005). Suppose that a popular passenger train route between two cities is currently run by Firm A, the national rail monopoly. After the market opening reforms that allow fair access for all players to railway infrastructure have been implemented, the newly-formed regional rail company Firm B is interested in operating train services in the same route. Moreover, suppose that 60 percent of customers prefer to take a morning train while only 40 percent prefer the evening schedule. Also, assume that the incumbent is preferred over Firm B at a ratio of 3:1. Reasons for this preference might include the incumbent's customer loyalty program, a larger network that makes it easier for connections, or riders' status quo biases that prevent them from switching to the unfamiliar service run by Firm B. The strategy combinations of time slot allocation and payoffs are as follows:

		Firm B	
		Morning	Evening
Firm A	Morning	45, 15	60, 40
	Evening	40, 60	30, 10

Table 1: Simultaneous game for time slot allocation

Firm A’s managers will seek their strategies in response to what they predict Firm B will do, or Firm B’s reaction function. If Firm B chooses to operate in the morning, Firm A will also choose a morning schedule, as the payoff is greater than an evening service. If Firm B chooses to operate in the evening, Firm A will obviously choose the morning schedule that riders prefer. The existing monopoly benefits from its established ridership and will always choose to operate in the time slot with more customers (morning). Therefore, Firm A’s dominant strategy is to choose the morning time slot, regardless of what B does.

As for Firm B, competition would be difficult if they chose to operate at the same time period as the incumbent. Therefore, Firm B will choose to operate in the evening if Firm A runs the morning service. Likewise, if Firm A selects the evening schedule, Firm B will try to avoid direct competition with Firm A by running a morning service. In other words, when riders’ preference for one schedule over the other is not overwhelming (60% for morning and 40% for evening), the new entrant Firm B is likely to select a different slot to avoid time conflict with the incumbent. This result is similar to the classical "Chicken Game" in which each player's best response is to choose the opposite strategy. In short, the pure strategy Nash equilibrium for this hypothetical game is: Firm A runs a rider-preferred morning schedule while Firm B operates their service in the evening, or $NE^{PS}_{\text{Firm A, Firm B}}$ = [Morning, Evening].

b. Price determination

As mentioned above, Preston, Whelan and Wardman's 1999 study highlighted that the rail transport demand in the United Kingdom was rather inelastic. When a new firm entered the market and introduced a lower fare, the incumbent monopoly was forced to reduce its existing fare as well. Moreover, this price reduction only brought about an insignificant increase in ridership. Even though the trend might vary between countries, the findings for the United Kingdom comply with the general tendency that transport demand is inelastic. In other words, there is a set number of frequent riders in most routes and a fare decrease does not expand ridership extensively.

Now, imagine the following price game. After the liberalization reforms, Firm B enters the railway industry dominated by Firm A, which charges the monopoly profit maximizing fare. The price strategy for Firm B can be explained by the following extensive form game:

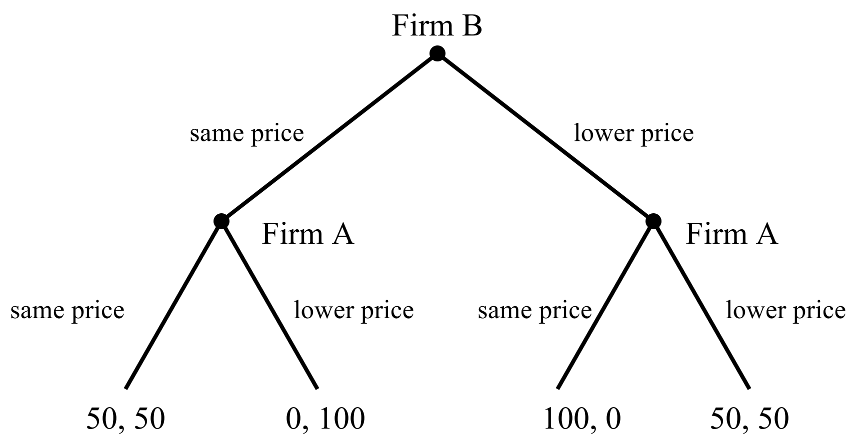

Figure 3: Sequential game for price determination

As the leader of this game for fare setting, newcomer Firm B has to determine how much they should charge per ticket given Firm A's existing monopolistic price. As it doesn't make sense if Firm B charges a higher fare while providing the same service, they will choose between a price level equal or lower than that of Firm A. As the follower, Firm A then considers whether they should keep their existing fare or reduce the price to match Firm B's new low price. When both railway firms have the same fare level, each of them covers half of the market, assuming that riders have no preference for one firm over the other. When the two firms charge different fares, the one with the lower price will cover the whole market. It should also be noted that the inflexibility of rail transport demand, as explained above, allows us to assume that the number of riders stays the same even after a price reduction.

Applying backward induction to find a sub-game perfect Nash Equilibrium specifies that Firm A will choose to lower its price if Firm B charges the previous monopoly price so that Firm A captures the entire market. On the other hand, if B sets a lower fare than A's previous fare, A will also reduce its price to match this lower ticket charge. Each firm now will cover half of the market. In the next step, knowing Firm A's price strategy, Firm B will decide to set its fare lower than previous monopolistic level so that it will have half of the market share. The sub-game perfect Nash equilibrium of this sequential game is:

$NE^{SP}_{\text{Firm B, Firm A}}$ = [lower price, lower price]

In fact, the fares of the two firms are not automatically equal at first. However, both firms continually reduce their prices until they reach an equal level at the marginal cost. As this is exactly what happens in a perfectly competitive market, this result complies with the Bertrand Paradox described in the previous section.

