Chapter 5

QUANTIFYING THE BENEFITS FROM STRUCTURAL REFORMS IN RAILWAY TRANSPORT MARKETS IN APEC ECONOMIES

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- Productivity has increased in a sample of rail systems among APEC economies: the average rate of productivity change for APEC rail systems rose by 3.5% per year
- However productivity growth in non-APEC economies productivity rose by 4.8% per year, indicating the scope for further gain in the APEC group.
- Nearly all the productivity growth in rail in APEC economies is associated with technical change and not with changes in efficiency.

5.1 INTRODUCTION

During the past 50 years the most common market structure in many economies' rail sectors was a single, publicly-owned firm entrusted with the unified management of both infrastructure and services. Despite some differences in their degree of commercial autonomy, the traditional methods of regulation and control of this sort of company have been relatively homogeneous. In general, it was assumed that the monopoly power of the national company required price and service regulation to protect the general interest. In addition, there was an obligation, often referred to as 'common carrier' status, on the part of the companies to meet any demand at those prices. The closure of existing lines or the opening of new services required government approval. Thus, competition was rare and often discouraged, and the preservation of the national character of the industry was considered the key factor governing the overall regulatory system.

Under this protective environment, most national rail companies incurred growing financial deficits during the 1970s and 1980s. Furthermore, social obligations to their staff made it nearly impossible to reach any agreement on redundancies or even wage adjustments. In some economies the companies were forced to finance their deficits by borrowing, so their accounts lost all resemblance to reality. The main problems associated with the traditional policies for railways were increasing losses, which were usually financed by public subsidies, a high degree of managerial inefficiency and business activities oriented exclusively toward production targets rather than commercial and market targets.

These distortions did not come from any artificial reduction in the range of services provided or from excessively high fares but, more commonly, from an unjustified increase in the supply of services (and where costs exceeded revenues). Such behaviour implied larger public subsidies. In many cases, the lack of commercially oriented tariffs and investment policies explained many of the difficulties faced by the companies. Together with the burden imposed by the

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technical characteristics of the sector, this placed most railways in a very weak position to compete against alternative transport modes. However, fierce intermodal competition alone was not able to improve the competitiveness of the railway system, it was necessary to adopt measures affecting the internal behaviour and structure of the sector itself. Therefore, the sector's overall decline sparked a widespread, restructuring movement around the world.

The worldwide restructuring process of the rail industry began with timid reforms. Many economies began by replacing their railways with autonomous commercial bodies possessing independent, realistic balance sheets, in which only public service obligations could be explicitly subsidised by the government. Other economies opted to substitute their old geographically based management with a multi-divisional structure, defined by the companies' different lines of business or services.

Some economies have carried out relatively long-term restructuring whereas others have preferred a quicker implementation. For example, privatisation in New Zealand and Japan was phased in over several years, while in Argentina and the United Kingdom it took less than 2 years. Yet a common characteristic is that all restructuring processes were undertaken to make the companies attractive to private investors, although full privatisation has been less preferred than concessioning.

The changes have involved the revision of laws and other regulations affecting railways: reducing staff, dealing with pension issues and deciding how much property should be sold and how much should be retained by the government. In addition, several arrangements for paying for unprofitable (but socially needed) train services were put into place, together with a precise definition of the concession contracts and their main terms.

With regard to results, in general most of the restructuring experiences detailed below seem to have been positive. The objectives of stopping the industry's drain on public sector resources, along with the stabilisation of market share for both passengers and freight, were achieved in most economies. Likewise, the companies succeeded in raising their levels of productivity.

The objective of this paper is to assess the effectiveness of the main restructuring measures in the world rail sector, with special emphasis in the assessment of the national rail networks of the Asia-Pacific Economic Cooperation (APEC) economies. The study is based on a sample of European and APEC economies with data for the period from 2001 to 2008, and uses non-parametric techniques (DEA and the Malmquist productivity index) to calculate indexes of productivity growth, while also disaggregating their various components. This latter aspect is important, as we aim to determine the impact of changes in the sector, not only in efficiency but also in the overall evolution of productivity and its components (technical change and changes in efficiency).

The results of the work show that, on average, productivity, efficiency and technical changes are slightly lower for APEC members' rail systems than for other national rail systems. In particular, the average rate of productivity change for APEC rail systems rose by 3.5% per year, while for non-APEC economies it rose by 4.8%. We also find that the productivity improvements are mainly explained by the technical change, while changes in efficiency are less relevant. In particular, for APEC member economies our results show that no rail system, except Viet Nam, improved its efficiency. Finally, APEC member economies improved, on average, their rate of technical change by 3.2% while non-APEC economies improved by 3.7%.

The paper is structured as follows: Section 5.2 briefly describes the restructuring measures for the world rail industry; Section 5.3 provides a short review of the literature; Section 5.4 presents the methodology, the data used in the study and estimations of productivity growth and its components; and Section 5.5 presents the main conclusions.

5.2 RESTRUCTURING MEASURES FOR THE RAIL INDUSTRY

Despite all these changes, the most salient characteristic of the restructuring process of the rail industry in the last decades has been the consolidation of different and alternative organisational structures for the industry as a whole. These structures differ in three main features to be analysed in detail: how access and infrastructure and multimodal competition are considered; what extent of vertical separation is introduced after the change; and what degree of competition (and private participation) is allowed in the industry after the reform.

The next subsections are devoted to describing the main restructuring measures undertaken in the vertical and horizontal dimensions.

5.2.1 The degree of vertical separation

The management of rail infrastructure not only includes simple pricing principles, it also encompasses access rights and long-term development provisions. Each economy addresses these matters differently: while most have opted to retain infrastructure in public hands, creating government management agencies to regulate private train operators, others have established nominally independent (actual control from political independence varies) but government-owned enterprises to manage stations and tracks.

One of the most clearly defined patterns emerging from deregulation and restructuring is that they carry out two critical dimensions: the degree of vertical separation between infrastructure and services and the promotion of competition within the sector. With respect to the first dimension, there are three main options for the vertical organisation of the railway industry: vertical integration, competitive access and vertical separation.

The first option of vertical integration corresponds to the traditional, historical model of railway organisation described above, where a single (usually public) entity controls all the infrastructure facilities as well as the operating and administrative functions. Less frequent competitive access is characterised by the existence of an integrated operator, who is required to make rail facilities (tracks, stations etc.) available to other operators on a fair and equal basis through the trading of, for example, circulation rights. This has the advantage of integration (economies of scope, coordinated planning and reduction of transaction costs) but its overall effectiveness may be jeopardised if the integrated company has incentives to leave out other operators.

