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U.S. and European Freight Railways: The Differences That Matter

by Francisco Manuel Bastos Andrade Furtado

This paper examines the differences between the United States (U.S.) and European (EU27) freight railways. The inherent or structural factors influencing the railways modal share will be evaluated. It was found that nearly all of the disparity in modal share can be explained by structural or inherent differences, like the competitiveness of non-surface modes, shipment distances (both influenced by geography), and commodity mix (namely, coal). More striking are the differences in productivity, to move the same number of tons seven times, more trains are required in Europe compared with the U.S.. Operational revenues per ton-mile are around two times higher in Europe, while the operational expenses in the U.S. are four times lower than in Europe. It is argued that setting a goal for modal share similar to the U.S. is not realistic for the EU27. A key concern for European freight railways should be the reduction of operational costs, by increasing the trains' sizes.

Distinct policy answers were given to the railroads' crisis in the post WWII years. Soon after 1980 when reforms were introduced in the U.S. there was a revival of the sector. The same has not happened in Europe, where questions regarding infrastructure financing or the coordination of network investments and operational needs remain.

INTRODUCTION

Over the last 30 years, the U.S. rail freight industry has witnessed an increase in its modal share, productivity, and profitability (Association of American Railroads 2012, Shi, Lim, and Chi 2011). In Europe (EU27), the industry has been unable to achieve the same results, even after the introduction of legislative and regulatory reforms that started in 1991 and culminated in 2007 with the implementation of full open access for freight rail operators (European Commission 2010, European Commission 2009b).

There are significant differences between the United States (U.S.) and European freight railways and these differences can be classified into three broad groups. First, there are structural or inherent natural disparities (Table 1), that can limitedly (or not at all) be changed by any level of decision making. Second, train characteristics (Table 4) and operations vary widely between the two areas (Table 5). Third, both in Europe and the U.S., railways faced a deep crisis in the post World War II years, but the policy answers and how the market evolved followed distinct paths (Table 6).

It was found that the disparity in modal share can be mostly explained by structural or inherent differences like the competitiveness of non-surface modes, shipment distances (both influenced by geography), and commodity mix (namely, coal and other bulk materials). More striking than the differences in modal share are the discrepancies in productivity and train sizes with U.S. railways greatly surpassing the European ones. Soon after 1980, when major regulatory reforms were introduced in the U.S., there was a revival of the sector. The same has not happened in Europe, where questions regarding infrastructure financing or the coordination of network investments and operational needs remain. But other factors, besides legislative reform, influenced both the U.S. revival and the anaemic European results.

All of the above—structural, operational, and policy factors—impact the performance of the freight rail industry. When comparing the railroads' stance in the U.S. and Europe, all these factors should be taken into account. This paper attempts to provide a comparative analysis that covers the

key factors conditioning the freight railroads on both sides of the Atlantic and contrast them. The goal is to be able to contribute to answering the following question: what are the differences that really matter? More precisely, given the underperformance of European railways when compared with the U.S., are there any guidelines that can be obtained to foster the industry in Europe from a comparative analysis with the U.S.? On the other hand, are there any lessons from the European experience that can be useful for U.S. railroads and policy makers? In addition, can valuable insights be obtained for other regions in the world where rail freight plays an important role in the economy or is intended to do so?

In the European Union (EU), the Commission's 4th Railway package proposal that reinforces the separation between infrastructure and operations is under discussion and awaiting approval by the European parliament (European Commission 2013). In the U.S., there are requests to reform existent legislation and change the current switch agreements (Surface Transportation Board 2012). In Brazil, a major expansion of the rail network is planned, as well as a change in the railroads' governance model (Governo Federal Brasil 2012). These are some examples of current policy proceedings that might benefit from the insights provided by this paper. Moreover, in these policy discussions, features of other regions' railroad models are often mentioned, but they are generally handpicked and taken out of context. One example is the discussion in the European Commission (2013) regarding infrastructure governance. In that document, the North American model of parallel competition is mentioned and is immediately followed by a defense of EU endeavors to reinforce the separation of infrastructure managers (that run the network) and rail undertakings (that run the train services). The fact that this separation is the opposite of one of the cornerstone elements of the current North American model, vertically integrated railroads, is not mentioned.

This paper is divided into four parts. First, a literature review of other studies in this area of research is presented. Second, the modal share in the two regions will be compared. A measure of the effect of the structural differences in the gap between shares will be provided. It follows a similar methodology to Vassallo and Fagan (2007), which is briefly described in the literature review. Third, productivity indicators (including financial results) will be presented. The disproportion between these numbers will be discussed, including the influence of structural differences, plus the impact of the train characteristics and operations. Fourth, the diverse policy and market answers will be examined. Conclusions will then be delivered, highlighting the differences that matter and providing some guidelines for European freight railways improvement.

For the analysis, the insights provided by several interviews with academics and industry representatives, plus visits to rail terminals and yards, were valuable. Both these visits and interviews were done in the U.S. and the EU (Furtado 2012).

LITERATURE REVIEW

This research area has been addressed by several academic and non-academic studies. Vassallo and Fagan (2007) focused their research on the modal share difference measured in ton-km (tkm) between the U.S. and European freight railways. Their aim was to quantify how much of the existing difference can be attributed to structural factors and how much to policy differences, thus determining if it was plausible for the EU to increase rail's modal share by adjusting its policies.

The year 2000 was chosen for this analysis. The authors identified four inherent differences: the transportation volume (total tkm over all modes), competitive position of non-surface modes (coastwise/sea, inland waterways, and pipeline), shipment distances, and commodity mix. For each of these differences, the structural conditions of Europe are sequentially applied to the U.S., while maintaining the relative difference between the U.S. road and rail modes – e.g., to assess the impact of the transportation volume, the U.S. percentage share of each mode is kept, but the total tkm applied is the European value. The 38% U.S. rail modal share was applied to a 3,068 billion tkm total movement, which is the European total; the U.S. total was 6,495 billion tkm. So, if the total

transportation volume in the U.S. would be the same as in Europe, the U.S. railroads would have moved 1,166 billion tkm (not the 2,468 billion actually moved). For measuring the impact of the competitiveness of the non-surface modes, the non-surface modes share in Europe was applied while keeping the U.S. road/rail relation. So, in Europe, the non-surface modes have a 48.24% share (in the U.S. it's 35.4%), which means that road+rail modes have a 51.76% share. The U.S. road/rail relation is $26.6/38.00=0.7$. So in the U.S., the rail share would be $51.76/1.7=30.45\%$. Considering the previous 1,166 billion tkm total, the U.S. would move 934 billion tkm. Thus, the higher competitiveness of the non-surface modes in Europe explain 232 billion tkm (1,166 - 934 billion) of the U.S.-EU rail freight volume gap. A similar logic is then applied to evaluate the shipment distance and commodity mix differences. All the numbers presented above were taken from the article.

The authors found that about 83% of the modal share difference was probably due to natural differences. It is argued that the remaining difference (17%) is presumably due to public policy differences like priority of passenger services, lack of productivity-enhancement infrastructure, and lack of incentives of the rail operators (lack of competition between rail companies). It is stated that "One policy difference which is unlikely to impact the residual is the European Union's requirement to separate infrastructure from operations and require open access." In fact, it is suggested that unbundling infrastructure from operations as a way to introduce competition might be one of the ways of increasing the European railroads' market share, having a somewhat similar affect to what deregulation did in the U.S.

Rodrigue and Notteboom (2010) present a qualitative analysis of the different configurations of the European and North American transport and logistics networks. They point to several relevant contrasts, e.g., the higher number of ports in Europe when compared with North America, the shorter distances between the ports and respective hinterlands in Europe, the nonexistence in Europe of anything like the land bridge between the east and west coasts in North America, the more concentrated nature of traffic flows along certain corridors, and thus the possibility of bigger scale economies in North America. Regulatory, policy, and governance differences are also discussed. Europe's multitude of nations with their respective histories and cultures means that coordinated action is much more difficult to attain than in North America. Important infrastructure projects are designed in a more national than continental logic. The market is much more fragmented and less homogeneous than in the U.S. and there is a higher need of customization for each specific national market, thus there is less room to take advantage of scale economies in distribution centers and networks.

