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Competition in the railway passenger market: The challenge of liberalization

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Abstract

European country members have been opening up to competition railway passenger services in recent years, whereas others still remain on the way to liberalization. The recent Commission's fourth European Union (EU) Railway Package has updated the European legislation to ensure an effective liberalization within the EU country members by 2020. It is intended to enhance firms' efficiency and also consumers' benefits. In this article, we study different paths towards liberalization from the traditional state-owned monopoly configuration. First, the monopoly outcome is presented, as it is the current situation in a number of EU country members. Second, the oligopoly models are introduced to study different paths towards an effective competition as a result of different market configurations. It is found that liberalization may enhance consumer surplus keeping operators' profitability only when variable costs and access charge to the network are low. Finally, some regulatory measures are discussed.

Keywords

Railway passenger services, liberalization, competition, regulation

Introduction

In the early stages of the European transport reform, the railway market proved to be reluctant to pursue liberalization, especially when it was compared to other modes of transport. Railway market liberalization means that new operators may enter the market in passenger services, cargo services or both. The railway market reform starts with Directive 91/440/EC. It had a little impact

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on the market: a small number of new operators, mainly in cargo services, entered the railway market. Since then, four regulatory Railway Packages had been passed in 2001, 2004, 2007 and 2016. Following the directives enclosed in these programmes, some European countries began to open up railway markets to competition in the last two decades. To ensure fair competition, European Union (EU) Member States have regulatory bodies in place to monitor railway markets in the case that railway companies believe they have been unfairly treated. The four railway packages consecutively brought together previous Directives, updated them and facilitated market development. The most ambitious programme has been made in the Commission's fourth Railway Package. It requires the introduction of competition in the passenger market, included those services run under public service contracts. Overall, effective competition in the passenger market is expected by 2020 and by 2023 for those services under public service obligations (PSOs). Table 1 presents an updated overview of the railway legislation at EU level.

The fourth Railway Package includes a *Technical Pillar* for rail safety and interoperability and a *Market pillar* for the governance of railways and the opening up to competition of the passenger market. When initially presented in 2013, the Market Pillar set out far-reaching measures to enable new entrants to access the market, including a requirement for member states to competitively tender all public service contracts, as well as a proposal to enforce full separation between railway undertakings (RUs) and infrastructure managers. These reforms, in their initial drafts, did not find unanimous acceptance among Member States. After some debate, its final version includes three core legislative provisions:

- Regulation 2016/2337/EU to support common rules for RUs' accounts: It repeals Regulation (EEC No 1192/69), allowing Member States to compensate 40 enumerated RUs for the payment of obligations (such as special family allowances and pensions). When the rules for normalization are correctly applied, such state support is considered compatible with the internal market and Member States are exempted from state aid notification obligations. This regulation was adopted before the rail market was liberalized and when railways in Europe were developing primarily within national borders, with integrated companies both operating railway services and managing railway infrastructure. Today, this regulation is inconsistent and incompatible with legislative measures currently in force. In the context of a liberalized market where RUs compete directly with the traditional monopolies listed in the regulation, the Commission considers that it is not appropriate to discriminate between these two groups of companies.
- Regulation 2016/2338/EU on the award of public service contracts: It is intended to facilitate competition in the market for domestic rail passenger services. Competitive tendering will become the norm for public service contracts by December 2023, with exceptions permitted under specific circumstances and direct award contracts required to include performance and quality targets.
- Directive 2016/2370/EU on the Single European Railway Area: It is intended to strengthen the independence and impartiality of infrastructure mangers to facilitate the opening up of the domestic passenger market and establish the rules for the practice of commercial rail passenger services. According to the Directive, although vertical separation is desirable, vertical integration is allowed: allocation of train slots and infrastructure access charge to enter the network under competitive basis should be also achieved within a vertically integrated structure. The Directive also establishes conditions whereby commercial passenger services will be opened to competition by 2020 on an open access basis.

Table 1. EU railway legislation.

Package	Directives	Contents
Initial reforms 1990–1999	Directive 91/440/EEC	On the opening of the Railway Market.
	Directive 95/18/EC	On criteria for the Railway License.
	Directive 95/19/EC	On the allocation of capacity infrastructure.
	Directive 96/48/EC	On technical specification of interoperability of high speed.
First Railways Package (2001)	Directive 2001/12/EC amending Directive 91/440/EEC	On the development of community railways.
	Directive 2001/13/EC amending Directive 95/18/EC	On the granting of licences to railway undertakings.
	Directive 2001/14/EC	On infrastructure capacity, royalties and certification of safety.
Second Railway Package (2004)	Directive 2004/49/EC amending	On the safety of Community railways
	Directive 95/18/EC, and	On the granting of licences to railway undertakings
	Directive 2001/ 14/EC.	On the allocation of railway infrastructure capacity, application of royalties for its use and certification of safety.
	Directive 2004/50/EC amending Directive 96/48/EC, and Directive 2001/16/EC	On the interoperability of the trans-European high-speed rail system On the interoperability of the trans-European conventional rail system.
	Directive 2004/51/EC amending Directive 91/440/EEC	On the development of Community railways.
Third Railways Package (2007)	Directive 2007/58/EC amending Directive 91/440/EEC and	On the development of Community Railways
	Directive 2001/14/EC	On the allocation of capacity and the application of royalties for its use.
	Directive 2007/59/EC	On the certification of the machinists of locomotives and trains in the railway system of the community.
	Regulation (EC) No 1370/2007 repealing Regulation (EEC) N° 1191/69 Regulation (EEC) N° 1107/70	On the public services of transport of passengers by rail and road.
	Regulation (EC) N° 1371/2007	On the rights and obligations of railway passengers.
First recast railway Package	Directive 2012/34/EU	Establishing a single European railway area.
Fourth Railway Package (2016)	Technical pillar:	
	Regulation (EU) 2016/796 repealing Regulation (EC) N° 881/2004.	Concerning the railway agency of the EU. On the interoperability of the railway system within the EU which refunds the Directive 2008/57/CE.
	Directive (EU) 2016/797	
	Directive (EU) 2016/798.	On the railway safety which revision of the Directive 2004/19/EC.