Alternatively, in the complete vertical separation scenario, the management (and possibly the ownership) of facilities is fully separated from other rail functions. This is very attractive because, although infrastructure may remain a natural monopoly, it is separated from rail services, where potential competition among different operators is possible. In general, the main advantage of this vertical unbundling is that rail transport is placed in a similar situation to road transport, especially regarding the tariff system and infrastructure planning. Investment proposals could be studied on the basis of a cost-benefit analysis, while pricing policies could be based on social cost. In addition, separating infrastructure from services greatly facilitates the entry of more than one operator in a single route. For profitable services this would permit notable improvements in efficiency by allowing direct competition among operators. For non-profitable services, infrastructure separation can be accompanied by tendering to stimulate increased efficiency through competition for the market, the introduction of innovations and marketing improvements.

However, the vertical unbundling of the rail industry also implies several disadvantages. The main problem is the potential loss of economies of scope derived from the joint operation of tracks and services. It is often noted that the relationship between the services supplied and the rolling stock used, as well as the quality, quantity and technical characteristics of the infrastructure, is so close that both aspects need to be planned together. Thus, assigning different services to several operators may decrease the utilisation of the sector's staff and physical assets. Also, the new system may become less attractive to the user than an integrated system because of the lack of interchangeable ticketing, the absence of an integrated national network and the high risk. Vertical separation may also require such a complex institutional arrangement that the resulting transaction costs may be prohibitive for many economies. A final consideration with vertical separation is the reduction of investment incentives. For example, an infrastructure owner considering an investment in a facility with only one potential buyer will anticipate bargaining away some of the benefit from the new service once it comes on line. This problem becomes less relevant with more competition in the market, since competition weakens the bargaining position of individual operators by reducing the specificity of the assets.

5.2.2 Promotion of competition (horizontal dimension)

Reforms to the horizontal dimension have been very different all over the world. Horizontal level reforms in Europe have been very moderate and have consisted mainly of new operators entering the freight sector and of a franchising system in passenger services. In contrast, there are many instances across the world where some of these measures have been undertaken.

Although it is accepted that infrastructure (characterised by its high levels of sunk costs) may be managed under monopoly conditions, competition can be introduced into operations in two different ways. The first option consists of directly facilitating the free entry of new companies into the railway network. This can be done in either passenger transport or freight transport sectors, but, it has been much more usual in the latter.

The alternative is to foster competition for the market by means of a franchising or concessions system in which the franchised companies compete for the right to use the infrastructure during a certain period of time, which is in all cases notably shorter than the infrastructure concession period. This second option has proved to be very attractive in the European context, in which many railway services are heavily subsidised.

However, this new structure can also have serious drawbacks. As Nash and Rivera-Trujillo (2004) point out, the entry of various companies using the same infrastructure leads to obvious problems in a schedule design that must efficiently assign slots among companies and operations and at the same time satisfy all of them. These problems significantly affect service quality, since coordination is lost as a result of the separate management of infrastructure and operations.

Table 5.1 summarises the features of the APEC rail networks. We observe that China; Malaysia; the Philippines; Chinese Taipei; and Viet Nam maintain a vertically integrated structure without introducing horizontal reforms. Canada; Japan; and the USA maintain a vertically integrated industry but allow the entry of new rail operators, and the rest of the rail systems have fully separated the infrastructure and the rail operations. Finally, some economies like Chile; Mexico; Peru; and Russia have introduced franchising systems and free open systems in their rail networks, while Canada; Japan; and the USA have only reformed the sector at horizontal level by allowing the free entry of new operators.

Table 5.1: The main features of APEC members' rail networks.

	Vertical dimension			Horizontal dimension	
APEC member	**Integrated monopoly**	**Competitive access**	**Vertical unbundling**	**Franchising system**	**Entry new operators**
Canada		✓			✓
Chile			✓	✓	✓
China	✓				
Indonesia			✓		
Japan		✓			✓
Korea			✓		
Malaysia	✓				
Mexico			✓	✓	✓
Peru			✓	✓	✓
Philippines	✓				
Russia			✓[1]	✓[2]	✓[1]
Chinese Taipei	✓				
Thailand	✓				
USA		✓			✓
Viet Nam	✓				

Note: [1] Implemented in 2003; [2] Implemented in 2006

5.3 LITERATURE REVIEW

There are many studies in the literature analysing productivity and efficiency in the railway sector. However, most of the vertical, and particularly horizontal, separation processes have taken place in recent years, and as a result there is very little conclusive empirical evidence on the effects of these processes on productivity and efficiency. Furthermore, most of the studies are focused on analysis in the European rail network; there are few studies devoted to other, and different, experiences.

In general terms, the first studies in this field (see Gathon & Perelman 1992; Oum & Yu 1994; Gathon & Pestieau 1995) indicated that the economies with the most liberalised railway sectors were the most efficient. An excellent survey can be found in Oum et al. (1999) covering many of the results obtained in the previous literature.

Likewise, more recent studies have obtained similar results. Cantos et al. (1999; 2010) also conclude that rail operators with a higher degree of autonomy and independence are the most efficient, are more technologically advanced and achieve higher gains in productivity. Similarly, Cantos and Maudos (2001) estimate efficiency in costs and revenue, and show that companies need to move towards more commercial policies that also encourage their competitiveness.

Friebel et al. (2005) carried out an initial analysis of some of the restructuring measures in the sector for the 1995–2000 period, focusing on measures designed to separate the industry vertically. Their results suggest that, in general, the reforms have furthered more efficient behaviour; however, these reforms must be carried out sequentially if they are to be effective. In addition, Driessen et al. (2006) study the efficiency of a sample of European companies for the period 1990–2001. These authors do not come to a decisive conclusion on the impact of vertical separation of infrastructure and operations. They find that vertical separation does not seem to be necessary to achieve an increase in productive efficiency, although tendering processes do appear to favour an increase in efficiency. In all events, these authors recognise certain data definition problems and particularly acknowledge that many of the predicted effects may still not have been in evidence, since the sample period ended in 2001.

Positions supporting disparate opinions on the efficiency of separating infrastructure and operations are therefore not difficult to find. Evans (2003) states that the process leads to gains in efficiency, transparency and greater competition. Other authors such as Pfund (2003) believe, however, that the disadvantages clearly outweigh the benefits of separation. In the same vein, as noted above, the initial empirical studies to approach the subject (Friebel et al. 2005; Driesden et al. 2006) provide no conclusive results.