Pouryousef, Lautala, and White (2013) provide a review of capacity definitions used in both Europe and the U.S., followed by a description of differences in the respective rail systems regarding infrastructure and operations. They then present several methodologies to evaluate capacity, including case studies both in the U.S. and Europe. In Europe, the preponderance of passenger services and corresponding requirement of on-time performance for train services requires a level of reliability that is typically secured through structured/planned/scheduled operations. In the U.S., operations commonly follow a more flexible dispatching pattern. This difference leads to different metrics, concepts, and methodologies to evaluate capacity. The European rail networks typically take advantage of several commercial simulation software available in Europe, which have been developed based on the timetable compression concept, while the U.S. railroads usually apply the non-timetable-based simulation, in addition to the general analytical tools and modeling approaches. The authors argue that as the U.S. continues developing its passenger traffic on shared corridors, the future operational patterns of shared corridors in the U.S. will likely have a closer resemblance to the European shared-use lines. The accuracy of capacity analysis methods becomes more important, and tools applied in Europe may become more applicable to the U.S. conditions as well.

Drew (1999) reviews the history of rail legislative and regulatory reforms in North America and different parts of Europe. The study underlines that the ideal form of regulation depends on a number of other inter-related choices, like the type of ownership of the assets, vertical separation or

integration, open access. or limited access. Furthermore, these choices should take into account the particularities of the market for rail services, e.g., whether freight or passenger services dominate the railway. In the conclusion, the author warns that open access might not always maximize efficiency since it can reduce the fragile profitability margin of railway operators acting in certain markets.

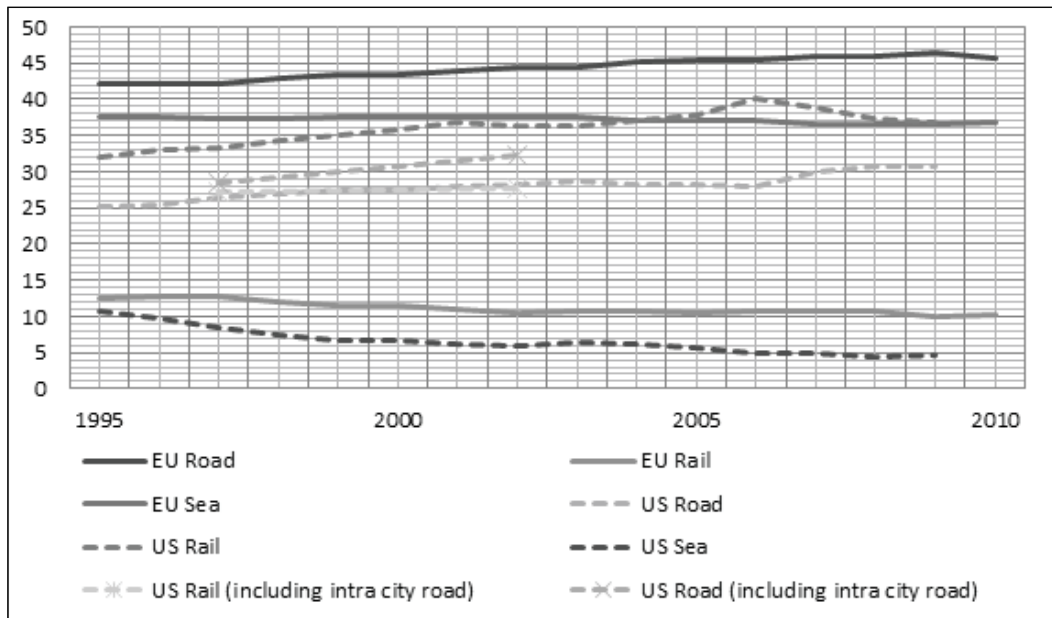
Posner (2008) bases his essay on the experience he had as a manager and investor in freight railways both in the U.S. and Europe. This work mentions several physical and geographical differences between Europe and North America that condition the freight railroads' activity, but the article emphasizes the institutional differences. Posner argues that parallel competition between vertically integrated railroads in the U.S. was a result of deregulation, whereas on-rail perfect competition in Europe was artificially induced by restraining regulations. Moreover, while EU policymakers' efforts were focused on promoting intra-rail competition, important service and capacity requirements were not considered.

Concerning the available literature, the present paper brings three key contributions. First, it updates the discussion on this area, whether it is on the modal share trends or regulation and its impacts on the railroads' performance. Second, it presents a comprehensive analysis that encompasses several factors that influence the freight railroads' activity which are inter-related, such as structural factors, productivity and profitability, operational logic, institutional framework and history of the legislative reforms. Third, productivity and profitability differences are mentioned in other studies, but not with the emphasis presented here.

MODAL SHARE AND STRUCTURAL DIFFERENCES

In 2009, the rail share of the modal split, based on tkm, was 36.8% in the U.S. (the mode with the highest share) and 9.9% in EU27 (below road and sea). This gap has existed for several decades (Figure 1) and it is mentioned in several European publications, including policy setting European Commission documents (European Commission 2001).

Figure 1: EU27 and U.S. Freight Transport Modal Split (% based on tkm)



Source: Eurostat, U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS), DOT-BTS 2004.

There are structural factors that limit the share of rail in Europe when compared with the U.S. Europe has around half the land mass of the U.S., but more than three times the U.S. coast line. This limits the shipments' distances for surface modes in Europe, where there is no equivalent to the inland coast-to-coast trips in the U.S. While in the U.S., 48% of the shipments (in ton-miles) of surface modes (road and rail) are above 1,200 km, in EU27, only 15% are above 1,000 km (Eurostat, DOT-BTS 2010, Tavasszy and Meijeren 2011).

Furthermore, geography is a major factor in creating higher competitiveness of the sea mode (coastal shipping) in Europe (36.7% of the modal share in 2009) compared with the U.S. (4.6% of the modal share in 2009); adding to geography, the sea mode is constrained in the U.S. by the Jones Act of 1920¹ (Rodrigue and Notteboom 2010). As for other non-surface modes – inland waterways (river and lakes) and pipelines – they have higher shares in the U.S. than in Europe. While in the U.S. inland waterways and pipelines move, respectively, 6.5% and 21.1% of the total ton-miles; in Europe they have a 3.6% and 3.1% share. The difference in the pipelines' modal share is significant, which is probably due to geography and because the U.S. produces more petroleum products than Europe. Still, the combined share of non-surface modes (sea, inland waterways, pipelines) is higher in Europe (43.7%) than in the U.S. (32.2%) (Eurostat, DOT-BTS).

Another key factor is the type of goods moved. Rail is especially suited for heavy low-value commodities over long distances. In the U.S., coal accounts for about 29% of the ton-miles of surface modes and around 44% of the ton-miles moved by rail, while in Europe, it is less than 3% of the surface modes and around 13% for rail (DOT-BTS 2010, Eurostat).

Table 1: Structural Differences

	<i>Europe (EU27)</i>	<i>U.S.</i>	<i>Comments</i>
Geography	Area = 4,414 thousand km ² Coastline = 65,993 km	Area = 9,629 thousand km ² Coastline = 19,924 km	Higher competitiveness of sea mode in Europe. Higher inland shipment distances in the U.S.
Commodity Mix	More manufactured goods	More raw materials	Higher share of bulk, high weight and low value commodities more suitable for rail in the U.S.