(continued)

Table 1. (continued)

Package	Directives	Contents
	Market pillar:	
	Regulation (EU) 2016/2337 repealing Regulation (EEC) N° 1192/69	On common rules for the normalization of the accounts of railway undertakings.
	Regulation (EU) 2016/2338, amending Regulation (EC) N° 1370/2007	On the opening of the market for National rail passenger transport services.
	Directive (EU) 2016/2370 amending Directive 2012/34/EU,	On the opening of the market for National rail passenger transport services and the governance of railway infrastructures.

EU: European Union.
Source: European Court of Auditors (2016) and author's own elaboration.

EU Member States had until December 2018 to transpose the Directives into national legislation. Following the entry into force of the Technical Pillar in 2016, the European Railway Agency (ERA), created in 2004, replaced the European Union Agency for Railways, which was entrusted with a stronger role regarding vehicle authorization and safety certification, issuing single authorizations and certificates for the whole EU.

The implementation of the Technical Pillar represents the most important effort in all railway organizations and stakeholders such as International Rail Transport Committee (CIT), Community of European Railway and Infrastructure Companies (CER), UNIFE (The Association of the European Rail Industry) and UIP (International Union of Wagon Keepers). European Rail Traffic Management System implementation, intermodality and the new role of the ERA are also key issues to be implemented in the new regime based on the fourth Railway Package. Furthermore, future PSO, digitization (including ticketing arrangements), passenger rights, track charges and economic equilibrium test are on the core for future regulation developments, as it was stated at CIT.

Literature describing railway liberalization by countries around the world is wide. Concerning the EU, Campos and De Rus (2009) have empirically examined the implementation of high speed railway services in a number of countries. They studied operating and maintenance cost and some economic facts related to liberalization processes by country. Concerning regulation of liberalized railway networks, in a recent paper by Laurino, Ramella, and Beria (2015), it is concluded that overall, public authorities still play a dominant role after liberalization because vertical integration structures remain. They also emphasize that liberalization processes depend on the shape of the transportation system in each country and the monopoly structure before liberalization. Overall, there is no common knowledge as to how the liberalization process has to be done. Indeed, it is the main argument to study alternative ways towards an efficient liberalization. Concerning the opportunity for a disaggregated vertical structure or not, Smith, Benedetto, and Nash (2018) argue that for European railways, the presence of strong economic regulation implies that vertical separation may be beneficial in terms of cost reduction depending on the degree of market openness, vertical structure and the intensity of network usage. In Cui and Besanko (2016), the relationship between network quality and organizational structure is analysed. They argue that horizontal separation dominates vertical separation. Aligned with these results, the European

commission allows some countries, including the key markets of Austria, France, Germany and Italy, to maintain infrastructure and operations within the same holding company (as claimed by Henrik Hololei, Director General of the European Commission's Directorate-General for Mobility and Transport).[1] This feature is one of the most important regulation changes that could affect future organizational developments. For the case of passenger rail services in Fraszczyk, Lamb, and Marinov (2016), the current performance of the EU railway systems is evaluated. Overall, it can be said that public authorities still play a dominant role because in every country, the state continues to own the infrastructure and (except in Britain) the main passenger operator, regardless of whether there is vertical integration.

The purpose of this article is to analyse the liberalization of railway passenger services in the EU. We also suggest some recommendations that could help EU railway transport policy developments in the future. The extent to which railway passenger services can both be exploited as a competitive market and, at the same time, ensuring service quality at moderate fares as well as operators' profitability in the long run is studied. Moreover, although there is still an open debate between the concepts of competition *for* the market versus competition *in* the market (see, for instance, Geroski 2003),[2] the fourth Railway Package favours the introduction of both types of competition. First, a review of the state of the art at the European level is presented. Second, simultaneous and sequential decision-making models are used to specify how market liberalization and the regulatory framework may improve frequencies at moderate prices yielding both higher consumer surplus (CS) and social welfare from the monopoly status quo. It is found that to ensure the successful of the liberalization process, a number of changes in regulatory measures as well as some particular market features should be discussed. Assignation of time slots under competitive basis ensuring equal opportunities for the incumbent operator and new entrants, vertical relationships between rail services and leasing of rolling stock and the level of access charge to the network are key features in the way towards an efficient liberalized market. Overall, we found that liberalization is profitable for consumers and operators when variable costs and access charge to the network are low when duopoly competition takes place (we assume a duopoly as we study early stages of the liberalization process). Finally, we introduce a discussion of some regulatory measures.

The rest of the article is organized as follows. The second section presents the European railway situation. The third section presents the general competition model. The fourth and fifth sections solve different competition models under alternative market configurations in the way towards the liberalization. The final section gives the conclusions. All errors are our own responsibility.

The European railway market situation

The railway sector has been a typical example of natural monopoly in theoretical literature on public economy (Walras, 1875). Following economic analysis advises and based on experiences by pioneering countries (in particular Sweden), the EU has decided unbundling railway operations (transport services) and infrastructure management. It has led to deep reforms in a sector traditionally characterized by vertically integrated monopolies. Moreover, as in other network

1. https://www.railjournal.com/in_depth/hololei-rail-must-show-it-is-worthy-of-further-eu-investment
2. Under competition for market, a regulator gives a franchise to an operator whereas competition in the market usually includes oligopoly competition.

industries, liberalization standards involve switching from a quasi-administrative system to a market-based organization. On one hand, a reduction in the level of public subsidies and opening transport services to new railway operators was expected (Alexandersson & Hulten, 2007; Crozet & Desmaris, 2011; Nash, Mathews, & Thompson, 2005). On the other hand, a body of legislation and regulatory measures to ensure concurrency under competitive basis become a key policy objective. The application of EU Directives in the railway sector by each European country member is still quite diverse by itself. Directives' transposition included in previous Railway packages and the fourth Railway Package currently in force is yielding to different institutional settings in member states. Depending on the level of liberalization, five different groups can be identified:

1. Fully liberalized markets. All passenger-kilometres (p/k, hereinafter) are in open access or all PSO are competitively tendered. This is the situation in Sweden and United Kingdom.
2. Largely liberalized markets. More than 33% of p/k are in open access or correspond to competitively tendered PSO. As is the case in Austria, Germany and Italy.
3. Partially liberalized markets. Less than 33% of p/k are in open access or correspond to competitively tendered PSO, although new entrants have taken up a significant share of the liberalized market, as in the Netherlands, Czech Republic and Portugal.
4. Quasi-liberalized markets. The whole market is open for access, but still there is no effective competition. New entrants operate directly awarded PSO, as in Denmark and Poland.
5. Non-liberalized markets: Incumbent operates all commercial services and PSO. France, Spain, Belgium and Finland are within this group.