Very little analysis has been conducted on the changes stemming from the horizontal restructuring of the industry. In particular, Driessen et al. (2006) find that processes of competition for the market (through concessions) encourage efficiency more than processes that foster competition in the market (through free entry), and that greater managerial independence does not encourage greater efficiency. These results contradict those from the previous literature (Gathon & Pestieau 1995; Cantos et al. 1999; Friebel et al. 2005).

Recent works have evaluated some of these reforms, particularly in those economies that have advanced more in these types of measures. Mulder et al. (2005) used an analysis on the basis of cost-benefit techniques in order to evaluate the efficiency of the reforms in the railway industry in the Netherlands. Their results indicate that separating the industry vertically is beneficial when competition is increased in an efficient way in the sector. Furthermore, the authors show that the introduction of competition in the freight sector has increased both efficiency and performance. Passenger transport, however, has had difficulties in realising historical performance levels. Similarly, in the case of the franchising process in passenger services in Sweden, Alexandersson and Hultén (2005) note some significant problems associated with very low bids in tenders, and the very low number of firms that compete in each tender. Some of these problems have also been observed in the Australian experience (Kain 2006).

To sum up, results from the majority of studies indicate that most of the reforms have made railway systems more efficient and productive (Cantos et al. 2010). However, a greater effort is still required in order to delineate the relevance and significance of each measure.

5.4 RESULTS

Before presenting the results, we must stress that the railway systems included in the sample vary significantly in terms of technology and quality of service. The comparison of their efficiency levels can therefore lead to misleading or confusing conclusions. For this reason, we will focus our results on the changes in productivity, efficiency and technical change and compare these changes mainly between the APEC economies and other economies. Our methodology is described in the Appendix.

Figure 5.1 shows the accumulated productivity index since 2001. Table 5.2 shows the productivity change for pairs of consecutive years as well as the average for the whole period. Results show that between 2001 and 2005, productivity growth was similar between APEC member economies and other economies. In 2006 the productivity for the non-APEC railway systems increased at a clearly higher rate than the rate for the APEC economies (12.1% against 0.3%). In the following 2 years productivity increased more for the APEC economies. On average, productivity for APEC economies rose by 3.5% per year, while for non-APEC economies productivity rose by 4.8%.

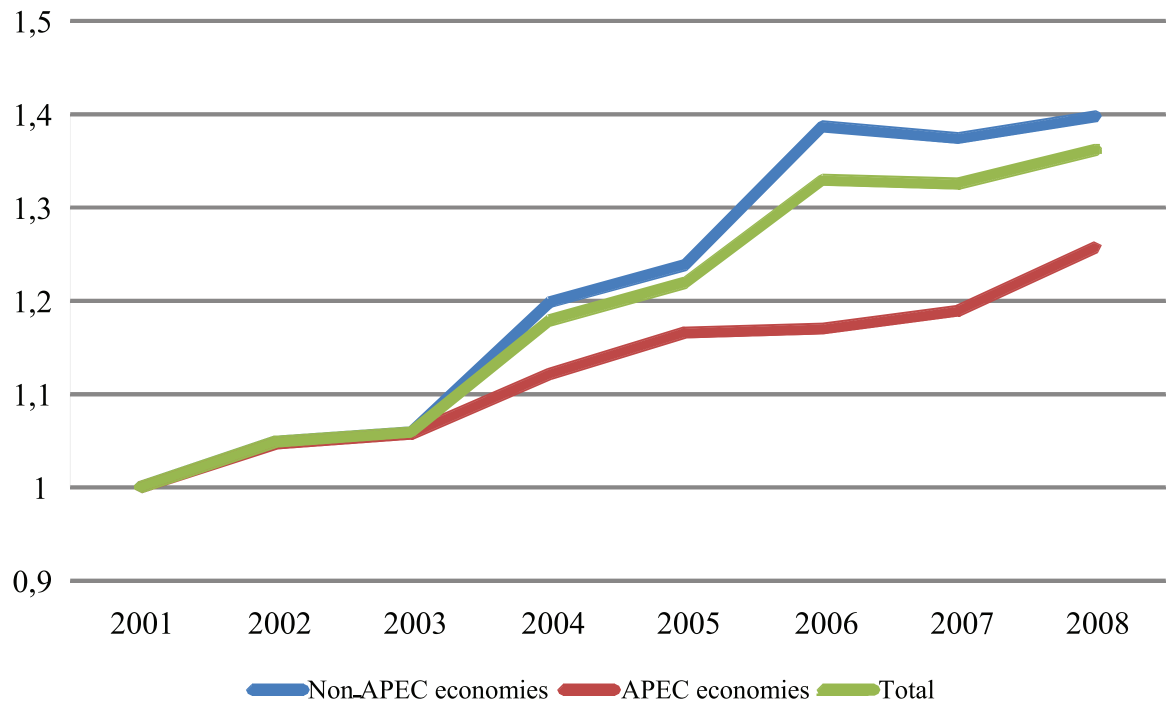

Figure 5.1: Productivity change (2001=1).

We then decompose the productivity change between efficiency changes and technical change in order to analyse the causes of the productivity changes. As we see in Figure 5.2, until 2005 the evolution of efficiency is similar, but in 2005 the efficiency notably improved for non-APEC economies, which partially explains the increase in productivity for these economies. But the efficiency of non-APEC economies decreased in 2007: the rates are again similar between the two groups of economies for the last year of the sample. At aggregate level, there were no significant efficiency improvements for APEC economies, while efficiency improved by 1.4% per year for non-APEC economies.

Regarding technical change, Figure 5.3 shows that the differences are not significant between the two groups of economies. However, from 2005 the technical change improved at a higher rate for non-APEC economies. At aggregate level, technical changes for APEC economies increased by 3.2% per year, while for non-APEC economies productivity increased by 3.7%.

Table 5.2 analyses the annual results per economy for pairs of consecutive years in terms of productivity. The last column expresses the average outcome over the whole sample period per economy.

Regarding productivity change, we can observe that the Russian Federation; Viet Nam; and China have the highest rates, while Chinese Taipei and Korea have the lowest. At aggregate level, APEC economies obtained an average increase of 3.5%, while non-APEC economies obtained an average increase of 4.8%.

Table 5.2: Productivity change.