Source: Eurostat, DOT-BTS, CIA World Factbook

To measure the impact of these factors in the gap between the rail modal share in the U.S. and Europe, the methodology applied will be similar to Vassallo and Fagan (2007), briefly described in the literature review. But there are three important differences. First, it will be taken into account the fact that the statistics in the U.S. exclude intra-city truck movements (Dennis 2005), underestimating this mode share. The latest estimates found for those numbers are in DOT-BTS (2004) and they can be seen in Figure 1. According to this, the U.S. rail share in 2002 would be 27.8%, below road's 32.1% share. Second, the data for this analysis refer to the last year with comparable estimates (2009), not to 2000. Third, Europe is represented by the EU27 (which includes Central and Eastern Europe), not the EU15 (which only includes Western Europe).

The estimation involved five steps (see Table 2). The data sources for the calculations were the Eurostat and DOT-BTS databases, plus Tavasszy and Meijeren (2011).

Table 2: Structural Factors Influence on Europe and U.S. Rail Share Differential²

	<i>Vassallo and Fagan - 2000</i>		<i>Furtado – 2009</i>	
	Value (million tkm)	% of gap	Value (million tkm)	% of gap
Total gap	925,794	100%	903,385	100%
<i>Structural factors share of the gap</i>				
Non-Surface/ Sea mode - Step 3	231,748	25.0%	237,847	26.3%
Shipment distances - Step 4	413,104	44.6%	413,206	45.7%
Commodity mix/ Coal - Step 5	123,680	13.4%	237,831	26.3%
Not explained by structural factors	157,262	17.0%	14,502	1.6%
Contribution of structural factors	768,532	83.0%	888,884	98.4%

Source: Eurostat, DOT-BTS, Vassallo and Fagan (2007), Tavasszy and Meijeren (2011)

The first step was to take into account intra city trucks. To do this, the ton-miles of the road/truck mode in the U.S. were increased so that this mode would obtain the same share as rail. According to DOT-BTS, in 2009, rail moved 1,582,093 million ton-miles and trucks moved 1,321,396 million ton-miles. It was assumed for the subsequent steps that the truck mode actually moved the same 1,582,093 million ton-miles as rail. By doing this, U.S. rail obtains a 35% modal share (below the original 36.8%) equal to truck. Other modes also see their shares slightly decreased. This is a conservative approach, since in the later estimates available road share was actually above rail (DOT-BTS 2004).

In the second step, the U.S. rail share (35%) is applied to Europe's total tkm movements (3,646,788 million tkm), to take into account that the total tkm in Europe for all modes is around half of the U.S. (the U.S. total movements correspond to 7,343,465 million tkm). So, if in EU27 the rail share would be the same as in the U.S., there would be 1.264 trillion tkm moved by rail ($0.34672086 \times 3,646,788 = 1,264,417$). According to Eurostat, 0.36 trillion tkm were actually moved by rail in Europe in 2009. This means that there is a 0.903 trillion tkm difference ($1,264,417 - 361,032 = 903,385$) between what European rails actually moved and what they would move had they a modal share equivalent to the U.S.

How much of this 0.903 trillion tkm gap can be attributed to structural differences? This is evaluated in the next three steps.

In the third step, the sea and other non-surface modes European share (43.7%) is applied to the U.S. (30.66% share for non-surface modes), while keeping the same road/rail ratio (1 for the U.S.). In this way the higher competitiveness of non-surface modes in Europe (namely sea, since there is a lower share of pipelines and inland waterways in Europe) is taken into account. In this situation the Road+Rail share in the U.S. would be equal to 56.3% ($100 - 43.7$). The U.S. road/rail relation would be kept (road/rail share=1). So the U.S. rail share would drop to 28% ($56.3\% \times 0.5 = 28.15\%$). In Europe, a 28% share would represent 1.026 trillion tkm ($0.2815 \times 3,646,788 = 1,026,571$). When the higher share of non-surface modes in Europe is taken into account, the gap between European and U.S. rail share is reduced. The gap would be 0.66 trillion tkm ($1,026,571 - 361,032 = 665,539$) not 0.903 trillion tkm (as calculated in the second step). So of the modal share gap, around 0.238 trillion tkm ($903,385 - 665,539 = 237,847$, or simply $1,264,417 - 1,026,571 = 237,847$) can be explained by the different competitive advantages of non-surface modes in Europe.

The fourth step takes into account the differences in shipment distance. The European distribution of surface modes tkm according to shipment distance class is applied to the U.S. rail share (versus road) by distance class. European shipment distance characteristics are applied to

the U.S. rail vs road competitiveness. For instance, in Europe 15% of the surface modes tkm (the total tkm for surface modes is $2,053,142 = 0.563 \times 3,646,788$) are for shipments above 1000 km (this corresponds to around 0.317 trillion tkm = $2,053,142 \times 0.1546$). In the U.S., rail has about 70% of the surface mode share for shipments above 1000 km. So, for the distance class above 1000 km, rail would move 0.22 trillion tkm ($317.366 \times 0.7 = 222,156$). The same calculations are performed for the other distance classes (0-50; 50-150; 150-500 and 500-1000 km) and then summed. In this scenario, rail would have moved 0.613 trillion tkm. So, 0.413 trillion tkm of the gap ($1,026,571 - 613,365 = 413,206$) can be explained by the longer shipment distances in the U.S.

The fifth and last step is to take into account the differences in commodity mix, namely coal. The U.S. proportion of coal in the tkm of surface modes (almost 30%) is applied to the European modal split between rail and road by commodities (it is 80% for coal and 8% for others). Had Europe moved the same share of coal as the U.S., 0.599 trillion tkm would have been moved by rail. This would represent a 66% increase compared with current numbers. That increase of 0.238 trillion tkm ($598,863 - 361,032 = 237,831$) corresponds to the difference accounted for by coal in the modal share gap.

The results show that Europe's and the U.S.' rail share differential can be mostly explained by the structural differences, nearly all for 2009 and around 80% for 2000. This divergence is related to the increase in the fraction of coal in the commodity mix in the U.S. (from 23% in 2000 to 29% in 2009). Moreover, there was a reduction of the starting gap caused by two factors. First, in 2009, there was a correction of the U.S. value to take into account intra city trucks (Vassallo and Fagan 2007, for the year 2000 had a 38% share for rail, versus a 35% share applied in this study). Second, the EU27 in 2009 had a higher rail share (9.9%) than the EU15 in 2000 (7.8%). The EU27 includes the Central-Eastern European countries that on average have higher rail shares than Western Europe. See Figure 4.

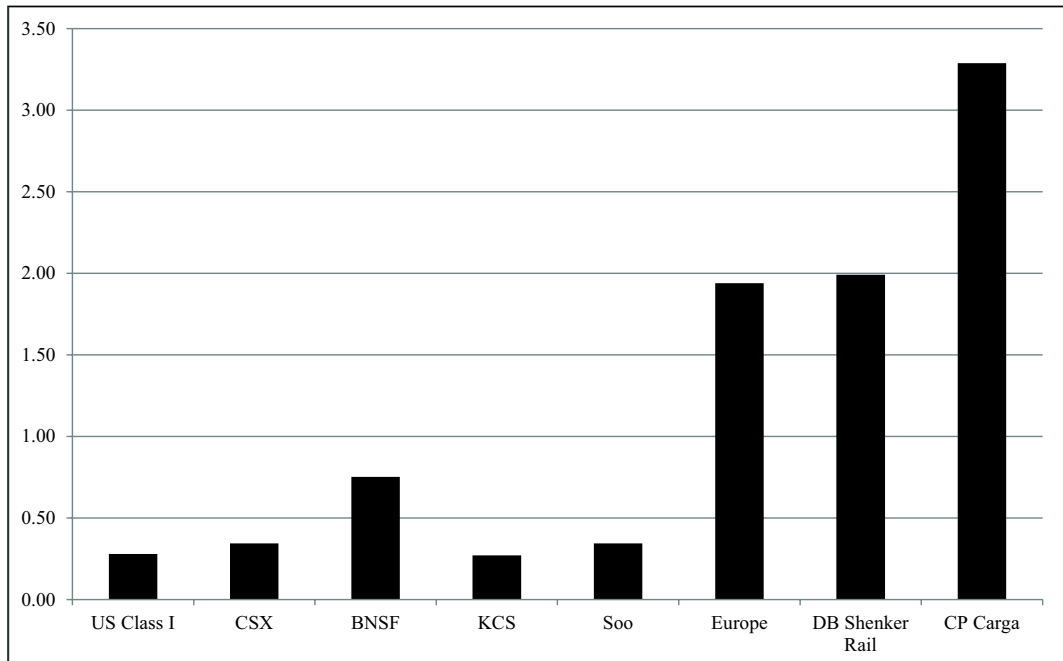
The structural factor that has the highest impact is the difference in inland shipment distances, which explains around 46% (almost half) of the differential. The higher competitiveness of non-surface modes in Europe and the differences in the importance of coal explain (for 2009) a similar amount of the gap, about 26% each. This analysis was based on the comparison of tkm. If the measure to compare would be in tons moved, the results would be different. For 2010, rail moved 1,515,332 thousand tons in Europe and 1,850,996 thousand tons in the U.S., which means 18% less in Europe (Eurostat, DOT-BTS). A much smaller starting gap than if measured in tkm (86% less in Europe). The difference in distances not only allows the rail industry in the U.S. to capture a higher share of the market, it also means that each ton moved by rail goes a much longer distance, multiplying the U.S. tkm *vis à vis* the EU27.