Part IV: Econometric Tests

1. Literature review

Studies on European railway networks' productivity after the liberalization process have exhibited different approaches to evaluate network efficiency. The efficiency definition, which mostly referred to either input-output efficiency or cost efficiency, led to somewhat contradicting interpretations of rail liberalization results. Friebel, Ivaldi & Vibes (2010) introduced a production frontier model, which directly measured the effect of the (de)regulation on network output. This study utilized a simple input-output regression model, which included a weighted sum of outputs in passenger transport and freight as the dependent variable and capital and labor plus a dummy variable for the policy implementation as explanatory variables. The findings justified the positive impact of the sequential reforms in rail transport on the network output productivity. As the model by Friebel et al. is very appropriate to my study, its properties will be discussed in detail in the next section.

Instead of using an increase in output as an efficiency indicator, other studies on European rail reforms have focused on operating costs to determine the impact of deregulation on the networks' performance (Asmild, Holvad, Hougaard & Kronborg, 2009; Driessen, Lijesen & Mulder, 2006; Growitsch & Wetzel, 2009). For instance, Asmild et al. (2009) employed this approach using a Multi-directional Efficiency Analysis with complete data from 23 European countries between 1995 and 2001, the main phase of policy implementation for vertical separation between infrastructure management and service operations. This Multi-directional Efficiency Analysis was aimed to identify how specific cost drivers changed as a result of these reforms. Results also showed that the liberalization implementations generally helped increase the operating cost efficiency of European railway networks. More specifically, vertical disintegration significantly reduced both material and staff expenditures, while other reform packages only resulted in improving efficiency in one of the two cost types.

Using a similar cost efficiency approach, Growitsch and Wetzel (2009) employed Data Envelopment Analysis to focus on the effect of vertical separation on the cost efficiency of railway companies. The analysis compared the vertically separated model of European railway companies after liberalization with a hypothesized integrated model. The results, which were based entirely on theoretical estimates rather than precise firm-level data, disregarded the reforms' aim to boost efficiency and favored vertical integration between infrastructure management and service operations.

Driessen et al. (2006) also used Data Envelopment Analysis at an international level and focused on measuring the relationship between competition design and rail transport productive efficiency. Given the worldwide variability of production models, this study highlighted that different methods of operating railway systems could result in different network efficiency levels. Competitive public tendering, which was commonly practiced in short distance routes in Europe, was found to significantly boost productive efficiency. However, this analysis also pointed out that free market entry had a negative effect on the networks' cost efficiency.

The relationship between infrastructure management and service operations, briefly mentioned in the production frontier model by Friebel et al., was fully analyzed by

Cantos Sánchez (2001) using a translogarithmic cost function analysis. Covering twelve European state-owned rail companies between 1973 and 1990, this mathematical study suggested diseconomies of scope between freight and passenger transport: freight transport costs were complementary to infrastructure costs while passenger transport costs were substitutes for infrastructure management costs.

2. Econometric models

In this section, I develop two regression models to examine the impact of vertical separation and market opening on network output. Test design is based on the production frontier model by Friebel, Ivaldi and Vibes (2010). This model captured the Cobb-Douglas production function which related output and two inputs, labor and capital. Friebel et al. introduced technical progress $(\gamma_i + \theta_0 Deregulation)$ on the input side to examine whether the implementation of railway reforms affected the productivity of national railway networks. In the first regression, Friebel et al. did not distinguish between the three types of reforms: vertical separation, third party access and formation of an independent regulatory entity. Their study later analyzed the efficiency impact of whether railway liberalization regulations were implemented as a package (two or three reforms within a year) or in sequence, and found the latter method to be more effective. My first study, however, focused solely on the vertical split between infrastructure management and operations and its impact on network output. The econometric model, thus, is specified as follows:

$$ln\ y_{it} = \beta_0 + \beta_1\ ln\ K_{it} + \beta_2\ ln\ L_{it} + \beta_3 Separation_{it} + \varepsilon_{it}$$

Capital (K) is measured by the track length of a particular country i in a specific year t. Labor (L) is represented by the annual number of employees in a national railway network. The dummy variable *Separation* takes the value of 0 in years prior to the vertical split and 1 in years following the implementation. This leads to another main difference between my test and the original production frontier model. Friebel et al. (2010) used $(\gamma_i+\theta_0 Deregulation)t$, a multiplicative variable between time and railway liberalization to examine how the reforms shifted the slope of the productivity trend. My study, however, employs a simpler dummy variable *Separation*, as the main focus of this test is on how vertical disintegration has changed the level rather than the slope of the productivity trend.

On the other hand, output (y) corresponds to a weighted sum of outputs in freight and passenger traffic, as suggested in the output measures by Friebel et al.: $ln\ y_{it} = \ln passkm_{it} + \lambda \ln tonkm_{it}$. Friebel et al. (2010) used an available estimate of $\hat{\lambda}$ based on an empirical measure for the relationship between freight and passenger transport. This finding suggested that $\hat{\lambda}$ lied between 0.24 and 0.27, which indicated that a one percent increase in the amount of goods carried in freight transport approximately resulted in a 0.25 percent decrease in passenger traffic (Friebel et al., 2010).