Sweden began the liberalization process in the 80s. The former national incumbent was split in two companies: Trafikverket, which manage infrastructure and also tendering processes, and SJ AB, the railway service provider.[3] In 2001, SJ AB was divided into eight companies. Concerning the passenger services, the liberalization process finished in October 2010. The most relevant country in terms of traffic and network within the first group is the United Kingdom. The United Kingdom has used franchising to split up British Rail extensively. They promoted the entry of new operators with the Railways Act in 1993. There was a concession system and the infrastructure was privatized. Overall, the British railway system is composed of firms that compete for the market in some segments and compete in the market in others, with no historical incumbent firm after an extensive period of liberalization. Within the second group, Germany is an interesting case with a vertically integrated model, which keeps the infrastructure manager and the service operator under a holding company. Moreover, the railway system was opened up to competition in 1994. The challenge is to induce more competition in the long-distance services by decreasing incumbent market power. Authorities may also implement a franchise system. The Italy case is also interesting. This railway system is vertically integrated. Government authorities opened up the market to competition in 2000. The companies *Arenaways* (in 2010) and *NTV* (in 2012) entered the competitive segment of the market. Overall, liberalization increases productivity as well as decreases the direct employment. Finally, there are countries included in the last group with a huge volume of operations and large networks and, thus, where liberalization would potentially produce deep changes in the market structure. France was reluctant to replace public ownership of the infrastructure, operator and maintenance of the national railway by a more competitive structure.

3. Until 2010, the infrastructure management was Banverket. The new company also has air, sea and road transport.

Recently, there is legislation to introduce opening reforms aimed at liberalizing some segments of the market. The Spanish market also remains under monopoly, the state-owned holding RENFE. Although in 2015 Spanish authorities amended the Law 39/2003 (17/11/03) by presenting a first approach to a new railway sector law following the Directive 2012/34/EU, little steps have been done in the way towards liberalization.

Liberalization involves different aspects. Mainly, the ownership of the infrastructure, the possibility for leasing rolling stock by part of new entrants, access fees to the network and the assignation of time slot under competitive basis. Thus, vertical relationship between rail operators, network ownership, downstream activities such as leasing of rolling stock and competitive access to peak and off-peak time slots become relevant. These aspects affect the firms' cost and efficiency levels. Growitsch and Wetzel (2009) employed data envelopment analysis (DEA) 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 favoured vertical integration between infrastructure management and service operations. Driessen, Lijesen and Mulder (2006) also used DEA at an international level and focused on measuring the relationship between competition design and rail transport productive efficiency. The study suggested 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. This analysis also pointed out that free market entry had a negative effect on the networks' cost efficiency. Cantos Sánchez (2001, 2010) used a translogarithmic cost function analysis to cover 12 European state-owned rail companies between 1973 and 1990. This mathematical study concluded the existence of diseconomies of scope between freight and passenger transport; freight transport costs that were complementary to infrastructure costs while passenger transport costs were substitutes for infrastructure management costs.

Since 2007, the Rail Liberalization (LIB) Index is used as a tool for analysing comparative market entry barriers to European railway markets. It presents information on the relative degree of market opening in the European rail transport markets within an enlarged EU, including Norway and Switzerland, as observed in May 2007. The study is a benchmark for the legal and practical market access barriers seen from the viewpoint of an external RU seeking access. It uses a system of three different indexes (LEX, ACCESS, COM) based on legal and practical barriers for newcomers and four categories (pending departure, delayed, on schedule, advanced) to rank on a scale from 100 to 1000 points the level of liberalization. In its more recent edition, only the United Kingdom, Germany, Sweden, Denmark, Austria and the Netherlands achieve advanced ranking (800–1000 points). This means that only 6 of 27 countries have completely incorporated the EU Directives. However, the LIB Index has its limitations as it only assesses the level of implementation of the existing regulation (see, for instance, Ruiz-Rua & Palacín, 2012), referring to it generally as competition level. Knorr and Eichinger (2006) performed a critical appraisal of the LIB Index, highlighting its key limitations. Others, like the Boston Consulting Group European Railway Performance index (2017), obtained a strong correlation between investments and demand boost. Table 2 summarizes the main results and conclusions of all the analysis.

Concerning the analysis of the level of competition between operators, economic theory and industrial organization indicators are widely accepted and acknowledged. In particular, the concentration index and industrial profitability measure in detail the rates of profit and the market share. In terms of demand, traffic growth or market share, the EU 15 railways do not demonstrate a particularly dynamic performance either measured in freight or passenger transport. But some

Table 2. Review of literature regarding the impact of vertical separation on costs.

Authors (year)	Countries	Effect of vertical separation	Effect of competition	Combined effect
Jensen and Stelling (2007)	Sweden	Negative	Positive	Positive
Friebel et al. (2010)	Europe	Positive if appropriately phased	Positive if appropriately phased	Positive if appropriately phased
Cantos et al. (2010)	Europe	Positive	Positive	Positive
Cantos et al. (2011)	Europe	Not significant	Positive	Positive
Wetzel (2008)	Europe	Not significant	–	–
Growitsch and Wetzel (2009)	Europe	Negative for most countries	–	–
Mizutani and Uranishi (2012)	Europe and Japan	Depends on train density	–	–
Van de Velde et al. (2012)	Europe	Misalignment issues are important (due to up to 20% total rail system costs)	Vertical separation is not needed to obtain benefits from competition	The most effective model in terms of costs differs with circumstances

Source: Own elaboration based on Van de Velde et al. (2012). 'EVES-Rail Economic effects of Vertical Separation in the railway sector a.

experts (see, for instance, Thompson & Bente, 2014) argue that the outcome would have been worse without the implementation of the four European Railway Packages. Figure 1 contains the number of RUs for all passenger services (incumbents and non-incumbents): regional, suburban and long-distance services.