When comparing the U.S.' and Europe's railways performance measured by modal share, the difference is marginal (if the structural constraints existing in Europe versus the U.S. are accounted for). Therefore, it is not reasonable to expect the EU27 railways to ever achieve a similar modal share to the U.S., even less to set this as a policy target. So, is this the difference that matters?

PRODUCTIVITY

To move the same number of tons, around seven times more trains are necessary in Europe. For a thousand tons the U.S. Class I railroads require 0.28 trains; in Europe it is 1.94 (Figure 2). Even taking into account the higher costs of the larger U.S. trains, this is a very significant distinction that implies that European railways have much higher costs per ton and tkm, which is the case. As shown in Figure 3, the operational revenues per ton-mile are higher in Europe, almost two times more than in the U.S. (DB Shenker, being the largest European freight railway, will be used in the comparison, and data for CP Carga the main Portuguese freight railway are also presented). But the operational expenses are almost four times higher than the ones in the U.S. In fact, European railways are barely profitable or not profitable at all (European Commission 2009b).

Figure 2: Number of Trains Per Tons Moved (thousand) in 2010

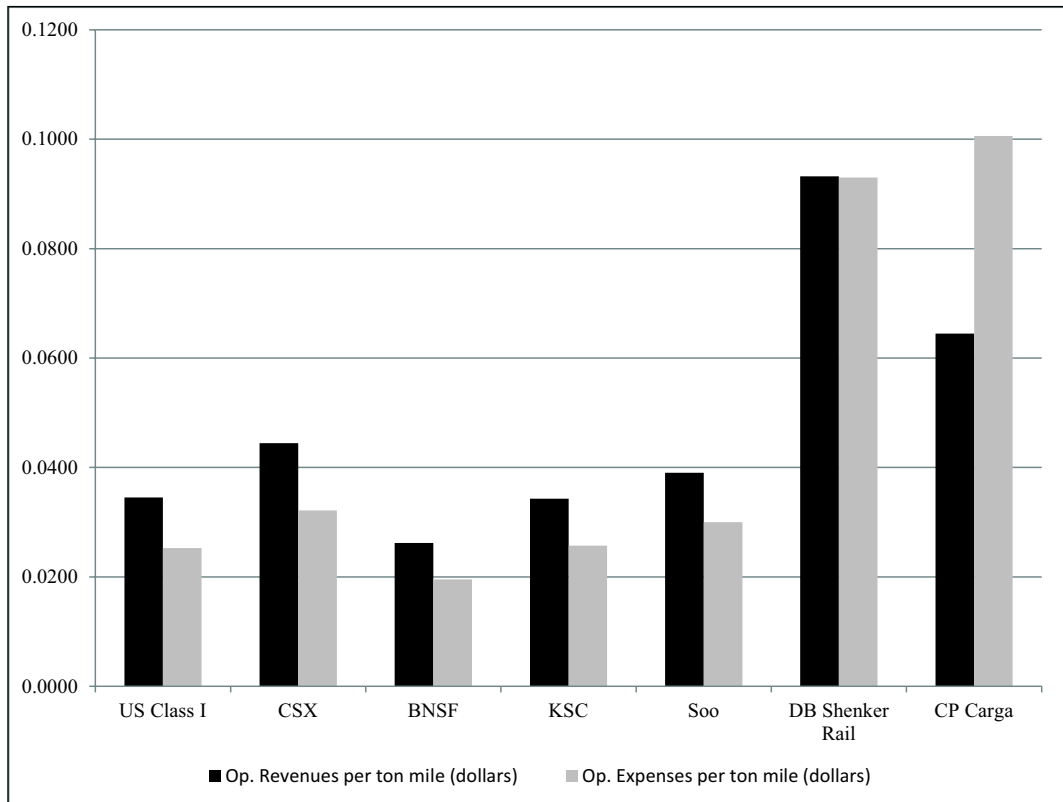


Source Eurostat; Association of American Railroads (AAR); Surface Transportation Board (2010); DB, CP Carga annual reports.

Having more trains (even if smaller) for less cargo moved implies higher fixed and variable costs. It implies more labor, line capacity use, and a smaller net/gross tons ratio per train for the same amount of goods moved. This explains to a large extent why U.S. railways are profitable and have been financially stable for the last 10 years, while in Europe their financial situation is, at best, precarious.

Besides the train's weight/length, the much longer shipment distances also contribute to a higher productivity in the U.S., especially if the outputs are measured in ton-miles. In Europe, the length of haul is mainly restrained by structural factors already mentioned. There are fewer long distance inland shipments than in the U.S. There are also interoperability barriers in the EU27 that are nonexistent in the U.S., such as different gauges, signalling systems, and electric systems (in the U.S. there is almost no electrification, while in the EU27, half the lines are electrified).

Figure 3: Operational Revenues and Expenses for U.S. and European Freight Railways in 2010



Source: Association of American Railroads (AAR); Surface Transportation Board (2010); DB, CP Carga annual reports.

Table 3: Freight Railways Statistics for 2010

	<i>Average³</i>				<i>trains per</i>		
	Length of haul (miles)	net tons (per train) A	tons (thousands) B	ton-miles (million)	trains (B/C)	tons (thousands)	ton-miles (million)
U.S. Class I	913.6	3585	1,850,996	1,691,000	516,338	0.28	0.31
CSX	549.2	2902	417,303	229,172	143,789	0.34	0.63
BNSF	1114.3	1330	580,206	646,549	436,295	0.75	0.67
KSC	390.7	3692	75,833	29,629	20,540	0.27	0.69
Soo	426.7	2902	77,703	33,157	26,771	0.34	0.81
Europe	159.9	516	1,515,332	242,335	2,938,746	1.94	12.13
DB Shenker Rail	158.3	502	415,500	64,737	826,921	1.99	12.58
CP Carga	138.6	304	9,224	1,278	30,331	3.29	23.73

Source: Eurostat; Association of American Railroads (AAR); Surface Transportation Board (2010); DB, CP Carga annual reports.

As for the trains' weight, the structural factors also have some influence. Heavier trains on average are expected in the U.S. versus EU27 since the commodities shipped by rail in the U.S. are heavier, and include more bulk and fewer manufactured goods than in Europe. Still, this is not the main explanation for the huge discrepancy in the average tons per train (86% less in Europe). In fact, if the comparison is made only between heavy bulk trains, most of the difference concerning tons per train remains. The disparity in the train's average weight is much more a result of the infrastructure and equipment constraints in Europe than any structural factor (see Table 4).