The second linear regression also employs this production frontier model, but focuses on how the level of competitiveness affects network output. The econometric model is designed as follows:

$$ln\ y_{it} = \beta_0 + \beta_1\ ln\ K_{it} + \beta_2\ ln\ L_{it} + \beta_3 COM_{it} + \varepsilon_{it}$$

The new explanatory variable COM represents IBM and Kirchner's COM Index (2011), which assessed the market opening level of national railway networks in Europe. The COM Index captured three aspects of market opening reality: modal split between track management and train service (20%), number of licensed and active railway companies other than the incumbent (20%), and market share of these newcomer competitors (60%) (IBM & Kirchner, 2011). Regarding the reality of vertical disintegration, the index focused on operational share and improvement across time of modal split in both passenger and rail transport. The second criterion on the number of newcomer railway companies took into account three measures: certified new railway undertakings in relation to network length, a ratio of active to certified railway undertakings and number of railway undertakings with regular passenger transport service. Market share of external railway undertakings, the most important category that contributed 60% to the total index, consisted of share percentage as well as share increases across time. Overall, with its comprehensive assessment of competitive dynamics, the COM Index is an appropriate measure for the reality of railway market opening in Europe. A summary of how the 2011 index was conducted is illustrated in table A.1 of the Appendix.

3. Data collection

Information on the annual track length of all national railway networks was obtained from the World Bank (2012) database. The International Union of Railways database

(2011) provided my study with annual number of employees, number of passengers transported per kilometer and the amount of goods carried per kilometer. Friebel et al. (2010) also summarized information on years of vertical separation between infrastructure management and service operations. Details are illustrated in Table A.2 of the Appendix. My dataset comprises of twelve countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom over a twenty-three year period from 1985 to 2008, when all railway reforms in the European Union took place.

The measure for competitiveness in my second regression model is the COM Index from IBM and Kirchner's 2011 study on EU rail liberalization. The data is collected from the DICE Database of Center for Economic Studies, University of Munich (2011). As this data source covered a more recent time frame, my study will include nine newer members of the European Union: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. As the total number of countries has now increased to twenty-one, the study on market opening reality is expected to provide a broader perspective of railway competition in the European Union of the modern day. It should also be noted that this index has only been published four times in 2002, 2004, 2007 and 2011. The data for other input and output variables will thus be collected for only the year prior to each publication. In other words, compared to the first study on vertical split, the dataset for this second econometric model captures a larger geographical span of twenty-one railway markets but a smaller time frame of four years: 2001, 2003, 2006 and 2010. The latest COM Index of the countries in this study is illustrated in Table A.2 of the Appendix. According to this 2011 chart, the United

Kingdom was the most competitive national railway network while sparsely-populated Finland and Lithuania ranked last. Another interesting fact of this index was the low ranks of large rail networks such as Spain and France – third and fourth to last, respectively. The detailed analysis of rail liberalization situations in different railway networks will be coupled in my case studies chapter.

4. Regression results

a. Vertical disintegration

Table 1 summarizes the results of the first regression, which focuses on the vertical split's impact on productivity. The dependent variable is the weighted sum of outputs in freight and passenger transport with λ chosen at 0.25, as explained in the previous section. The parameter estimates for labor and capital are both positive. Furthermore, the regression outcome indicates that a 25-percent increase in the number of employees doubles the aggregate output, while an 81-percent increase in track length leads to the same result. The positive sign of these parameter estimates is exactly in accordance with the model design based on the Cobb-Douglass function as well as the result by Friebel et al. (2010). However, the regression outcome in Friebel et al.'s study showed that doubling the aggregate output would require a 53-percent increase in labor or a 74-percent increase in capital, ceteris paribus. As my dataset covers more recent years' information than that of Friebel et al. (2010), the vast difference in the parameter estimate for labor might indicate technical advancement of rail transport, which leads to much improvement in productivity in terms of labor input. The sum of β1 and β2 is slightly bigger than 1, which suggests small increasing economies of scale: increasing all inputs by the same percentage will lead to a proportionally larger increase in output.

Source	SS	df	MS		
Model	304.897734	3	101.632578	Number of obs =	288
Residual	67.8211753	284	.238806955	F(3, 284) =	425.58
				Prob > F =	0.0000
Total	372.718909	287	1.29867216	R-squared =	0.8180
				Adj R-squared =	0.8161
				Root MSE =	.48868

output	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lncapital	.2501608	.0596072	4.20	0.000	.1328329	.3674888
lnlabour	.80738	.052531	15.37	0.000	.7039805	.9107796
separation	.5636402	.0656746	8.58	0.000	.4343694	.6929109
_cons	3.575818	.3174415	11.26	0.000	2.950981	4.200655

Table 1: Regression results: vertical split model

More importantly, my regression results highlight a positive relationship between the policy implementation variable and aggregate output. On average, the vertical separation between infrastructure management and train service helps increase the network's output by 0.56 percent. All t-values for the three parameter estimates are also statistically significant at a one-percent confidence level. Furthermore, the t-value of the parameter estimate for vertical split in this study is far more significant than that of Friebel et al.'s test, which failed to meet the 5% confidence level that rejected the null hypothesis that railway deregulation did not improve productivity. Small standard errors in the results also indicate the sample's representativeness of the population, which can be explained by the large sample size and the comprehensiveness of data from the International Union of Railways (UIC) and the World Bank. Thus, my regression results suggest that vertical separation between infrastructure management and train service has brought about greater network productivity in years following its implementation.