The case of Germany is quite interesting. Twenty-six operators, mostly smaller RUs, provided transport services in the long-distance segment. The majority of these passenger RUs focuses exclusively on providing special non-scheduled rail services and consequently do not compete with regular services. A number of RUs provide transport services in the passenger rail transport segment and in the rail freight segment.

In the opposite pole, Italy has only one private operator and it is in high-speed services, as it is shown in Table 3. The four operators in France include both SNCF and Thello, the French simplified joint company ("Société par actions simplifiée") that launched after the cooperation between SNCF and Trenitalia, whose night trains operate daily since 11 December 2011. Eurostar and Thalys (SNCF is also partner of these societies), the services to Great Britain and Belgium, complete the sketch. However, effective competition is almost zero because services offered by these new entrants are in international relations and without competition against SNCF trains. Table 3 describes the situation in those countries where liberalization is effectively an ongoing process.

Summarizing, the application of EU Directives in the railway sector has produced very different results and is still quite diverse. The institutional setting in the Member States from the Directives

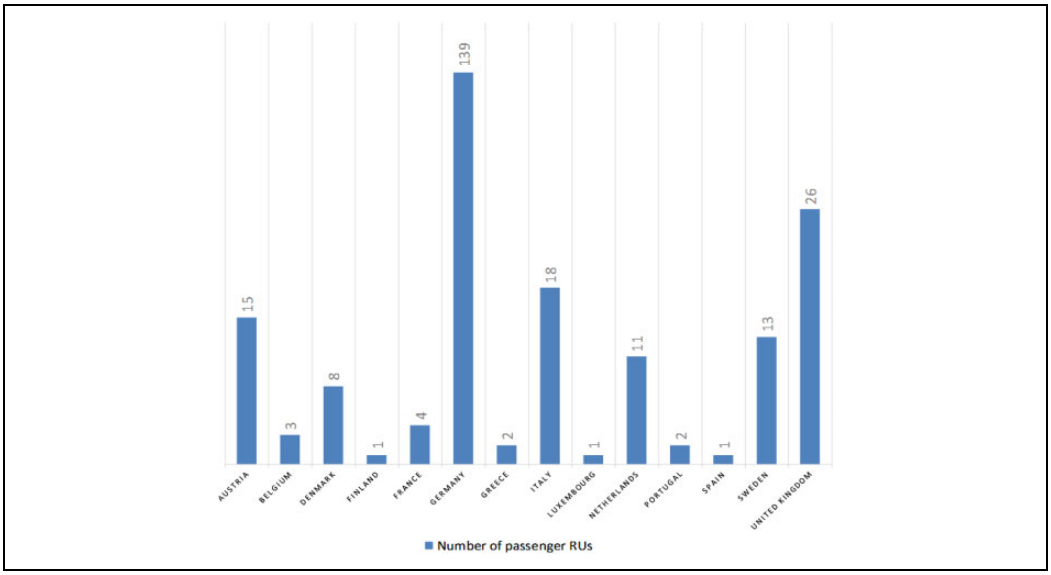

Figure 1. Total number of passenger RUs (2016). *Source*: IRG-RAIL (2018) and author's own elaboration. RU: railway undertaking.

transposition is summarized in Figure 2 where various national governance structures of the main infrastructure managers are presented.

Next section attempts to model the ongoing liberalization process to analyse some of the issues treated above in the way towards an effective competition in the railway passenger market.

An explanatory model on railway liberalization

Efficiency can be considered a measure of the railways regulation success. Indeed, efficiency involves an increase of the railway services at competitive prices under quality standards. Thus, an exhaustive analysis of competition may help to identify drivers which yield to an efficient liberalization. Following the discussion addressed in the previous sections, we present a general analysis of competition based on industrial organization game theory models. It provides economic insights about the robustness of the ongoing liberalization of the railway passenger market. Understanding the functioning of the railway market includes several aspects. Depending on the market configuration, the railway liberalization process may achieve different results in terms of prices, number of frequencies, operators' profits and social welfare.

Railway passenger services have been traditionally exploited as a natural monopoly. In this article, we assume a duopoly market configuration where a new operator competes with the former state-owned monopolist. In accordance with the fourth Railway Package, the market will be open to competition gradually.[4] Indeed, it is expected that in early stages of liberalization, only a private

4. Although previous packages said nothing about domestic passenger services, the fourth Railway Package provides for both competition in the market for commercial services and franchising for services operated under a public service contract.

Table 3. Non-incumbent railway undertakings by countries.

Country	Operator (in bold the missing RU)	Duration	Type of entry
Sweden	SNALLTAG (2010)		Line-Niche: Low cost
	BLA TAG (2011)/GRONA TAG (2016)		Line-Niche luxury / Low Cost
	MTR (2015)		Line-Intensive
United Kingdom	FIRST HULL (2000)		Line-Niche: route
	GRAND CENTRAL (2007)		Line- Niche: route
Germany	HEX (2005)		Line-Niche: Ultra- Low Cost / route
	HKX (10.2012-10.2017)-FLIX (2018)[2]	5 years and 9 months	Line-Niche: Low Cost
	LOCOMORE (12.2016-5/20117)-FLIX (2018)[3]		Line-Niche: low Cost
Italy	NTV (2012)		Network Entry (High speed)
Austria	WESTBAHN (2013)		Intensive line
Chez Rep.	REGIOJET (2011)		Line-Intensive
	LEO EXPRESS (2012)		Intensive Line
Slovakia	REGIOJET (2014)[1]		Non-intensive line (service extension)
	LEO EXPRESS (2014)		Non-intensive line (service extension)
Poland	LEO EXPRESS (2018)		Line – non-intensive (service extension)
Netherlands	**LOVERS RAIL (8.1996-09.1999)**	3 years and one month	Line-Niche: ultra-low cost/ route

PSO: public service obligation; RU: railway undertaking.
Note: Updated at 29 November 2018.
Source: Ramos (2019) and own authors' elaboration. (1) Operates the Bratislava-Kosice route from December 2014 to January 2017. (2) The operation continues as Flix Train from March 2018. (3) RU LOCOMORE, after bankruptcy, LEO EXPRESS takes over the service, locomotives on leasing and staff, and tickets are sold by FLIX https://www.railwaygazette.com/news/passenger/single-view/view/leo-express-to-relauch-locomore-service.html. (4) All passenger service is a PSO subscribed by both private operators and a public service contract.

operator enters the market. Let us assume the market includes an incumbent state-owned operator (I) and an entrant operator (E). Once models are solved, we study how changes in some parameters affect frequencies, prices, CS and social welfare. To keep tractability and following previous literature, it is assumed that demand is linear; $p(Q) = A - Q$,[5] with $Q = \sum_{i=I,E} q_i$. The number of trains operated by each service provider is q_i, whereas Q stands for the total number of trains run. We assume trains run an identical itinerary within the railway network. Thus, there is a matching between train kilometre and number of trains operated. Moreover, operators use identical rolling stock.