Table 4: Train Characteristics

	Length (<i>feet/m</i>)		Containers (40' – 2 TEUs) per Intermodal train ⁵	Net tons per bulk train (typical)
	Typical	Maximum ⁴		
U.S. Class I	6500/2000	10000/3000	150-300	9000-12000
Europe	1640/500	2460/750	25-50	1200-2000

Source: several industry reports

Nonetheless, to reach a financially stable situation, European railways do not need to have trains with the exact same characteristics as in the U.S. They do need to get bigger, but not to the same level. The fuel prices in Europe are around double that of the U.S., which increases the railways costs, but also allows them to have higher charges (the effect of higher fuel costs is felt more by trucks than rail [Owens, Seedah, and Harrison 2013]). Road charges are applied much more extensively in Europe than in the U.S. (increasing the costs of the road mode, which also allows higher charges by rail), e.g., in the U.S., only about 6% of the interstate highway system has tolls (Weiss 2008). In Italy and France, almost all the motorways (Autostrade and Autoroutes) have tolls and in Germany, there is a "truck-toll" (LKW-Maut) for all trucks that drive on the motorways (Autobahnen).

Besides the train size, other features also constrain European freight railways' productivity (see Table 5). The existence of passenger trains, which constitute 79% of the train-kms in the European rail network, have priority over freight trains (Eurostat 2007). Access to the network and dispatching flexibility is more constrained in Europe. Additionally, in the U.S., investments in the past 40 years were focused on increasing freight trains' productivity (Martland 2012) by: increase in train length (with associated changes in terminals and increase in sidings); increase in the net weight per rail car; and increase in track resistance and double stacking of containers (with the associated increase in clearances). In Europe, investment was concentrated on passenger services, namely, high speed rail. Since 1990, there was a 545% increase in the length of high speed lines (some of which cannot be used by freight), while the total rail network had a 10% decrease (Eurostat, European Commission 2012).

Even more striking than the difference in modal share are the differences in productivity. More importantly, there are strong structural restraints on increasing the railways modal share in Europe. They also affect productivity, but to a lesser extent. One of the key restrictions in productivity, the train size, is more limited by a lack of investment due to other priorities than any unchangeable natural obstacle.

A key concern of all agents involved in fostering freight railways in Europe should be to decrease the costs per unit moved (ton and tkm). To achieve this, one of the solutions is to increase the net tons per train and reduce the number of trains. Other strategies include restructuring the services offered (namely by dropping unprofitable services/routes), changes in charges to the customers, and a concentration of efforts and investments on the network segments that will provide higher returns.

Table 5: Train Operations

	<i>Europe (EU27)</i>	<i>U.S.</i>	<i>Comments</i>
Scheduling	Most services follow a strict schedule	There are some scheduled services, namely for intermodal trains (generally these schedules are not strict having 1-3 hours lags). In many cases the dispatchers define the arrival and departure times to maximize the load per train	In Europe the railway operators do not control scheduling it is an Infrastructure manager decision. Freight train's schedules are subject to the passenger train's schedules. For more on these differences see Pouryousef, Lautala and White (2013)
Passenger services	Extensive passenger services, 79% of the train-km are by passenger trains	Few passenger services mostly concentrated along the Northeast corridor, some commuter services	In Europe passenger trains have priority. Lines are more congested. Most investment goes to improve passenger services

Source: Eurostat, Furtado 2012, Pouryousef, Lautala and White (2013)

Even if sizable gains in the train's capacity were to occur in Europe, it is not clear to what extent this could indeed ensure financial stability of the railways. A reduction in the number of trains would imply a reduction in frequency of service and an increase in the lot sizes to be shipped. Can this be accommodated by the market and industry? Such a move would probably narrow the client base of European railways to heavy industries and ports, but that is exactly the client base that sustains freight railways. The question then is, to what extent, given the market conditions, the investments required to enhance productivity can be covered by the productivity gains, namely, the reduction in operational costs?

POLICY AND MARKET STRUCTURE

Some policy differences have already been mentioned: the Jones Act that restricts cabotage in the U.S., the priority given to passenger rail in Europe, plus higher fuel costs and more extensive road tolls. But what about the distinct market structure and regulation? How does it affect the railroads' performance and productivity?

Both in Europe and the U.S., railways faced a deep crisis in the post World War II years, but the policy answers and how the market evolved followed distinct paths. In the U.S. the railways had been privately owned but heavily regulated. The "Northeast rail crisis" in the 1970s (when several major U.S. railways went bankrupt) was the starting point for sweeping reforms. The Rail Passenger Service Act of 1970 that created Amtrak relieved freight railroads from the losses associated with providing intercity passenger services, around \$200 million per year, or \$850 million in today's dollars, according to Association of American Railroads (2012). The Regional Rail Reorganization Act of 1973 consolidated all the bankrupt railroads into Conrail (Consolidated Rail Corporation). The Railroad Revitalization and Regulatory Reform Act of 1976 allowed for extensive federal funding to ensure both Conrail's financial survival and capital investments. It also significantly reduced federal regulation of railroads, starting the deregulation process. In 1980, the Staggers Rail Act, the most mentioned legislative reform, was passed. It allowed railways to decide which routes to use, which services to offer and what prices to charge. Two other events occurred, including a process of mergers. There were more than 70 Class I railroads in the early 1970s; now and for the last 10 years there were only seven (DOT-BTS). Second, there was an increase in the quantity of track owned by non-Class I railroads (regional, local, and switch and terminal). They owned 10% of the tracks in 1980 and 32% in 2008 (Martland 2012). These companies took over many low density

traffic lines abandoned by the Class I railroads and concentrated in “maneuver intensive” sites (large industrial sidings, ports, some terminals).

These reforms, together with the productivity enhancement investments already mentioned, resulted in a revival of the U.S. railways (see Figure 1) (Wright 2011, Kriem 2011). A key driver for this was a dramatic reduction in costs that led to a great increase in productivity (Wilson 1997, Velluro et al. 1992).

In order to revitalize the industry in Europe, the EU response, starting in 1991 (Council of the European Communities 1991), was to move towards a single and open market. An open market means the end of state-owned monopolies, and the separation of infrastructure and operations, either through full separation or the creation of holdings where different divisions of the same group are responsible for either operations or infrastructure. This allowed different railway operators to compete for rail services on the same network. A single market means that no country could block companies of other countries (at least from the EU) to provide services on their network, and also that technical and operational barriers between different countries’ networks should progressively be removed.

Table 6: Policy and Market

	<i>Europe (EU27)</i>	<i>U.S.</i>	<i>Comments</i>
Political	27 sovereign member states	One sovereign state	It is slower and more complex to implement common policies across the EU27.
Market Structure	Open access. Separation of infrastructure and operations. Regulator supervises non-discriminatory access to the infrastructure	Vertical integration. Railways provide transportation and own the infrastructure	In the U.S. each railway has control over its network. In Europe no operator controls the network.
Competition	”Coincident” over the same lines/routes rail competition.	Parallel competition with other railways. Competition with trucks and sometimes barges.	In the U.S. almost all regions/clients can be served by two railways, nonetheless they can better protect their market.
Types of railroads	Infrastructure Managers, Freight Operators, Passenger Operators, Freight and Passenger Operators, Holdings	Class I, Regional, Local, Switch and Terminals (difference is business volume and length of network owned)	In the U.S. railways are classified by their size. In Europe by their function.