Economy	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	Average 2001–08
Austria	1,056	1,055	1,042	0,950	1,088	1,006	1,064	1,037
Belgium	1,067	1,006	1,085	1,042	1,116	0,977	0,999	1,042
Bulgaria	0,919	1,095	1,058	1,025	1,000	1,015	0,910	1,003
Czech Republic	0,990	1,016	1,002	0,991	1,138	1,048	0,948	1,019
Denmark	0,808	0,914						0,861
Estonia	1,127	1,031	1,064	1,131	1,066	0,791	0,804	1,002
Finland	1,043	1,071	1,320	0,856	2,417	0,465	1,060	1,176
France	1,070	1,030	0,994	0,666	1,640	1,029	1,087	1,074
Germany	0,992	0,854	1,281	0,923	1,019	1,007	1,004	1,012
Greece	1,099	0,889	1,114	1,162	1,040	1,159	1,086	1,078
Hungary	1,009	1,098	1,118	1,006	1,139	0,966	0,964	1,043
Ireland	1,018	1,007	0,989	1,190	1,057	1,143	1,458	1,123
Italy	1,006	0,961	1,029	0,985	1,014	1,010	0,985	0,999
Latvia	1,122	1,203	0,975	1,132	0,877	0,968	1,059	1,048
Lithuania	1,266	1,194	1,019	1,101	1,041	1,016	0,992	1,090
Luxembourg	0,876	0,981	1,026	0,852	1,117	0,848	0,994	0,956
Netherlands	1,152	1,083						1,118
Norway	0,999	1,225						1,112
Poland	1,010	1,085	1,008	0,958	0,970	1,022	0,958	1,002
Portugal	1,137	1,012	1,074	1,043	1,122	1,049	1,049	1,070
Romania	0,915	1,091	1,052	1,102	0,915	1,046	0,821	0,992
Slovak Republic	0,963	0,971	1,009	0,965	1,065	0,979	1,005	0,994
Slovenia	1,084	1,180	1,056	1,007	0,987	1,047	1,013	1,053
Spain	1,056	1,021	1,010	2,076	1,035	1,010	1,098	1,187
Sweden	1,458	0,291	2,722	0,424	0,896	1,042	1,019	1,122
Switzerland	1,049	0,911	0,948	1,158	1,031	1,131	1,042	1,039
Canada	0,999	1,047	1,088	1,011	1,016	0,979	1,018	1,023
China	1,050	1,022	1,108	1,042	0,931	1,071	1,160	1,055
Japan	1,013	1,055	0,992	1,020	1,023	1,014	1,037	1,022
Korea	0,981	1,019	0,995	0,998	1,006	1,010	1,014	1,003
Russia	1,210	1,099	1,000	1,079	1,037			1,085
Chinese Taipei	0,963	0,903	1,068	1,023	0,984	0,957	0,978	0,982
USA	1,028	1,035	1,050	1,106	1,028	0,994	1,011	1,036
Viet Nam	1,143	0,891	1,179	1,045	1,000	1,102	1,183	1,078
Total	1,049	1,010	1,112	1,034	1,091	0,997	1,027	1,045
APEC members	1,048	1,009	1,060	1,040	1,003	1,018	1,057	1,035
Non-APEC	1,050	1,011	1,130	1,032	1,121	0,990	1,018	1,048

Note: Blank cells correspond to missing data in the sample.

Table 5.3 presents the results for the efficiency change. The results show that China; Japan; Russia; and the USA were efficient during the whole period and thus cannot obtain efficiency changes. In any case, we observe again that, on average, APEC members' rail systems improved their efficiency level only by 0.2%, while non-APEC economies improved the efficiency scores by 1.4%.

Rates of technical change are expressed in Table 5.4. At aggregate level, we can conclude that APEC economies improved their rate of technical change an average of 3.2%, while non-APEC economies improved 3.7%. Distinguishing between economies, Russia obtains the highest score (8.5%), followed by China (5.5%) and the USA (3.6%). The reasons for this increase may be related in a higher investment in the technology of the railway infrastructure and rolling stock systems.

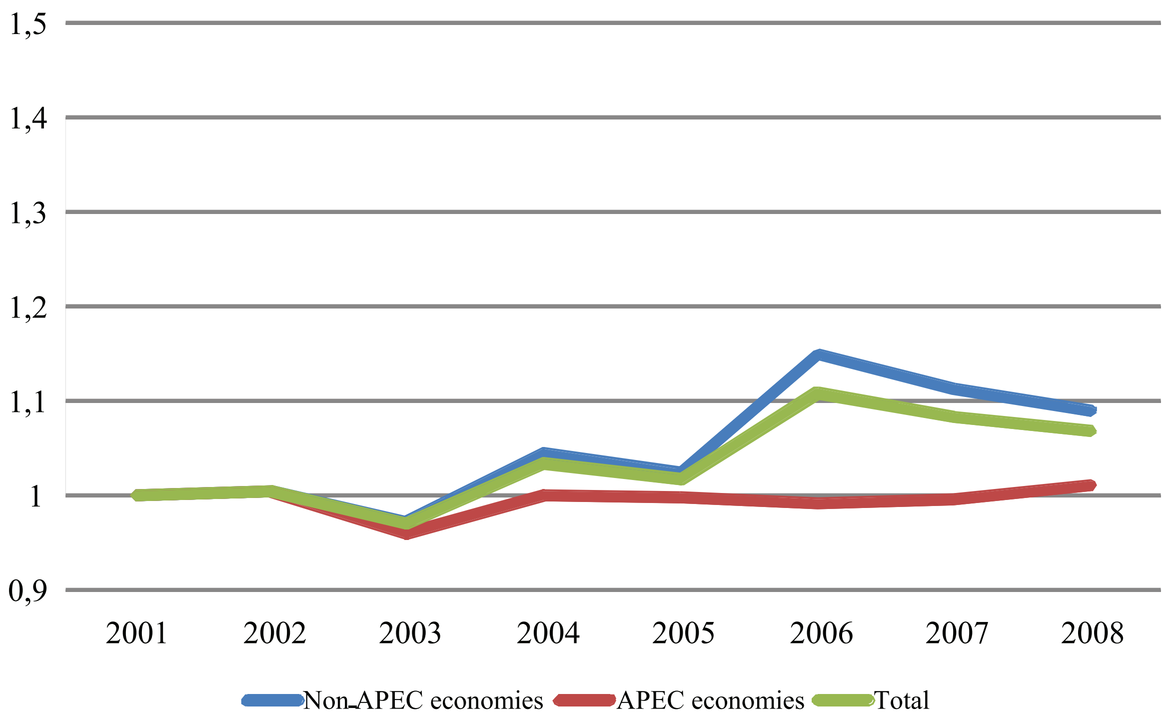

Figure 5.2: Efficiency change (2001=1).