Friebel et al. (2010) also underlined the data unavailability for the United Kingdom as an important factor that might affect their regression interpretation. In my study, the UK data from the International Union of Railways is partially inconsistent, especially in labor input, as many of the new rail franchises did not report their data annually. Missing values are estimated using data from the previous submission. Because of this shortcoming, I ran an alternative regression without the United Kingdom as suggested by Friebel et al. (2010). The regression results are as follows:

```
. regress output lncapital lnlabor separation

      Source |       SS       df       MS              Number of obs =     264
-------------+------------------------------           F(  3,   260) =  375.18
       Model |  268.300145     3  89.4333817           Prob > F      =  0.0000
    Residual |  61.9771018   260  .238373468           R-squared     =  0.8123
-------------+------------------------------           Adj R-squared =  0.8102
       Total |  330.277247   263  1.25580702           Root MSE      =  .48824

------------------------------------------------------------------------------
      output |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lncapital |   .2313242   .0597267     3.87   0.000     .1137145    .3489338
     lnlabor |   .7930444   .0535237    14.82   0.000     .6876494    .8984395
  separation |   .5376439   .0676925     7.94   0.000     .4043487    .6709392
       _cons |   3.883821   .3256507    11.93   0.000     3.242573     4.52507
------------------------------------------------------------------------------
```

Table 2: Regression results: vertical split model (without United Kingdom data)

Removing the United Kingdom data does not cause much change in the regression results. The new fitted model dictates that, under ceteris-paribus conditions, a 79-percent increase in the number of employees would lead to a doubling of output while a 23-percent increase in track length would bring about the same result. Besides, excluding data from the United Kingdom (or reducing the sample size) makes the effects less significant, indicated by smaller t-values for all parameter estimates of the new model. Interestingly, in Friebel et al.'s 2010 test, the model that omitted the United Kingdom data actually resulted in a higher t-value for the parameter estimate of the deregulation variable. The opposite trend observed in this study might come from the fact that the UIC's data for the United Kingdom are now available for all years covered in the analysis despite their inconsistency, while the dataset by Friebel et al. had to exclude the period when data were unobtainable. The difference in my study's time frame might also lead to different regression outcomes. In addition, the sum of β_1 and β_2 in this model is reduced much closer to 1, which nearly suggests constant returns to scale: if all inputs are increased by the same percentage, output will increase by a proportionally equivalent amount.

b. Competitiveness

In my second econometric model, the dummy variable for vertical disintegration in the first regression is replaced by a variable for IBM and Kirchner's COM Index, a measure of competitive dynamics levels across Europe. With a larger geographical coverage and different time span, this model is expected to provide an alternative view of rail transport productivity after market opening. Table 3 below illustrates the regression results.

```
. regress output lncapital lnlabor com

      Source |       SS       df       MS              Number of obs =      74
-------------+------------------------------           F(  3,    70) =   67.32
       Model |  141.071756     3  47.0239188           Prob > F      =  0.0000
    Residual |   48.896592    70  .698522743           R-squared     =  0.7426
-------------+------------------------------           Adj R-squared =  0.7316
       Total |  189.968348    73  2.60230614           Root MSE      =  .83578

------------------------------------------------------------------------------
      output |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lncapital |   .2761368   .1826284     1.51   0.135     -.088104    .6403776
     lnlabor |   .9372098   .1695211     5.53   0.000     .5991106    1.275309
         com |   .0020791   .0005115     4.06   0.000     .0010589    .0030993
       _cons |   1.252618   .9194929     1.36   0.177    -.5812524    3.086489
------------------------------------------------------------------------------
```

Table 3: Regression results: competitiveness model

The fitted model denotes that with other inputs remaining constant, a one-point increase in the level of railway market competitiveness leads to a 0.2-percent increase in aggregate output. The t-value for the COM variable's parameter estimate is also significant at a one-percent confidence level. We thus can conclude that an increase in market competitiveness can help improve overall productivity. Both coefficients for capital and labor input have positive signs, which is in accordance with the results from the first study. However, capital is surprisingly not statistically significant at a five-percent confidence level in predicting overall output. The most likely reason for this is differences in rail technology across the present-day European Union where the relationship between track building and overall output can vary greatly between different rail networks. The limited time span of the COM Index also poses another shortcoming of this model, which might result in the insignificance of the capital variable.

Part V: Country Comparison

1. Overview

IBM Global Services, in conjunction with Christian Kirchner (2011), introduced the Rail Liberalization Index (LIB Index) to measure the relative degree of market opening of rail transport markets in the European Union, Switzerland and Norway. This index was a combination of two indices for market competition in theory and practice: the LEX Index and the ACCESS Index. Kirchner (2004) described the LEX Index as a measurement of the "law in books," as it captured the degree of market entry support and external railway undertakings in the national competition regulation. On the other hand, the ACCESS Index indicated a "law in action" measurement that evaluated the reality of market accessibility and barriers to entry from potential external competitors' point of view (IBM & Kirchner, 2011). The combined LIB Index put more weight on the reality of railway markets after liberalization, with the ACCESS Index accounting for 80 percent of the total measurement. This 2011 study placed Sweden, the United Kingdom, Germany, the Netherlands, Denmark and Austria at the top tier in its chart as markets with accessibility at the "Advanced" level. The majority of EU member states were in the second tier as networks with "On Schedule" market opening, while Lithuania, Greece, Latvia, Luxembourg, Spain and Ireland fell behind at the lowest "Delayed" level.