Source: Author

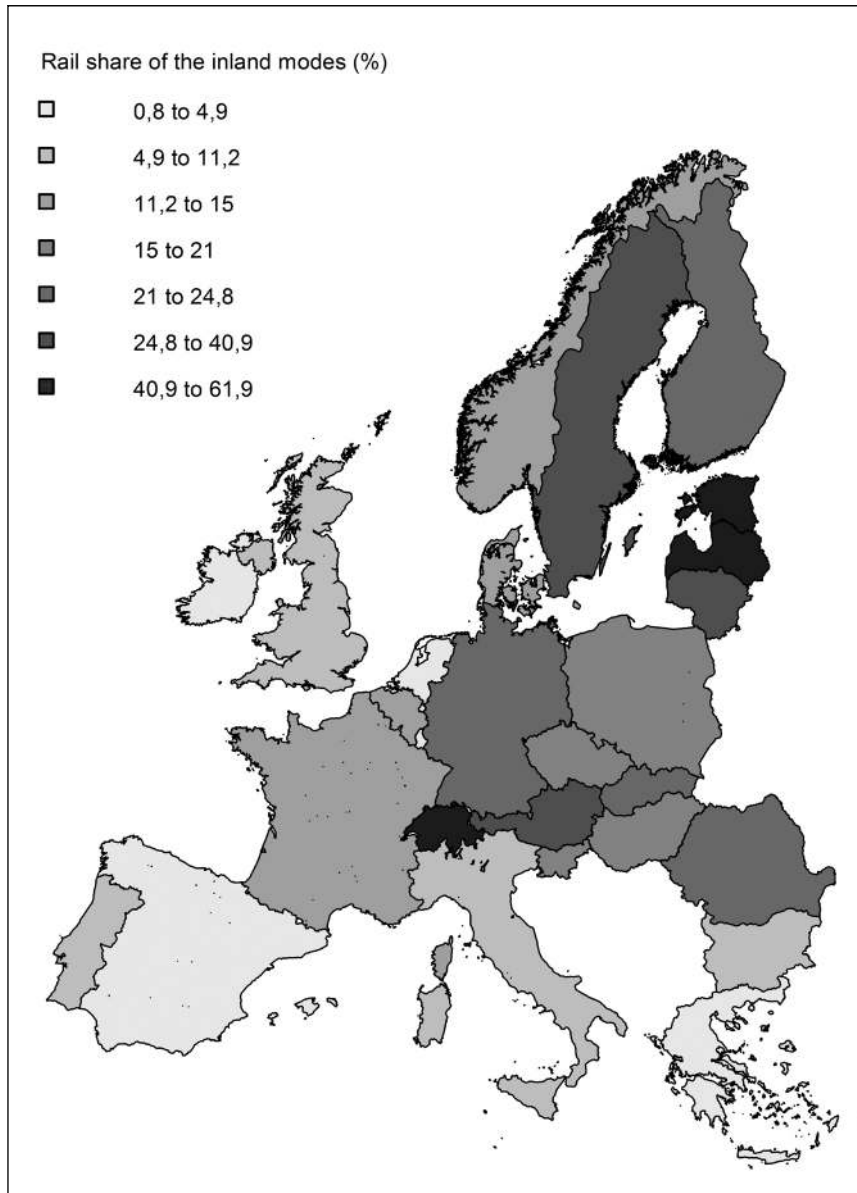
The first railway package in 2001, the second package in 2004, and the third in 2007 all introduced legislation in order to further pursue the original goal of a single and open market. For freight services, the second railway package introduced full open access in 2007. This was applied in all EU countries except Ireland, but the removal of barriers to interoperability is still an ongoing process (Zunder, Islam, and Marinov 2010). The European Commission 4th Railway package draft proposal of December 2012 aimed at the complete separation between infrastructure and operations, no longer allowing for a holding model (e.g., Deutsche Bahn). This was dropped in the final proposal due to intense lobbying by Germany (Berkeley 2013).

The results of these reforms are far from what was achieved in the U.S. It is recognized in European Commission (2010) that, at best, there was a stabilization of rail modal share and that de

facto monopolies still exist in most EU countries. As was previously mentioned, the financial results of most rail undertakings are precarious.

Posner (2007) argues that “in North America there is competition as a result of deregulation, whereas in Europe, you are trying to force competition through regulation.(...)It is an institutional fundamental of the European environment, and I think it is the single biggest problem.(...)In Europe, in my opinion, the focus has been more on having competition even before considering service or capacity, so the priorities have been reversed and I think that explains much of the results.”

Figure 4: Rail Share of Inland Modes, 2010 (% based on tkm)



Source: Eurostat

The assumptions made in Europe regarding the positive effects of introducing intra-rail competition on the same network/lines and implementing a market structure that completely separates operations and infrastructure are disputable (Cantos 2001, Growitsch and Wetzel 2009, Ivaldi and McCullough 2008, FriebeI, Ivaldi and Vibes 2010, Asmild et al. 2009, Merkert, Smith and Nash 2010, Bitzan 2003). As stated in Association of American Railroads (2011a), “open access would make it more difficult to operate a railroad efficiently and profitably due to government interference and a lack of coordination between infrastructure investment decisions and operational goals.”

It is also challenging under an “open access” model to capture private investment for infrastructure management. The UK experience with Railtrack had to be reverted because access charges could not finance a privately owned company (Jupe 2009). In Estonia, the vertically integrated railways were privatized in 2001, but in 2007 they were renationalized because regulation made private management unfeasible (Posner 2007). The only significant privately owned rail infrastructure in Europe is the Eurotunnel.

Still, the ongoing reforms seem to be delivering some positive results (FriebeI, Ivaldi, and Vibes 2010, Growitsch and Wetzel 2009), including vertical separation (Cantos, Manuel Pasto, and Serrano 2010, Asmild et al. 2009). But many of the studies do not take into account external factors that greatly influence freight railways’ productivity, e.g., in the United Kingdom, coal production decreased and imports increased, so the tkm of coal moved by rail greatly increased (Posner 2008). External factors like these vary widely across Europe, as do the ways the reforms were implemented (IBM Business Consulting Services 2006). The networks and railways themselves are very distinct, including their modal share (Figure 4). Finding causal relationships between each component of the reform and its effects on productivity (either positive or negative) across Europe is problematic.

The situation in Eastern Europe and Scandinavia is examined by Ludvigsen and Osland (2009). In Norway, the reforms were an opportunity for wider changes in the existing system, namely, in the services provided. The main railway operator (the incumbent) focused on the most profitable services (combined/intermodal), while new entrants (including incumbents from other countries) picked up some of the abandoned markets (carload). This situation has some similarities with what happened in the U.S. between Class I railroads and Short Lines. In Norway, there was some recovery of rail modal share and the financial situation of the railways improved, although it is not yet stable.

In Eastern Europe, new entrants competed directly with the incumbents for the same services (namely, the more profitable unit/block trains) and gained a sizable market share (40% in Romania and, above 20% in Poland, according to European Commission 2009a), but rail modal share continued to decrease.

The article by Santos, Furtado, and Marques (2010) about the effects of regulatory changes in Portugal, illustrates the complexity of actually implementing reforms beyond legislative compliance. The negative (in the case of the infrastructure manager), or anaemic (in the case of the operator), evolution of productivity during the period studied, in a country where the reforms “seemed to be appropriate and ambitious, at least when compared with those that occurred in other EU countries, like in France, where the regulator is not separate from the government, or in Germany, where there is vertical integration,” should lead to the question: Are there other factors more relevant to productivity increase than regulatory changes per se? The Portuguese freight operator average net ton per train is 60% of the European average (see Figure 2). This greatly explains the high expenses per ton-mile (see Figure 3). Without significantly decreasing this number there is little hope of obtaining increments in productivity and a financially stable situation. The regulation adopted should help solve this problem, or at least it should not be an obstacle. But it cannot, by itself, solve the problem.

The same can be argued for the increase of rail’s modal share. There is evidence of structural inelasticity of modal substitution in freight transport. Rich, Kveiborg, and Hansen (2011) examined the Scandinavian case (where rail has a higher share than the EU27 average). For many commodities

and Origin – Destination pairs, modal substitution from truck to rail does not occur even if rail prices decrease and service level increases. The main reason is the sparsity of the rail network when compared with the road network. A reduction of this inelasticity and correspondent increase in demand is only possible if there are improvements (or extensions) of the rail infrastructure/network.