Railway industry is complex, and it bears different types of costs. First, a number of licenses and administrative requirements are necessary to run locomotives, rolling stock and wagons. Once such costs are incurred, they are assumed to be sunk costs. Concerning network access, it can generally be a two-part tariff. First, a fixed component $c \geq 0$ goes to the infrastructure manager to

5. To keep tractability, it is also assumed that A = 1.

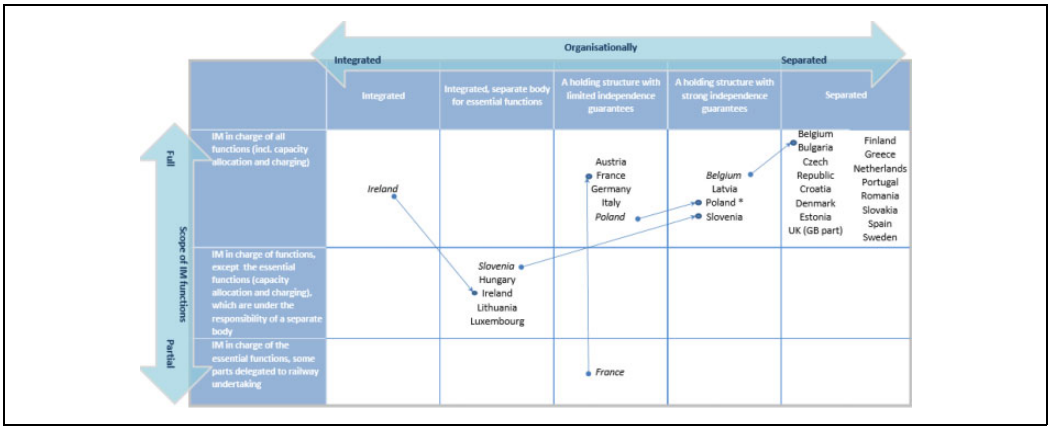

Figure 2. The institutional setting in Member States (end 2015). *Source*: European Commission.

enter the network, run trains once time slots are assigned and occupy platforms. However, this fixed component may represent an entry barrier because a new operator usually attains lower economies of scale than the state-owned operator. Thus, competition authorities advise the reduction or almost total disappearance of the fixed component. Indeed, some studies reinforce this idea. For instance, in Nash (2005), it is argued that European directives state that the average and marginal charges in the network access should be close, which rule out the possibility of two-part tariffs.[6] Following this idea, European country members tend to minimize or almost withdraw the fixed component of the network access (in Germany and France, it is almost zero, whereas in Spain regulatory authorities advise the introduction of long-term contracts for new operators instead of including a fixed component on the network access). Hence, let us assume that the fixed component is almost zero, $c \cong 0$.

The variable part of the network access costs is related to train kilometre. In our model, as we have stated that trains run an identical itinerary and use identical rolling stock, charges per train kilometre translate to a charge per train run. Notice that under this assumption our models provide comparable results for those itineraries covering similar distances using identical rolling stock. To analyse a national railway network, further assumptions have to be included, because different railway itineraries and heterogeneous rolling stock are observed.

Network access variable costs are related to the traction power system, typically by electricity or diesel. In the case of electric power, the network owner charge to the railway operator costs associated with running trains. Run a passenger train unit (locomotive and wagons) has a huge cost, in particular when a train starts, which almost becomes a quasi-fixed cost. Differences in passenger occupation and luggage are relative small in comparison with the acceleration cost (around 10%). According to most of the studies (see, for instance, His & Chen, 2001; Hwang, 1998), the electricity consumption profile incurred by railway passenger units has a quasi-concave shape which moves upwards as the load of the train increase. A proper analytical approximation of traction power costs is $q_i \cdot (f_e + e)$, where

6. To facilitate new operators enter the market, network access charges are on the type of marginal cost plus other additional charges as a result of the application of technical restrictions, avoiding fixed charges.

Table 4. Oligopoly models and regulation schemes.

$n = 2$	Leadership (in choosing time slots)	Fair competition (in choosing time slots)
Bundled (state-owned holding)	Stackelberg	Cournot
Unbundled (vertical separation)	Stackelberg	Cournot

- f_e stands for the quasi-fixed cost incurred in accelerating a high-speed train (Δ) covering a given distance d, $(f_e = \Delta + d)$. This cost is quasi-fixed relative to a given distance.
- e captures the marginal cost as a result of running a train with passenger and luggage occupation for a given distance d.

Staff costs and operational costs by ticketing, advertisement, passenger attendance and so on are assumed to be the same for the two companies , $\gamma \cdot q_i$, where $\gamma > 0$. Finally, the entrant operator has to assume the cost of leasing rolling material to offer the service. Although the question about the nature of such cost is an open issue, in this article, we take the access to rolling stock as an essential facility. In our model, we assume that the state-owned firm has to provide rolling stock to new operators, although train operators may lease rolling stock from elsewhere (it includes leasing from the manufacturer, as does NTV in Italy). Also access to rolling stock owned by the incumbent may be regulated to prevent discrimination. Rolling stock costs may be considered sunk costs in the short run for the incumbent but in due course it will need to be replaced. We assume that the state-owned service provider is a Holding with business separation between railway services and the leasing business; then our benchmark model includes vertical bundling. This introduces a great obstacle for fair competition because the incumbent receives an extra income as a result of leasing. Lease material includes the maintenance, so lease costs are, $T(q_i) = \alpha + \sigma \cdot q_i$, where $\sigma > 0$. Summing up, the costs structure is as follows: fixed costs $c \cong 0$, whereas without loss of generality variable costs are $m = \theta + \gamma$, where $\theta = f_e + e$. $T(q_i)$ is endogenously given because, depending of the model of competition, the incumbent has an extra income as a result of leasing rolling stock.