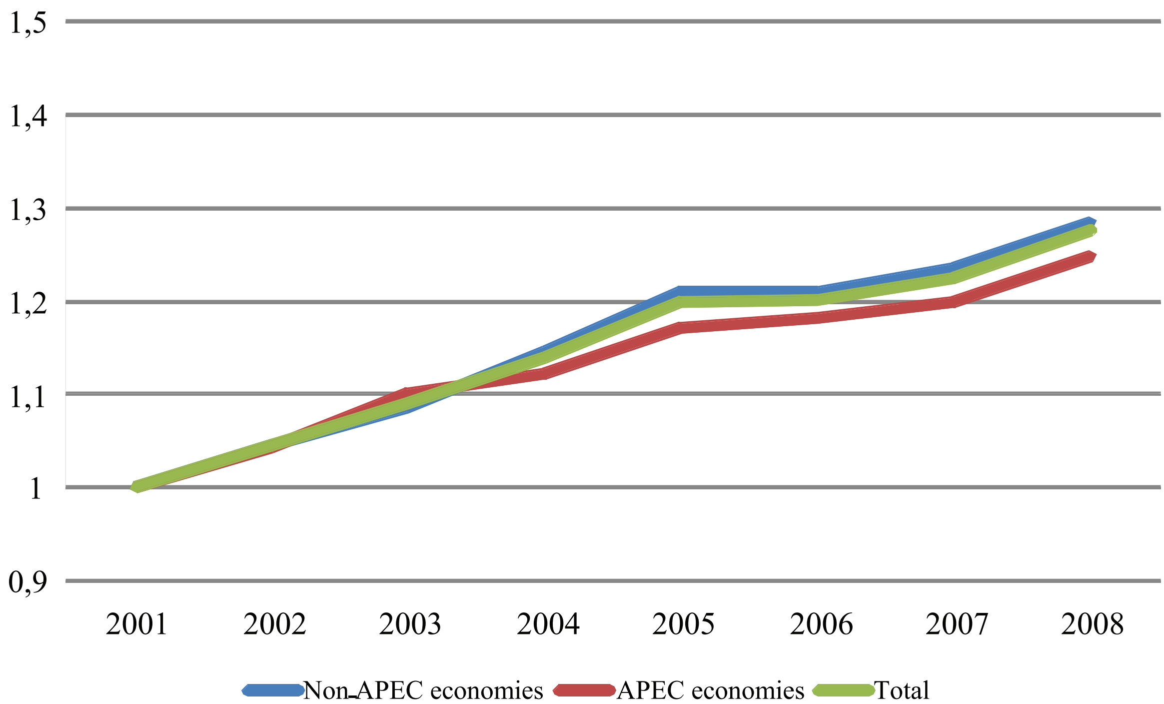

Figure 5.3: Technical change (2001=1).

From these results we conclude that productivity improvements are mainly explained by technical change, while changes in efficiency are less relevant. In particular, for APEC economies our results show that no rail system other than Viet Nam improved its efficiency significantly. Figures 5.4 to 5.6 summarise the results for each APEC member economy.

Table 5.3: Efficiency change.

Economy	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	Average 2001–08
Austria	1,024	1,027	0,987	0,896	1,068	0,974	1,014	0,999
Belgium	1,033	0,948	1,026	1,001	1,197	0,940	0,942	1,012
Bulgaria	0,892	1,043	1,002	0,969	0,967	0,991	0,858	0,960
Czech Republic	0,958	0,969	0,927	0,928	1,189	1,023	0,913	0,987
Denmark	0,753	0,845						0,799
Estonia	1,087	0,984	0,990	1,037	1,054	0,785	0,793	0,961
Finland	1,016	1,006	1,241	0,802	2,345	0,457	1,031	1,128
France	1,032	0,998	0,971	0,628	1,608	1,023	1,058	1,045
Germany	0,981	0,803	1,242	0,874	1,044	0,983	0,966	0,985
Greece	1,081	0,829	1,049	1,135	0,998	1,144	1,050	1,041
Hungary	0,990	1,032	1,083	0,945	1,108	0,964	0,932	1,008
Ireland	1,001	0,939	0,930	1,163	1,026	1,127	1,418	1,086
Italy	0,994	0,895	1,022	0,952	1,000	0,996	0,965	0,975
Latvia	1,098	1,158	0,951	1,044	0,866	0,928	0,991	1,005
Lithuania	1,224	1,129	0,966	1,011	1,023	0,992	0,961	1,044
Luxembourg	0,843	0,934	0,943	0,807	1,223	0,813	0,929	0,928
Netherlands	1,123	1,060						1,092
Norway	0,956	1,317						1,136
Poland	0,980	1,034	0,938	0,894	1,017	0,996	0,921	0,968
Portugal	1,117	0,945	1,011	1,015	1,078	1,036	1,016	1,031
Romania	0,889	1,034	0,999	1,037	0,918	1,034	0,792	0,957
Slovak Republic	0,920	0,932	0,929	0,917	1,155	0,937	0,940	0,961
Slovenia	1,049	1,128	1,010	0,948	0,973	1,029	0,972	1,016
Spain	1,037	0,954	0,950	2,023	0,994	0,997	1,062	1,145
Sweden	1,024	0,372	2,637	0,394	0,868	1,042	0,984	1,046
Switzerland	1,025	0,854	0,915	1,113	1,075	1,099	0,997	1,011
Canada	1,001	1,025	1,000	1,000	1,000	1,000	1,000	1,004
China	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Japan	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Korea	0,962	0,949	1,010	0,980	0,997	0,990	0,988	0,982
Russia	1,000	1,000	1,000	1,000	1,000			1,000
Chinese Taipei	0,961	0,828	1,153	1,007	0,972	0,943	0,964	0,975
USA	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Viet Nam	1,105	0,853	1,168	1,000	0,978	1,098	1,147	1,050
Total	1,005	0,965	1,066	0,985	1,088	0,978	0,987	1,011
APEC members	1,004	0,957	1,041	0,998	0,993	1,004	1,014	1,002
Non-APEC	1,005	0,968	1,075	0,980	1,121	0,970	0,978	1,014

Table 5.4: Technical change.