In the U.S., the legislative reforms gave railways a free hand so that they could adapt their services and network to the market. But these reforms were not confined to deregulation (Staggers Act). They were part of a wider set of changes: some services were abandoned; some routes were consolidated; charges were lowered or increased depending on existing competition and cost coverage; investments were focused on productivity enhancements like longer and heavier trains or double stacking, especially on high density lines where demand justifies it. At the same time there were mergers between the bigger companies, which likely allowed gains from economies of scale and gave the railroads networks that are closer to the size of their markets (Martland 2012, Furtado 2012). Still, it is hard to quantify the exact impact of mergers and if those impacts were all positive (Velluro et al. 1992). Specialized non-Class I railroads took over several lower density lines abandoned by the Class I and “maneuver intensive” sites such as ports or other large industrial sidings. Coal production increased in the Powder River Basin (whereas, before it was mostly concentrated in the Appalachian Region), increasing the distance of coal shipments from production to consumption centers and the corresponding length of haul for rail (Association of American Railroads 2011b). Technological breakthroughs in other fields, like advances in communications and information technologies, allowed increases in labor productivity (Martland 2012).

All the above are examples of developments, some more related to regulation changes than others, that played a role in transforming the industry. From a situation of crisis, which the “Northeast rail crisis” of the early 1970s is the most acute example, the railroads recovered and have stable financial results.⁶ The critical contribution of regulation reform to the sector revival was that it increased the control railroads have over their own networks and services provided.

In Europe, the regulation introduced did the opposite, control over the rail systems was divided. In each European country there are different nuances on how this was implemented (European Commission 2009b), but the trend to split control over the system between different entities is common. Like in the U.S., changes were necessary in order to revive the sector. The previous model of state-owned monopolies closely linked to the government needed to be reformed. The shock provoked by the introduction of competitive pressure and the dismantling (or reorganization) of the previous monopolies seems to have produced some positive results, but they are far from uniform across the EU27. Contrary to the U.S., a clear revival of the sector did not occur after the reforms were set in motion. It should be noted that full open access for freight was implemented only in 2007 and soon after there was a world crisis that caused a sharp fall in freight movements.

CONCLUSIONS AND FURTHER RESEARCH

U.S. railways have around 35% of the modal share measured in tkm. In Europe the number is close to 10%. Structural differences can explain nearly all that gap, about 98% according to the methodology employed. Competitiveness of non-surface modes accounts for around 26% of that difference, underlying the importance of the sea mode in Europe. Shipment distances for surface modes is responsible for almost half the gap (46%); the much longer shipment distances in the U.S. play a crucial role. The difference in the commodity mix corresponds to 26% of the gap. This gives a measure of the impact of the much higher proportion of coal moved in the U.S. by surface modes. Given these inherent differences, the modal share gap between the U.S. and Europe is very small. So, it is not reasonable to expect that railways in the EU27 should have a similar modal share to the U.S., even less to set this as a policy target.

To move the same number of tons, seven times more trains are necessary in Europe. The average net tons per train in Europe is 86% less than in the U.S. In addition, this disparity is much less

constrained by structural factors. This is an important reason why the U.S. railways have a stable financial situation, while the same is not true in Europe. Costs per ton-mile in Europe are four times higher than in the U.S., while revenues are only two times higher. The revival of U.S. railways was greatly due to an increase in productivity, for which a reduction in costs was crucial.

A key component for a revival of European freight railways has to be a reduction of operational costs, of which an increase in the net tons per train, by increasing their length/weight, is an important component. An important question for future research is to what extent, given the existing market and its medium-term evolution, the investments required to enhance productivity can be covered by the productivity gains, i.e., the reduction in operational costs. This question can be further detailed: given an investment plan and set of actions geared to enhance productivity, could the freight railways be financially sustainable? Or what would be the share of public funding needed? To what extent could the freight operator cover the infrastructure investment costs required for its own sustainability? To answer this, a more in-depth analysis of a case study is required. Portugal, where the average net tons per train is 60% below even the European average, is a case where productivity enhancements are even more necessary than in other EU27 member states.

Changes in legislation and regulation impact productivity, only to the extent that they can actually induce pressure that results in technical, operational, or service changes that increase the outputs/inputs ratios, including the financial ones. The European “open access” model faces some questions for which there are no conclusive answers yet. To what extent can an alignment in operational needs and infrastructure investment be achieved? How will the returns of such investments be shared by the different agents? How can there be private financing of infrastructure, when there is no control over the charges and services there provided? The changes introduced in the U.S. from 1970 to 1980 seem to have delivered more than the European reform process started in 1991, and that culminated in 2007 with full open access for freight services. But other factors, besides these reforms, influenced both the U.S. revival and the anaemic European results.

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Endnotes

1. Requires that all goods transported by water between U.S. ports be carried in U.S. flag ships, constructed in the United States, owned by U.S. citizens, and crewed by U.S. citizens or U.S. permanent residents.
2. The number of significant figures used in the table was the same as Vassalos and Fagan (2007) in order to present a consistent comparison. These numbers do provide an order of magnitude of the effects studied, but it should be taken into account that they are strongly dependent on the assumptions made and on the accuracy of the data employed (some of which are also obtained through estimation).

3. These numbers are averages and common statistical indicators for freight railroads' performance. Length of haul is the ratio between total ton-miles and total tons moved (ton-miles/tons). Net tons is the ratio between total ton-miles and total train-tons (ton-miles/train-miles). The number of trains presented in the table was obtained by dividing the total tons (B in the table) by the net tons (A in the table). So the number of trains presented is a reasonable estimation, but not the actual number of trains.
4. Contrary to Europe, in the U.S., there is no maximum train length imposed by regulation. Still, trains are generally no more than three km long. In Europe, some bulk trains in Eastern and Scandinavian countries are longer than 750 meters, but even there they are the exception.
5. Besides the difference in length, with intermodal trains in the U.S. ranging mostly from around 1.2 to 2.4 km (in Europe they are from 0.5 to 0.75 km), in the U.S. along many routes, double stacking was made possible by upgrades to the infrastructure and rolling stock.
6. Although railways can finance maintenance, renewals and some new projects, major new investments require some degree of public funding. In Cambridge Systematics (2007) and Association of American Railroads (2007), it is estimated that around 30% of the capital investment necessary to increase the network capacity will have to come from some sort of government financing. It is argued that this is necessary in the long term (having 2035 as a horizon) to relieve congestion in the main rail corridors, due to an increase in demand. Another issue would be to have public policy explicitly designed to move freight from trucks to rail. This was not the case in the U.S. Such policies may even require railroads to focus less on productivity. Indeed much of the short-haul and general merchandise traffic was abandoned by the railways, which concentrated resources in more productive long-haul bulk and container traffic.

References

Asmild, Mette, Torben Holvad, Jens Leth Hougaard, and Dorte Kronborg. "Railway Reforms: Do they Influence Operating Efficiency?" *Transportation* 36 (5), (2009): 617-638.

Association of American Railroads. *America's Freight Railroads: Global Leaders*. AAR, 2011a.

Association of American Railroads. *Railroads and Coal*. Association of American Railroads, 2011b.

Association of American Railroads. *A Short History of U.S. Freight Railroads*. Association of American Railroads, 2012.

Berkeley, Tony. "Germany Rewrites the Fourth Railway Package." *International Railway Journal*. accessed 02/07, 2013, http://www.railjournal.com/index.php/blogs/tony-berkeley/germany-rewrites-the-fourth-railway-package.html?channel=&utm_source=WhatCounts+Publicaster+Edition&utm_medium=email&utm_campaign=U.S.+HSR+spurs+supply+industry%3b+transportation+committee+looks+at+federal+role+in+infrastructure&utm_content=Full+Blog.

Bitzan, John D. "Railroad Costs and Competition: The Implications of Introducing Competition to Railroad Networks." *Journal of Transport Economics and Policy* 37(2), (2003): 201.

Cambridge Systematics. and Association of American Railroads. *National Rail Freight Infrastructure Capacity and Investment Study*. Cambridge, Mass.: Cambridge Systematics, 2007.