This same report also classified national railway networks in the EU into three categories based on the forms of vertical separation between the infrastructure manager and the service operator: separation, integration and hybrid. A separation model featured completely separate ownership of infrastructure management and network services, as found in the national railway networks of Bulgaria, Denmark, Spain, Finland, Greece, the Netherlands, Norway, Portugal, Romania, Sweden, Slovakia and the United Kingdom. On the other hand, an integration model was characterized by a legal and functional separation of infrastructure and service levels but these two branches still existed under an umbrella corporation. As of 2011, this was the model of the railway networks in fourteen countries: Austria, Belgium, Switzerland, Denmark, Germany, Estonia, Hungary, Ireland, Italy, Latvia, Luxembourg, Lithuania, Poland and Slovenia. Lastly, the hybrid model in France and the Czech Republic specified an independent infrastructure manager delegating its tasks back to the incumbent train service operator as part of an agency agreement. To address the concern of whether the network's operation model affects its accessibility, IBM and Kirchner's 2011 study also showed no correlation between the model types and the degree of market opening.

2. The United Kingdom and the franchising system

Ranking first in 2007 and second in 2011 (behind Sweden) in IBM and Kirchner's Rail Liberalization Index report (2011), the United Kingdom has one of the most liberalized rail transport markets in the European Union. The British railway network is a foremost example of the separation model that involves a complete vertical split between infrastructure managers and service operators. The Railways Act 1993, the first regulatory implementation of railway liberalization, imposed structural reforms focusing on the transfer of railway companies' ownership to the private sector, as well as a fundamental separation between infrastructure management and train operations.

Following the Act, a new government-owned infrastructure manager, Railtrack, was formed in 1994 as a completely separated entity from British Rail, the dominant incumbent at the time (Kain, 1998). In May 1996, the liberalization process took a further step as Railtrack became publicly traded on the London Stock Exchange. On the other hand, the remainder of British Rail was completely split into privatized companies with different concentrations in operations, including (Kain, 1998):

- Seven in infrastructure maintenance
- Seven in infrastructure services design
- Six in track renewal
- Three in rolling stock leasing (ROSCOs)
- Six in freight transport operations
- Twenty-five in franchised passenger transport operations

With a very large number of newly formed entities from the previous dominant British Rail, the railway liberalization process in the United Kingdom achieved not only a complete vertical separation but also a thorough horizontal split.

A notable characteristic of the British rail transport liberalization is its franchising system. The fundamental railroad reform in 1993 helped establish twenty-five privately owned passenger train operations units that went under a franchising process administered by the Director of Rail Franchising, which was also formed following the Railways Act. Currently, the process is carried out by the Department of Transport, which invites potential bidders to tender for a specific route as the previous franchising contract is expiring. The governing authority then takes into account numerous criteria such as service frequency, infrastructure payment and the level of public subsidy the bidder needs. The standard length of a rail franchise is seven years; however, franchise holders that make additional investments in special routes have the option for longer contracts. It should also be noted that rolling stocks, such as locomotives, train cars and wagons, are not owned by franchised service operators. The liberalization process has established a separate group of companies, the ROSCOs, which provide the franchise holders with the rolling stocks through independent leasing contracts. Overall, the British regulators' attempt to liberalize the rail transport market could be seen as very thorough and systematic: the reforms help boost newcomers' fair access to all of the network's primary resources including rail tracks, rolling stocks and government subsidies. A detailed map of the relationships between the newly formed entities after their split from British Rail was highlighted in Kain's 1998 report:

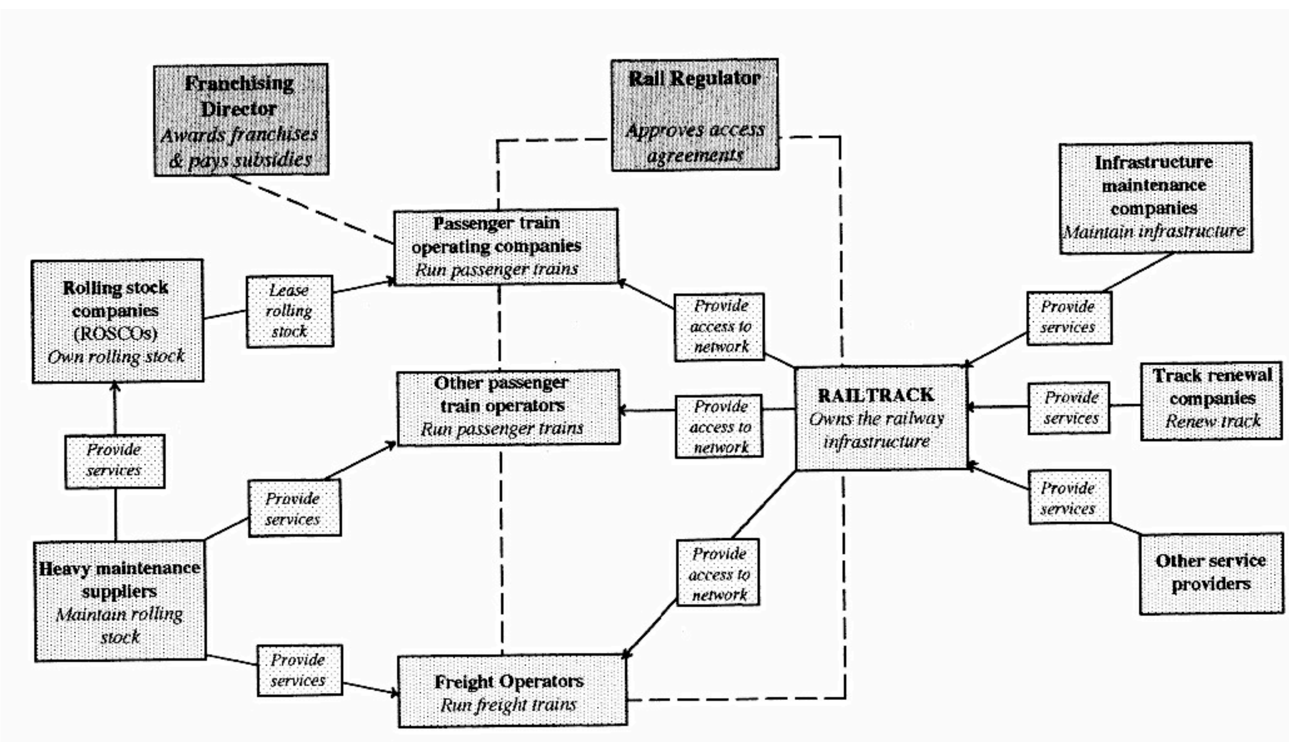

Figure 4: Relationships between rail transport entities in the UK (Kain, 1998)

The British franchising system has been proved successful with significant increases in passenger volume and service frequency of 70.1% and 36.7% respectively (European Commission, 2010). Politt and Smith (2001) also pointed out that privatization helped lower both prices and public subsidies. However, since the Railways Act's implementation in 1994, its complexity and unclear accountabilities have been widely criticized (BBC, 2006). First of all, the governing authority of the franchising process seemed to place a strong emphasis on the financial aspect of the bids. For a franchise that required a public subsidy, lowest-bid winners had to comply with stricter standard requirements, which were generally close to the levels of the British Rail service before privatization. On the other hand, operators of profitable routes, who paid infrastructure fees instead of receiving government subsidies, were likely to gain more freedom in their operations (Preston, Whelan, Nash & Wardman, 2000). This has led to critical questions on the franchises' safety standards. Furthermore, severe railway accidents following British Rail's vertical and horizontal split also casted a doubt on the maintenance and renewal process of Railtrack, the private-sector infrastructure manager, and the short-term investment tendency of franchise holders was also blamed for devaluing the system maintenance and durability (European Commission, 2010). As a response to this, in 2001 the Strategic Rail Authority was formed to improve the administration of the franchising process while stricter maintenance requirements were introduced to raise the network's standards. Moreover, the highly-criticized for-profit infrastructure manager Railtrack was succeeded in 2002 by Network Rail, which has operated as a non-profit entity.

3. Germany: open access and public service obligations

IBM and Kirchner's 2011 European Rail Liberalization Index report ranked Germany as the third most advanced railway market in the rail transport liberalization process, behind Sweden and the United Kingdom. With the infrastructure manager and service operator functioning independently under an umbrella corporation, the national railway network in Germany is a notable example of the integrated model in IBM and Kirchner's 2011 study. Before the rail liberalization policy took place, Deutsche Bahn AG was the sole provider of both national and regional services in Germany (European Commission, 2010). Following the implementation of the EU Council Directive 91/440, the passenger traffic division DB Bahn, the logistics unit DB Schenker and the infrastructure management subsidiary DB Netze were established in 2007 as separate organizational entities at the accounting level. The detailed functional relationships between different railway entities in Germany are demonstrated in Figure 5 (Link, 1994).

The further privatization process of the state-owned Deutsche Bahn has been under heated debate: the Merkel government approved a plan in 2007 that aimed at splitting Deutsche Bahn gradually while granting it the control over the track network for the following 15 years. This plan was met with uneasy response from the sixteen states' transportation ministers, as they feared Deutsche Bahn's overpowering track management could hamper competition, which would lead to lower service frequency in remote areas (Lindsey, 2007). A 2007 report by Slack and Volt also signified Deutsche Bahn's dominance in both infrastructure and the traffic services in the future despite legislative measures (Slack & Volt, 2007).