Next, alternative duopoly models are introduced to achieve a more competitive market. Table 4 sketches the oligopoly models studied depending on the regulation applied to the market. We focus in two possible changes in the regulation schemes. First, by unbundling the state-owned Holding group by creating a state-owned firm that leases rolling stock to the state-owned operator and the new entrant.[7] Second, allowing both operators to gain access to any time slot under equal opportunities (and thus, removing the current time schedule in which the state-owned operator offers the *well-known* time table).

There are other regulatory changes that we will study by making comparative static (other things being equal) from the equilibria set at the end of the section. They include changes in m (i.e. changes in θ and/or γ).

Monopoly in the service provision and the benchmark model.

We start this section by presenting the monopoly solution which indeed was the service provision scheme in every Country Member within the EU previously to the liberalization process. It is

7. It is also recommended to let it gradually become a fully privatized operator, with public participation but an independent board of administration.

assumed that under this configuration, separation between service provision and network ownership exists. This is the common scheme, although vertical separation between service provision and network ownership was not complete under previous railway packages (indeed, holding companies were permitted to engage in both segments). Once the monopoly solution is presented, we introduce a market situation in which the state-owned holding provides railway passenger services and also has a leasing division to serve rolling stock to the new entrant. Moreover, time slots previously assigned before the liberalization process are given to the state-owned operator, leaving the unassigned time slots to the new entrant. We call this situation the benchmark model.

Monopoly configuration: A state-owned operator provides railway passenger services.

The monopolistic operator maximizes $\pi = p(Q) \cdot Q - m \cdot Q$. In this case, Q stands for both the amount of services of the state-owned operator and the total amount of services. Routine calculations yield to the following profits, price and quantity

$$\pi^M = \frac{(1-m)^2}{4},\ p^M = \frac{(1+m)}{2},\ Q^M = \frac{(1-m)}{2}$$

CS is equal to $\mathrm{CS}_M = (1-m)^2/8$, and total welfare ($W$) is the sum of CS and profits

$$W^M = \frac{3(1-m)^2}{8}$$

As expected, the larger the variable costs, the lower the operator's profits and railway passenger services. Moreover, CS decreases in m. As a result, total welfare decreases in m.

Benchmark model: A state-owned holding and leadership in choosing time slots.

It seems natural that in the way towards liberalization, the state-owned firm remains operating as a holding (a bundled configuration) and also preserves the time slot assignation previous to the opening up to competition a given route. Thus, it is assumed that the former state-owned monopolist has the ability to operate trains at any time slot, whereas the entrant has to gain access for any time slot it wants to run. In this market configuration, we assume that the incumbent state-owned operator has a leader advantage and competition à la Stackelberg takes place. Moreover, there are other reasons to assume that the incumbent operator exerts leadership in the market. On one hand, the incumbent may have a comprehensive network, facilities to sell tickets online and at stations, and it is a well-recognized brand. On the other hand, the entrant is often perceived as providing higher quality services. Under this situation, regulation is assumed to be passive, in the sense that it is in accordance with the status quo. By using the simple game theory concept of backward induction, the model is solved to characterize a (unique) subgame perfect Nash equilibrium. At the second stage, the entrant operator, E, maximizes[8]

$$\pi_E = p(q_I, q_E) \cdot q_E - m \cdot q_E - T(q_E)$$

The corresponding reaction function in response to a given quantity of railway passenger services by part of the incumbent operator is $\varphi(q_I) = (1 - m - \sigma - q_I)/2$. Notice that any

8. Notice that by assumption $0 < m + \sigma < 1$, because inverse demand has a maximum wiliness to pay at 1. Results of the model are maintained when y-intercept is equal to $A > 1$, but the tractability of the model decreases.

increase in marginal cost due to maintenance expenses yields to a lower quantity offered by the entrant, and the same occurs if the incumbent increases the level of services. The latter is the direct effect that any change in the level of incumbent services has in the entrant strategy. As we assume complete information, the incumbent operator, as a leader on the market, perfectly anticipates the entrant reaction function $\varphi(q_I)$. Thus, the incumbent operator, I, maximizes

$$\pi_I = p(q_I, \varphi(q_I)) \cdot q_I - m \cdot q_I + T(\varphi(q_I))$$

Optimal behaviour with respect to the quantity of services offered, q_I, yields to equilibrium profits

$$\pi^B{}_E = \frac{m^2 - 2m(1-2\sigma) + 1 - 4\sigma + 4\sigma^2}{16} - \alpha$$

$$\pi^B{}_I = \frac{m^2 - 2m(1-2\sigma) + 1 + 4\sigma - 4\sigma^2}{16} + \alpha$$

Market price and quantities offered by each operator are

$$p^B = \frac{1 + 3m + 2\sigma}{4},\ q^B{}_E = \frac{1 - m - 2\sigma}{2},\ q^B{}_I = \frac{1-m}{2}$$

A first insight is that any increase on m decreases both entrant and incumbent profits, as it is expected. However, due to the bundled configuration, $\partial\pi^B{}_I/\partial\sigma > 0$, whereas $\partial\pi^B{}_E/\partial\sigma < 0$, because $0 < m + \sigma < 1$. Hence, the incumbent always has an incentive to increase maintenance costs, which cause a business stolen effect in the entrant operator, that is, an increase in σ reduces the number of frequencies served by the entrant, lowering competitiveness. Second, it is also important to note that this configuration increases the total amount of services without further reductions in the services offered by the incumbent. Moreover, the price decreases. Indeed, the former state-owned monopolist maintains the number of services, $Q^M = q^B{}_I$. Finally, as it usual in oligopoly models, profits and total quantity decrease when σ or m increases, whereas price increases.