Cantos, Pedro. "Vertical Relationships for the European Railway Industry." *Transport Policy* 8(2), (2001): 77-83.

Cantos, Pedro, Jose Manuel Pastor, and Lorenzo Serrano. "Vertical and Horizontal Separation in the European Railway Sector and its Effects on Productivity." *Journal of Transport Economics and Policy* 44, (2010): 139-160.

CIA World Factbook. *Coastline*, 2012. <https://www.cia.gov/library/publications/the-world-factbook/fields/2060.html>.

Council Directive of 29 July 1991 on the Development of the Community's Railways (91/440/EEC), 1991.

CP Carga. *Relatorio e Contas*, 2010. <http://www.cpcarga.pt/index.php/pt/empresa/inf-financ/relatorios-e-contas>.

Dennis, Scott M. "Improved Estimates of Ton-Miles." *Journal of Transportation and Statistics* 8(1), (2005): 23-36.

Deutsche Bahn AG. *Annual Report*, 2010. http://www.deutschebahn.com/en/investor_relations/gb_online.html.

Drew, Jeremy. "Regulation of Freight Railways in North America and Europe." *Rail: Proceedings of Seminar Held at the European Transport Conference*. 1999.

European Commission. *Commission Staff Working Document Accompanying Document to the Report from the Commission to the Council and the European Parliament on Monitoring Development Of The Rail Market {COM(2009)676 final/2}*. Brussels, 2009a.

European Commission. *Communication From the Commission Concerning the Development of a Single European Railway Area*. Brussels, 2010.

European Commission. *Communication From the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on "The Fourth Railway Package – Completing the Single European Railway Area to Foster European Competitiveness and Growth."* Brussels, 2013

European Commission. *European Transport Policy for 2010: Time to Decide*, 2001.

European Commission. *Report From The Commission to the Council and the European Parliament Second Report on Monitoring Development of the Rail Market {SEC(2009)1687/2}*. Brussels, 2009b.

European Commission. *Communication From the Commission Concerning the Development of a Single European Railway Area*. Brussels, 2010.

European Commission. *EU Transport in Figures – Statistical Pocketbook 2012*. Luxembourg, 2012.

Eurostat. *Transport Statistics*. <http://epp.eurostat.ec.europa.eu/portal/page/portal/transport/introduction>.

Eurostat. "Rail Passenger and Goods Transport - stat/07/14." *News release*, 2007.

Friebel, Guido, Marc Ivaldi, and Catherine Vibes. "Railway (De)Regulation: A European Efficiency Comparison." *Economica* 77 (305), (2010): 77-91.

Furtado, Francisco. "Visits and Interviews - Freight Railways Operations, Network and Other Issues." Report on visits and collection of interview notes, Work document - Instituto Superior Técnico/Massachusetts Institute of technology (unpublished), 2012.

Governo Federal Brasil. *Programa de Investimentos em Logística: Rodovias e Ferrovias*. 2012.

Growitsch, Christian and Heike Wetzel. "Testing for Economies of Scope in European Railways an Efficiency Analysis." *Journal of Transport Economics and Policy* 43, (2009): 1-24.

IBM Business Consulting Services. *Rail Regulation in Europe. Comparison of the Status Quo of the Regulation of Rail Network Access in the EU-25 Countries, Switzerland, and Norway*. Deutsche Bahn AG, Zurich, 2006.

Ivaldi, Marc and Gerard Mccullough. "Subadditivity Tests for Network Separation with an Application to U.S. Railroads." *Review of Network Economics* 7 (1), (2008): 159-171.

Jupe, Robert. "A "Fresh Start" or the "Worst of All Worlds"? A Critical Financial Analysis of the Performance and Regulation of Network Rail in Britain's Privatised Railway System." *Critical Perspectives on Accounting* 20(2), (2009): 175-204.

Kriem, Youssef. "Productivity of the U.S. Freight Rail Industry: A Review of the Past and Prospects for the Future." M. Eng., Massachusetts Institute of Technology, Dept. of Civil and Environmental Engineering, 2011.

Ludvigsen, Johanna and Oddgeir Osland. "Liberalisation of Rail Freight Markets in the Old and New EU-Member States." *European Journal of Transport and Infrastructure Research* 9 (1), (2009): 31-45.

Martland, Carl D. "Productivity Improvements in the U.S. Rail Freight Industry 1980-2010." *Journal of the Transportation Research Forum* 51(3), (2012): 83-108.

Merkert, Rico, Andrew S. J. Smith, and Chris A. Nash. "Benchmarking of Train Operating Firms - a Transaction Cost Efficiency Analysis." *Transportation Planning & Technology* 33 (1), (2010): 35-53.

Owens, Travis, Dan Seedah, and Robert Harrison. "Modeling Rail Operating Costs for Multimodal Corridor Planning." Washington, D.C., 2013.

Posner, Henry, III. *Rail Freight in the USA: Lessons for Continental Europe*. Community of European Railway and Infrastructure Companies (CER), 2008.

Posner, Henry, III. *Why Europe is Very Different from North America*. Eurail Freight 2007 ed. Community of European Railway and Infrastructure Companies (CER), Brussels, 2007.

Pouryousef, Hamed, Pasi Lautala, and Thomas White. "Review of Capacity Measurement Methodologies: Similarities and Differences in U.S. and European Railroads." *2013 Annual Meeting of the Transportation Research Board* Washington, D.C., 2013.

Rich, J., O. Kveiborg, and C. O. Hansen. "On Structural Inelasticity of Modal Substitution in Freight Transport." *Journal of Transport Geography* 19(1), (2011): 134-146.

Rodrigue, Jean-Paul and Theo Notteboom. "Comparative North American and European Gateway Logistics: The Regionalism of Freight Distribution." *Journal of Transport Geography* 18(4), (2010): 497-507.

- Santos, J., A. Furtado, and R. C. Marques. "Reform and Regulation of the Portuguese Rail Sector. What Has Failed?" *Utilities Policy* 18(2), (2010): 94-102.
- Shi, Feli X., Siew Hoon Lim, and Junwook Chi. "Railroad Productivity Analysis: Case of the American Class I Railroads." *International Journal of Productivity and Performance Management* 60(4), (2011): 372.
- Surface Transportation Board. *Ep 711 Petition For Rulemaking To Adopt Revised Competitive Switching Rules*, 2012.
- Surface Transportation Board. *Class I Railroads Annual Report Financial Data*, 2010. <http://www.stb.dot.gov/econdata.nsf/FinancialData?OpenView>.
- Tavasszy, Lóránt A. and Jaco van Meijeren. "Modal Shift Target for Freight Transport Above 300km: An Assessment." Brussels, Belgium, 2011.
- U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS). *Freight Shipments in America, Preliminary Highlights from the 2002 Commodity Flow Survey Plus Additional Data* DOT - BTS, 2004.
- U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS). *National Transportation Statistics*. http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/national_transportation_statistics/index.html.
- U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS). *2007 Commodity Flow Survey* DOT - BTS, 2010.
- Vassallo, Jose Manuel and Mark Fagan. "Nature Or Nurture: Why do Railroads Carry Greater Freight Share in the United States Than in Europe?" *Transportation* 34(2), (2007): 177.
- Velluro, Christopher A. et al. "Deregulation, Mergers, and Cost Savings in Class I U.S. Railroads, 1974-86." *Journal of Economics and Management Strategy* 1(2), (1992): 339-369.
- Weiss, Martin H. *How Many Interstate Programs Were There?* U.S. Department of Transportation, Federal Highway Administration, 2008.
- Wilson, W. W. "Cost Savings and Productivity in the Railroad Industry." *Journal of Regulatory Economics* 11(1), (1997): 21-40.
- Wright, Robert. "Rail: Europe Fails to Follow U.S. Route." *FT.Com* (Sep 19, 2011).
- Zunder, T., D. Islam, and M. Marinov. "Key Issues For Pan-European Rail Freight Services." *Transport Problems* 5(3), (2010): 33.

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