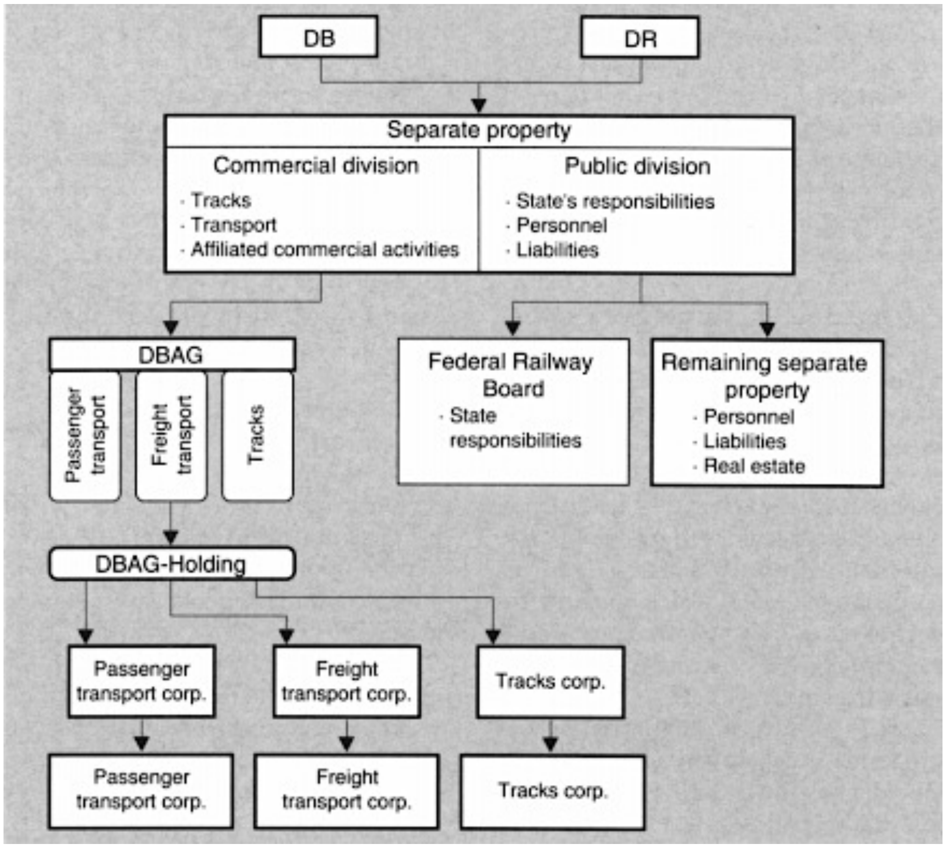

Figure 5: Relationships between railway entities in Germany (Link, 1994)

The German railroad liberalization process could also be characterized by the concurrent existence of two operational options: open access and public service contract. The European Commission's 2010 report recognized the common practice of public service obligations (PSOs) in the regional passenger market where external competitors had emerged by 2010 and DB Regio's dominance had been consistently reduced. In 2006, external operators achieved a 15.2 percent share of the regional passenger rail network, which translated to a 10.1 percent share of the overall system (Beria, Quinet, de Ruz & Schulz, 2010). Passenger transport in short distance is not profitable for the most part and thus requires public subsidies. The competitive tendering process in Germany is carried out similarly to the United Kingdom's franchising with the bidder for the lowest public subsidies winning the contract. The European Commission's 2010 study highlighted the success of Germany's PSOs as the regional passenger transport market achieved significant gains in ridership, service frequency and network extension. However, this report also underlined larger costs for local governments in providing public subsidies as competitive tendering became widely practiced in all regional networks, including very remote ones. Overall, public service obligations could be seen as socially beneficial but also financially burdensome.

On the other hand, Germany's interregional passenger network is characterized by the open access practice. The market is open to any competitor interested in operating for-profit in long distance routes. However, the European Commission pointed out the regulatory uncertainty and the very powerful position of the incumbent, Deutsche Bahn as reasons for the lack of market entry (2010). In 2006, external operators contributed to less than one percent of the market share in long distance passenger traffic (Beria et al., 2010). However, Germany's railway liberalization process could still be considered partially successful as the vertical disintegration at the accounting level led to a surplus in Deutsche Bahn's budget, which had never occurred before this policy implementation.

The introduction of the United Kingdom's competitive franchising, which was already employed in Germany's bus industry, was also unlikely: franchising would require a complete separation between infrastructure management and service operations as well as a breakup of the incumbent monopoly (Lalive & Schmutzler, 2008).

4. France and the hybrid model

The railway network in France exemplifies IBM and Kirchner's hybrid model of liberalization (2011): the independent Reseau Ferré de France (RFF) controls the infrastructure management level, but still transfers major track management tasks to the national rail transport provider SNCF through special contracts. This indicates an unclear vertical separation between infrastructure management and service operations. Furthermore, the French government owns both RFF and SNCF and acts as the decisive supervisor of SNCF to stabilize its financial flow and plan research and development projects. On the other hand, national infrastructure manager RFF, though owned by the government, operates independently (Szekely, 2009).

In IBM's 2011 Rail Liberalization Index report, France moved up from the "delayed" level in 2007 to the "on schedule" group in 2011. This highlighted the progress of railway liberalization in France, even though its market was still far less open than those of the United Kingdom and Germany. Following EU Directive 91/440, the RFF was split from SNCF in 1997 to become an independent infrastructure manager. However, after thirteen years of the supposed liberalization process, SNCF was still the sole provider of rail transport and operated under public service obligations both regionally and nationally. By 2006, a few service providers had licensed their operations but still remained inactive thereafter (Beria et al. 2010). Sakamoto (2012) underlined that the RFF formation was simply to obey EU regulations, while RFF and SNCF were almost integrated in reality: in 2004, RFF paid SNCF 2.6 billion euros for its infrastructure maintenance in exchange for 2.3 billion euros in infrastructure access fee from SNCF.

Moreover, Quinet (2006) labeled France as “one of the most reluctant countries to provide open access” and pointed out that the operation of the French railway network following liberalization had been rather unsuccessful and was under increasing pressure for productivity improvement. In this report, SNCF’s debt rose seventeen percent from 35 billion euros in 1991 to 41 billion in 2005, even though it had transferred more than half of its debt (20.5 million euro) to RFF through the modal split in 1996. Quinet (2006) also noted SNCF’s loss in eighty percent of its cargo services in 2004.

Regarding the low level of market opening in France’s rail transport, researchers have raised multiple questions about public opinions on railway liberalization. Tomeš’s 2008 study underlined the French government’s reluctance to liberalize the market as French politicians were skeptical about the benefits from greater competition and also questioned market opening’s suitability to the incumbent network. Moreover, Rogers (2007) highlighted France’s prevalent preference of minimizing competition to endorse social equality and cohesion as another barrier hindering the liberalization of rail transport, which was widely regarded as a non-profit public service. Therefore, with the skepticism of both the government and the general public about promoting competition, it is unlikely that significant progress in the liberalization of the French railway network will arise in the near future.