In the last decades, antitrust agencies and competition policy have focused in the effects that liberalization processes have in consumers instead of focusing on total welfare, which is measured by the CS. We present a disaggregated study of total welfare to capture this trend. Indeed, total welfare may increase due to two facts: by increasing CS, by increasing the operators' market power (and thus, profits), or both. The following two expressions account for the CS and total welfare under this market configuration

$$\mathrm{CS}^B = \frac{[(2\sigma - 3(1-m)]^2}{32},\ W^B = \frac{[2\sigma - 3(1-m)](m - 2\sigma - 3)}{32}$$

On one hand, a further inspection reveals that CS^B decreases due to an increase in σ. This is because an increase in the maintenance marginal costs of the leased rolling stock has a negative aggregate effect: the incumbent income per unit of rolling stock maintenance increases, but it is lower than the negative effect on the marginal profitability per unit of transport of the entrant operator. As the incumbent operator has two businesses and also exerts leadership in the market, it exploits its market power to pressure equilibrium price upwards with the subsequent damage in CS. On the other hand, an increase in m reduces CS, which has a straightforward economic intuition. Finally, when we focus in aggregate welfare partial derivatives reveal that increases in σ and m have a negative effect on W^B. The effect of σ needs further explanation. As we pointed out above,

when maintenance costs increase CS and entrant's profits decrease. Thus, the incumbent's profits increases are lower than the negative effect on CS and entrant's profits.

Steps towards competition in a liberalized market

In this section, it is assumed that two regulatory measures are implemented. First, the government may unbundle the state-owned holding into two independent businesses. Thus, the incumbent and the entrant operator have the same opportunities to access passenger rolling stock. The new independent firm, that leases material, could be a public or private firm or a partially state-owned firm. Second, the government introduces a competitive tendering process to access time slots. In our model, this assumption yields to a simultaneous competition when both operators are able to capture demand under equal conditions. In fact, it means that trains run by both operators compete continuously over each time slot.[9] Then, it is assumed that both operators compete simultaneously to get access to time slots. In other words, operators may offer any time schedule under equal opportunities competing à la Cournot. The implementation of these two measures (alone or both together) yields to three duopoly configurations,

a. Model UL: Unbundling + leadership when choosing time slots.
b. Model BS: Bundling + simultaneous competition when choosing time slots.
c. Model US: Unbundling + simultaneous competition when choosing time slots.

In what follows, we characterize these models to compare with the benchmark ones. Concerning model *UL*, the only conceptual difference is that the incumbent has to pay to get access to rolling stock, and thus the objective function has to include these costs

$$\pi_I = p(q_I, \varphi(q_I)) \cdot q_I - m \cdot q_I - T(q_I)$$

In addition, the unbundled leasing firm, L, has a profit function $\pi_L = \sum_{i=E,I} T(q_i)$, where the marginal costs incurred to lease rolling stock are normalized to zero. With respect to the model *BS*, the conceptual difference relates with the reaction function of both operators. Under this configuration, there is no advantage to capture demand so the entrant and the incumbent react at the same time in response to any rival's decision. Finally, the *US* model includes both regulatory measures and the market becomes almost symmetric, in the sense that both competitors bear the same costs structure and access to any time slot under competitive conditions. Thus, each operator maximizes

$$\pi_i = p(q_i, q_j) \cdot q_i - m \cdot q_i - T(q_i),\ i,j = I,E,\ i \neq j$$

Table 5 includes prices, profits, CS and welfare of the above three models. It provides useful information concerning the effects of regulatory measures.

To conduct a comparative analysis among the different equilibria, let us assume that parameters fulfil the following relationships (as it is highlighted in Table 5): $m \leq \frac{2}{3},\ \sigma \leq \frac{m}{2},\ 0 < m + \sigma < 1$. Then, let us assume that $m \leq 0,66$ $(\sigma \leq 0,33)$. In what follows, it is conducted a comparison among CS and welfare as a function of the value of m and σ. Notice that a higher CS implies more services at lower prices, so the study of the evolution of CS includes also the study of variables Q and p.

9. It is beyond the scope of this article to introduce structure on the way operators get access to time slots.

Table 5. Equilibrium magnitudes of the competitive models.

	UL	*BS*	*US*
Price	$(1+3m+3\sigma)/4$	$(1+2m+\sigma)/3$	$(1+2m+2\sigma)/3$
Profits	$\pi_I^{UL}=\frac{\varnothing+(1-\sigma)^2}{8}-\alpha$	$\pi_I^{BS}=\frac{\varnothing-7m\sigma+1+5\sigma(1-\sigma)}{9}+\alpha$	$\pi_i^{US}=\frac{\varnothing+(1-\sigma)^2}{9}-\alpha$
	$\pi_E^{UL}=\frac{\varnothing+(1-\sigma)^2}{16}-\alpha$	$\pi_I^{BS}=\frac{\varnothing+2m\sigma+(1-2\sigma)^2}{9}-\alpha$	$i=I,E.$
CS	$\frac{9(1-m-\sigma)^2}{32}$	$\frac{(2(1-m)+\sigma)^2}{18}$	$\frac{2(1-m-\sigma)^2}{9}$
W	$\frac{3(1-m-\sigma)(5(1-m)+3\sigma)}{32}$	$\frac{(4(1-m)+\sigma)(2(1-m)-\sigma)}{18}$	$\frac{(1-m-\sigma)(2(1-m)+\sigma)}{9}$
where	$\varnothing=m^2-2m(1-\sigma),\ m\leq\frac{2}{3},\ \sigma\leq\frac{m}{2},\ m+\sigma<1.$		

CS: consumer surplus.

Concerning CS, it is observed that as variable cost increases in the range $0 < m < 0,50$, and operational costs are relative low, consumers are better off when the incumbent operator remains bundled and it also exerts leadership in the market: the benchmark model *B*. In the limit, for values $0.50 < m < 0.66$, the monopoly outcome, *M*, reveals itself as better than any other configuration. This is because as operational cost increases, the average cost also increases and diseconomies of scale arise. The natural monopoly solution arises because total average costs are larger with two providers. Thus, the best configuration is to keep one operator covering all services and then to exploit the service as a natural monopoly. However, for a relative lower variable cost $[0 < m < 0.285$ and $(0 < \sigma < 0.197)]$, it can be checked that $\mathrm{CS}_B > \mathrm{CS}_{UL} > \mathrm{CS}_{BS} > \mathrm{CS}_{US} > \mathrm{CS}_M$. In other words, when variable costs due to operational and maintenance are relative low, vertical disintegration (model *UL*) is possible. Figure 3 describes the evolution of CS.