Economy	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	Average 2001–08
Austria	1,031	1,027	1,056	1,060	1,019	1,033	1,050	1,039
Belgium	1,033	1,060	1,058	1,042	0,932	1,040	1,061	1,032
Bulgaria	1,030	1,050	1,056	1,059	1,034	1,024	1,061	1,045
Czech Republic	1,034	1,049	1,081	1,067	0,957	1,024	1,038	1,036
Denmark	1,073	1,082						1,077
Estonia	1,037	1,049	1,075	1,090	1,012	1,007	1,014	1,041
Finland	1,027	1,065	1,064	1,068	1,031	1,018	1,028	1,043
France	1,036	1,032	1,024	1,060	1,020	1,006	1,028	1,029
Germany	1,011	1,064	1,031	1,057	0,976	1,024	1,040	1,029
Greece	1,017	1,072	1,063	1,024	1,042	1,013	1,034	1,038
Hungary	1,019	1,064	1,033	1,064	1,029	1,001	1,034	1,035
Ireland	1,017	1,072	1,063	1,023	1,031	1,014	1,028	1,035
Italy	1,011	1,074	1,007	1,035	1,014	1,015	1,020	1,025
Latvia	1,022	1,038	1,025	1,085	1,012	1,040	1,069	1,042
Lithuania	1,034	1,058	1,055	1,089	1,018	1,025	1,032	1,044
Luxembourg	1,039	1,050	1,088	1,056	0,913	1,044	1,069	1,037
Netherlands	1,026	1,022						1,024
Norway	1,045	0,930						0,988
Poland	1,031	1,050	1,074	1,072	0,954	1,027	1,041	1,035
Portugal	1,019	1,071	1,063	1,027	1,041	1,013	1,033	1,038
Romania	1,029	1,056	1,053	1,063	0,997	1,011	1,037	1,035
Slovak Republic	1,046	1,041	1,086	1,053	0,923	1,045	1,069	1,037
Slovenia	1,033	1,046	1,045	1,062	1,015	1,018	1,042	1,037
Spain	1,019	1,071	1,063	1,026	1,041	1,013	1,034	1,038
Sweden	1,425	0,783	1,032	1,078	1,032	1,000	1,036	1,055
Switzerland	1,024	1,066	1,036	1,040	0,959	1,029	1,046	1,029
Canada	0,998	1,022	1,088	1,011	1,016	0,979	1,018	1,019
China	1,050	1,022	1,108	1,042	0,931	1,071	1,160	1,055
Japan	1,013	1,055	0,992	1,020	1,023	1,014	1,037	1,022
Korea	1,020	1,074	0,985	1,018	1,009	1,020	1,027	1,022
Russia	1,210	1,099	1,000	1,079	1,037			1,085
Chinese Taipei	1,002	1,090	0,926	1,016	1,013	1,014	1,014	1,011
USA	1,028	1,035	1,050	1,106	1,028	0,994	1,011	1,036
Viet Nam	1,034	1,045	1,009	1,046	1,022	1,004	1,031	1,027
Total	1,045	1,044	1,045	1,053	1,003	1,019	1,041	1,036
APEC members	1,044	1,055	1,020	1,042	1,010	1,014	1,042	1,032
Non-APEC	1,045	1,040	1,053	1,056	1,000	1,021	1,041	1,037

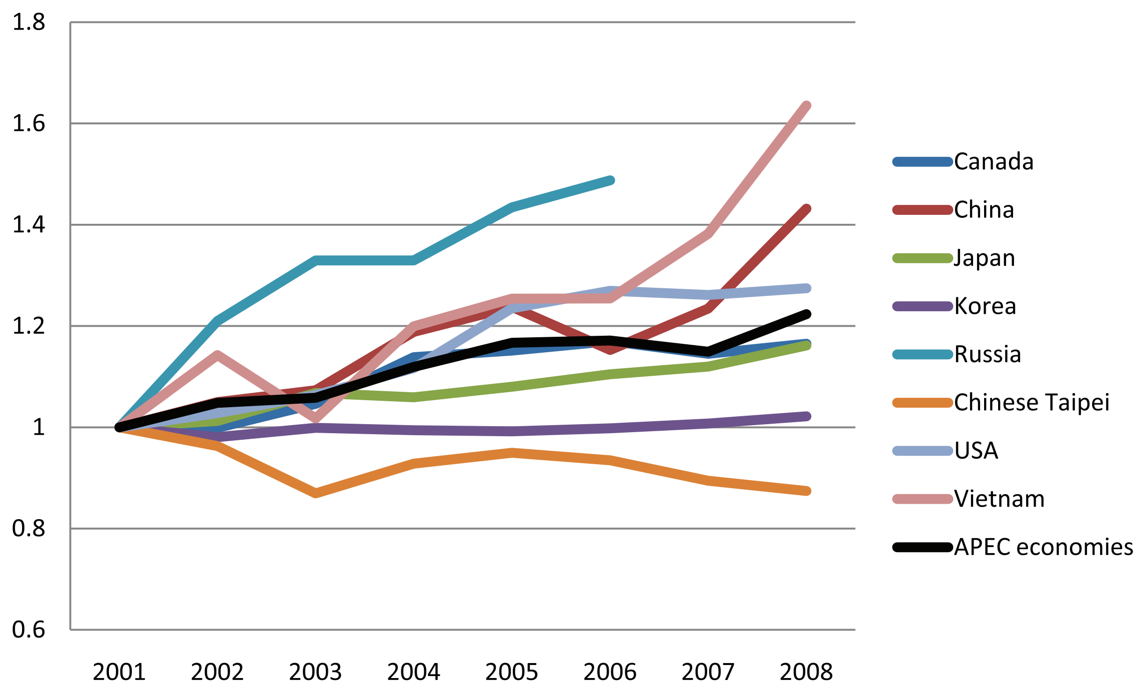

Figure 5.4: Productivity change for APEC economies (2001=1).