Part VI: Concluding Remarks

Rail transport liberalization has taken place in the European Union in the last twenty years. The core of the reforms was a vertical disintegration between track management and train service operations, which was initiated in Directive 91/440. Thereafter, the legislative mechanisms were further developed to enhance market entry, interoperability, competitiveness and service quality. In 1995, the European Commission adopted two key regulations to enable universal licensing procedures for train operators and guarantee non-discriminatory infrastructure allocation and capacity charging for new railway undertakings. The 2001 First Railway Package defined clearer relationships between infrastructure management and service operations and enhanced fair access by requiring an independent entity to set and collect infrastructure usage fees. The 2004 Second Railway Package focused on upgrading interoperability for international train services and established the European Railway Agency to harmonize safety principles between national networks. Interoperability was further enhanced in the 2007 Third Railway Package, which allowed free access to international passenger transport market, ensured passengers' rights across Europe and enabled common licensing for train drivers.

My theoretical framework analyzed how opening up monopolistic rail transport markets can eliminate the deadweight loss to society. Using a Bertrand analysis, my study furthermore specifies a fare reduction to the perfectly competitive level in rail transport markets after liberalization. Two game theoretical models also highlight how opening up rail transport markets leads to diversifying service schedules and lowering prices.

My econometric tests employ the production frontier model by Friebel et al. (2010). The regression results justify the effects of vertical split and market opening on network productivity, both of which are significant at a one-percent confidence level. Therefore, rail transport liberalization is a worthy process that European rail networks can benefit from in multiple aspects. Indeed, railway liberalization should be developed and carried out more thoroughly across the European Union, especially as the trans-European rail network becomes more integrated.

In practice, the modal split between infrastructure management and service operations exists in three main methods: complete separation (United Kingdom), functional and legal separation an umbrella company (Germany) and a hybrid model that involves special agreements between track management and operations (France). The result of market opening also varies widely between member states. The United Kingdom utilizes a franchising process and has liberalized its network to a great extent. In the United Kingdom and Sweden, the two most deregulated rail networks, passenger volume has increased, while fares and public subsidies have dropped since liberalization (European Commission, 2010; Pollitt & Smith, 2001; Alexandersson & Hultén, 2008). Germany has also achieved an advanced level in railway reforms, even though the incumbent's dominance has nevertheless remained prevalent. Meanwhile, given the government's stubborn ownership of the railway network and a social reluctance to open up the market, France still has a long way to go in its rail liberalization process.

A major concern arises over my study's sole focus on production output as a determinant of liberalization success. Are customers of the extensively privatized British rail network more satisfied than those of the vertically integrated French network? Rising questions on the British network's safety standards reflect public discontent with rail liberalization to some extent. Meanwhile, both France's government and general public consider rail transport as a non-profit public service and are not willing to implement liberalization reforms. However, a 2011 report by the European Commission pointed out that British train riders were significantly more satisfied with their country's network than French ones in multiple aspects. Eighty-four percent of passengers in the United Kingdom were "very or rather satisfied" with the frequency of trains, while 73 percent of passengers in France had the same response. Moreover, 87 percent of British train riders were pleased by the network's punctuality and reliability, while only 55 percent of French customers felt the same. The United Kingdom also ranked higher than France in traveling speed, information provision and connections. Notably, the UK ranked relatively low in rail cars' cleanliness and maintenance, which reflected the public concern mentioned in the case studies section. Thus, in short, this European Commission study (2011) suggested that passengers of the more liberalized British rail network were generally more satisfied with its services than those in France. However, given no data availability of customer satisfaction over the period prior and after liberalization, more studies need to be developed to capture the relationship between market opening and public opinion.

Appendix

Criteria	% in overall index	% in category
Modal split changes	**20**	
Change in the modal split for rail freight transport (2001 - 2008)		40
Change in the modal split for rail passenger transport (2001 - 2008)		40
Share of modal split for rail freight transport 2008		10
Share of modal split for rail passenger transport 2008		10
Number of external RUs 2009	**20**	
Certified RUs (excl. incumbent) in relation to network length		40
Ratio of active RUs to certified RUs		50
Number of active RUs providing passenger services on a regular basis		10
Market share external RUs 2009	**60**	
Market share ext. RUs in terms of transport performance		75
Increase in market share of ext. RUs between 2006 and 2009		25

Table A.1. The makeup of the 2011 COM Index (IBM & Kirchner, 2011)

Country	**Year of vertical split**
Austria	1997
Belgium	1998
Denmark	1997
Finland	1995
France	1997
Germany	1994
Italy	1998
The Netherlands	1995
Portugal	1997
Spain	1996
Sweden	1988
United Kingdom	1993

Table A.2. Time of vertical separation (Friebel et al., 2010)

Country	**2011 COM Index**
United Kingdom	866
Netherlands	680
Denmark	655
Estonia	629
Germany	615
Sweden	577
Austria	575
Hungary	522
Poland	518
Italy	470
Portugal	434
Belgium	424
Czech Republic	422
Bulgaria	421
Latvia	411
Slovakia	381
Slovenia	337
France	334
Spain	333
Finland	156
Lithuania	120

Table A.3. IBM's 2011 COM Index (Kirchner, 2011)

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