Results with respect to welfare are quite similar. Overall, it can be seen that welfare, *W*, is always maximized when liberalization includes the state-owned holding and its leadership. This seems very natural because competition remains very narrow: only two operators offer services so they have a huge market power, no matter the state-owned operator is leader or not. Moreover, as variable costs increase, the monopoly outcome gains positions in the ranking. Once again, economies of scale attained by the monopolist operate. However, it does not get the welfare level of the model *B*. The reason is that under the duopoly configuration, the state-owned operator and the entrant operator obtain more profits than the incumbent alone (under monopoly), and thus welfare is enhanced even if CS under *B* goes down faster than it goes in the model *M*. Figure 4 contains these observations.

Finally, let us recall that the model is a simple way to introduce competition from an industrial organization point of view. It has limitations and needs to be completed with further research. For instance, under monopoly, the state-owned operator does not pay to access rolling stock because it is assumed to be an essential facility provided by the state. Hence, it needs to be considered as an input to be compared with the other models. Moreover, it is a duopoly model. We consider that the presence of more operators in the market may alter results and that access to rolling stock as an essential facility should be reluctant, and thus operators may enter the market by using own rolling stock or lease it under competitive basis to a private or state-owned firm. These insights can be developed with further research.

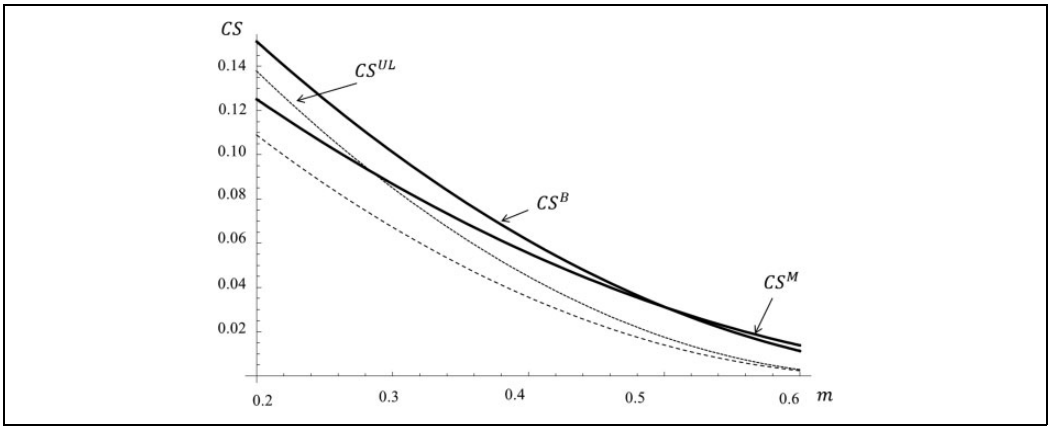

Figure 3. Evolution of consumer surplus.

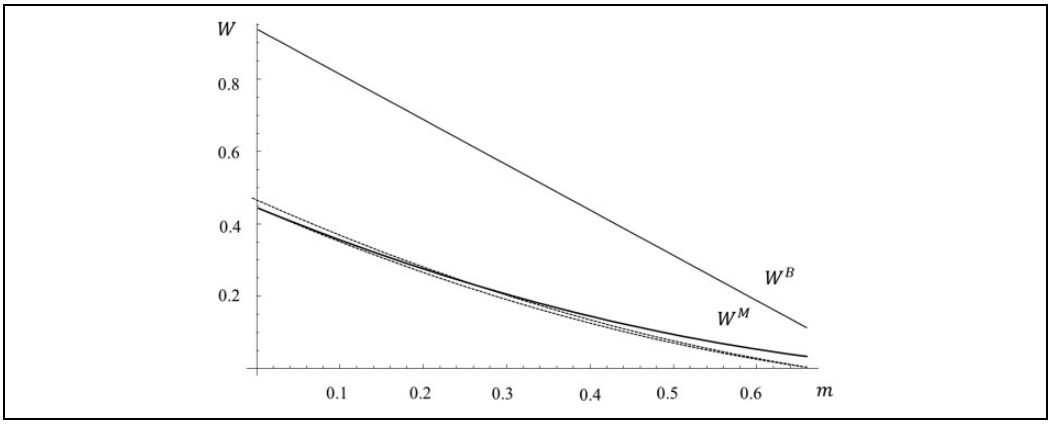

Figure 4. Evolution of welfare.

Conclusions

In this article, we have presented an overview of the liberalization process of the railway passenger market in the EU. First, a critical review of the ongoing liberalization of railway passenger services is conducted. The market pillar enclosed in the fourth Railway Package is introduced. The amended Directive 2012/34/EU, the previous Railway Packages and the Commission's fourth Railway Package (which contains the basic legislation of the liberalization process) are explained.

Second, oligopoly models are introduced to present different paths towards liberalization. Under general assumptions in operational costs, networks access, rolling stock leasing contracts and demand, it is concluded that liberalization may be successful depending on the relative performance of the above features. Overall, it is found that a number of changes in regulatory measures as well as some particular market features should be discussed to achieve efficiency in a

liberalized market. Each country may differ as to when and how to start the opening up of the railway passenger market, so the models presented are intended to be a general guide. Assignation of time slots under competitive basis may ensure equal opportunities for the incumbent operator and new entrants, vertical relationships between rail services and leasing of rolling stock and the level of access charge to the network are key features in the way towards an efficient liberalized market. In particular, our models suggest that liberalization is profitable for consumers and operators depending on the level of variable costs and maintenance cost, and thus different market structures may achieve the same objective. Further research needs to include different access charge schedules to enter the network and whether access to rolling stock is an essential facility or not. These features may alter significantly the market outcomes and should be included in future studies on the railway market.

Authors' note

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