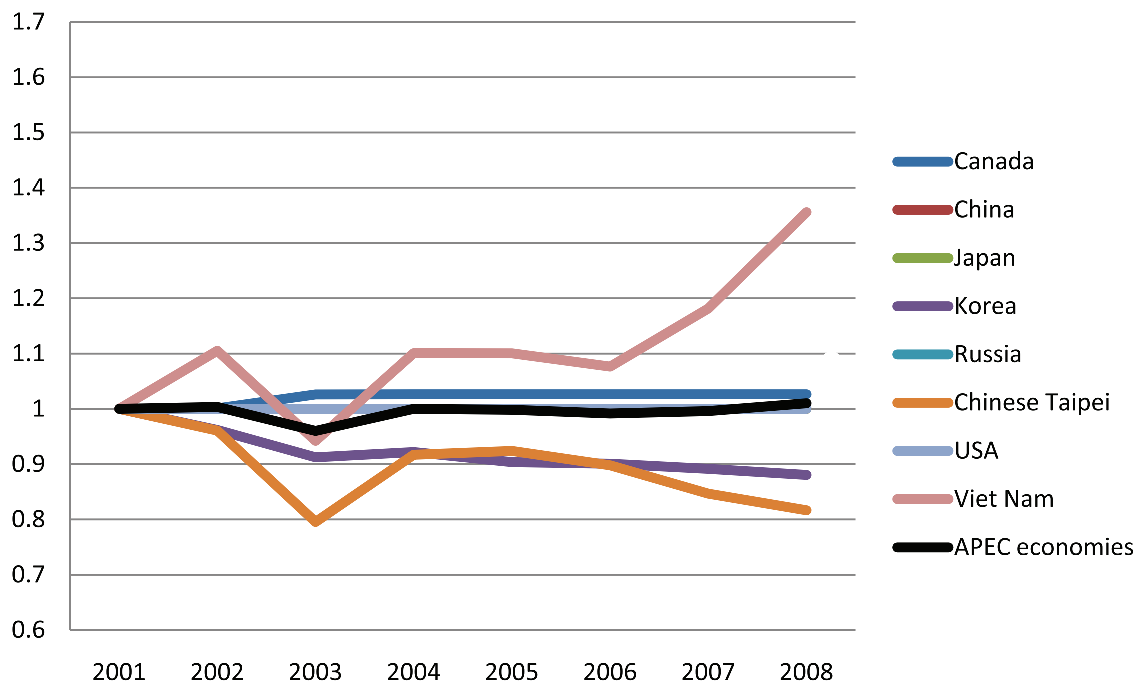

Figure 5.5: Efficiency change for APEC economies (2001=1).

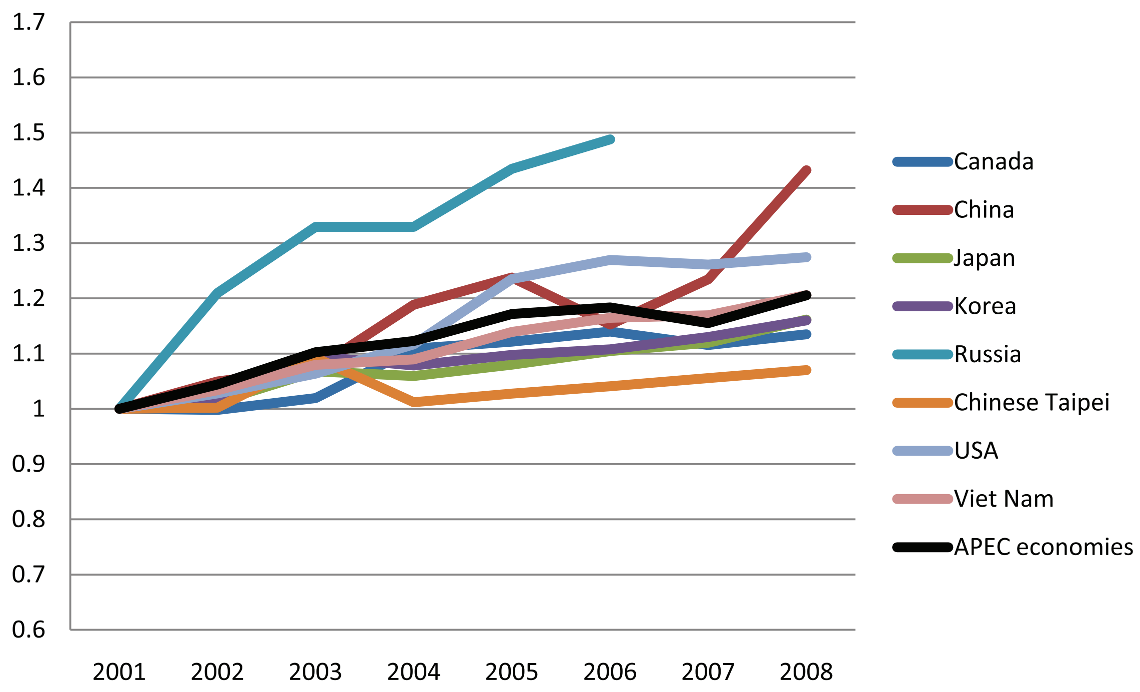

Figure 5.6: Technical change for APEC economies (2001=1).

5.5 CONCLUSION

We have estimated productivity change indicators for a sample of 34 railway systems during the period from 2001 to 2008. These indexes have been decomposed in efficiency changes and technical change. The methodology used to estimate these indexes has been the DEA approach. We must point out that, as the railway systems are very heterogeneous, it is very difficult to compare them individually.

We carried out a first analysis where APEC rail systems may be compared with non-APEC rail systems. The results show that, on average, the productivity, efficiency and technical changes are slightly lower for the APEC rail systems. In particular, the average rate of productivity change for APEC rail systems rose by 3.5% per year, while for non-APEC economies productivity rose by 4.8%. The Russian Federation; Viet Nam; and China showed the highest rates, while Chinese Taipei and Korea had the lowest.

However, China; Japan; and the USA were efficient during the whole period. In any case, we observe again that, on average and excepting Viet Nam, APEC rail systems did not improve their efficiency scores, while non-APEC economies did improve their efficiency scores by 1.4% per year.

Finally, APEC member economies improved, on average, their rate of technical change by 3.2%, while non-APEC economies improved by 3.7%.

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APPENDIX: METHODOLOGY

The Malmquist productivity index (Malmquist 1953) allows changes in productivity of railway companies to be broken down into changes in efficiency and technical change. Furthermore, it allows a different rate of technical change for each railway company. Also, if it is estimated using a non-parametric frontier model (data envelopment analysis; DEA), which is the most commonly used approach, it is not necessary to impose any functional form on the data or make distributional assumptions for the inefficiency term, unlike the Stochastic Frontier Approach (SFA). The main disadvantage of this approach is that the estimation of inefficiency may show an upward bias, capturing as inefficiency the influence of other factors, such as errors in data measurement, bad luck etc.

The Malmquist productivity index uses the notion of distance function, so its calculation requires prior estimation of the corresponding frontier. In this study we use the determinist DEA.

To illustrate the calculation of the Malmquist productivity index, let us assume that the transformation function that describes the technology in each period *t* is:

$$F^t(y^t, x^t) = 0; \quad t = 1, \ldots, T \qquad [1]$$

where $y^t=(y_1^t,\ldots,y_N^t) \in R_N^+$ is the output vector and $x^t=(x_1^t,\ldots,x_M^t) \in R_M^+$ the input vector corresponding to period *t*.

Following Caves et al. (1982), technology can be represented alternatively by means of the input distance function:

$$D^t(y^t, x^t) = Max\left[m^{t,t} : F^t\left(y^t, x^t / m^{t,t}\right) = 0\right] \qquad [2]$$

This function is defined as the maximum reduction to which it is necessary to subject the vector of inputs of period *t* (x^t), given the level of outputs (y^t), so that the new observation $(y^t, x^t / m^{t,t})$ is at the frontier of period *t*.

This function characterises completely the technology in such a way that $D^t(y^t, x^t) \geq 1$ if and only if $(y^t, x^t) \in F^t$. Furthermore, $D^t(y^t, x^t) = 1$ if and only if the observation stands at the limits of the frontier, which occurs when the observation is efficient in the sense used by Farrell (1957).

Figure A5.1 illustrates the above concepts for a situation with a single output and a single input. The observation (y^t, x^t) stands below the technological frontier of period *t*, which means that it is not technologically efficient. The distance function would be calculated as the maximum reduction in inputs, given the output, in such a way that the deflected input reaches the technological frontier. In the graph, this reduction in inputs would be represented by $x^{t,t} = x^t / m^{t,t}$. Farrell's output-oriented measurement of technical efficiency measures how much input could decrease, given the output.

In Figure A5.1 it can be observed that Farrell's measurement of technical efficiency for the observation (y^t, x^t) is $OD/OB = x^t / x^{t,t} = m^{t,t}$.

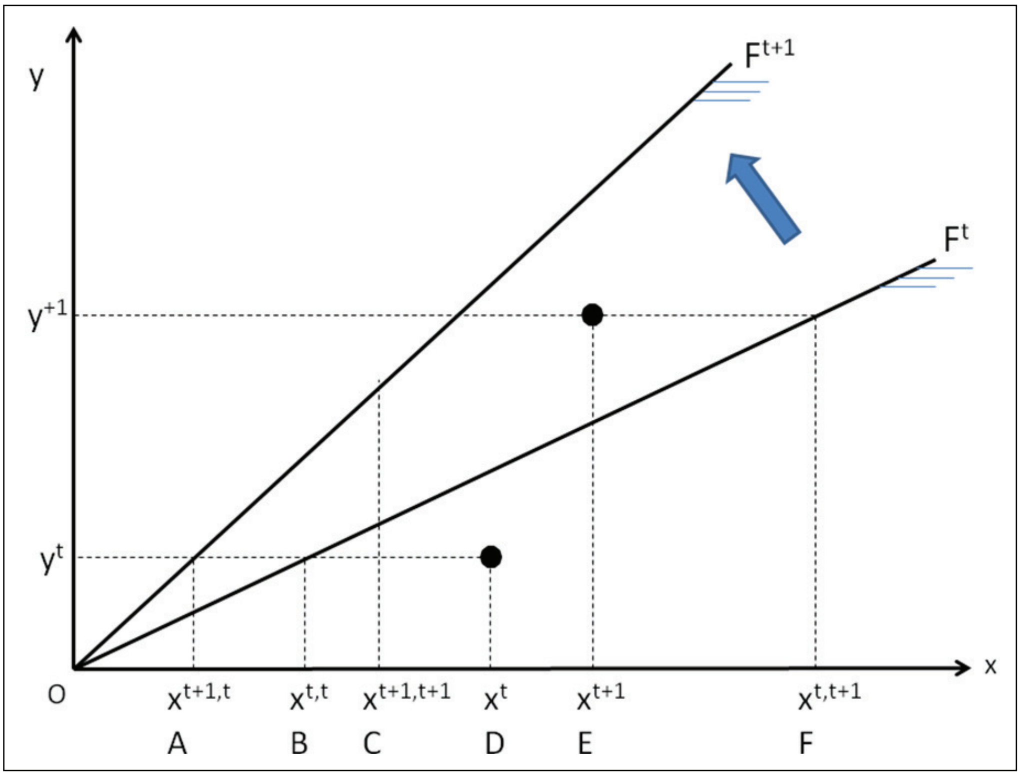

Figure A5.1: The input-based Malmquist productivity index.

Note that so far the distance function has been defined for a single period. Specifically, we have composed observations of one period with the technology of the same period. To define the Malmquist productivity index it is necessary to define distance functions with respect to technologies of different periods.

$$D^t\left(y^{t+1}, x^{t+1}\right) = Max\left[m^{t,t+1} : F^t\left(y^{t+1}, x^t / m^{t,t+1}\right) = 0\right] \quad [3]$$

In the above expression, the distance function $D^t\left(y^{t+1}, x^{t+1}\right)$ measures the maximum proportional reduction in inputs, given the outputs, to make the observation of period *t*+1, $\left(y^{t+1}, x^{t+1}\right)$, feasible in period *t*. In the situation represented in Figure A5.1 the observation $\left(y^{t+1}, x^{t+1}\right)$ is outside the feasible set represented by the technology in *t*, so the value of the distance function will be lower than one $\left(OE / OF = x^{t+1} / x^{t,t+1} < 1\right)$.

In a similar way, it is possible to define the distance function of an observation in *t*, $\left(y^t, x^t\right)$, to make it feasible in relation to a technology current in *t* + 1, $D^{t+1}\left(y^t, x^t\right)$.

Note that when comparing observations of one period with technologies of different periods, the distance function may be less than unity. In particular $D^t\left(y^{t+1}, x^{t+1}\right)$ and $D^{t+1}\left(y^t, x^t\right)$ may be less than unity if there has been technical progress and technical regress, respectively. And note further that in the situation represented in Figure A5.1 $D^t\left(y^{t+1}, x^{t+1}\right) < 1$, indicates that there has been technical progress.

On the basis of the above concepts, the input based Malmquist productivity index used to analyse productivity change between periods *t* and *t + 1*, taking the technology of period *t* as reference, is defined as (see Caves et al. [1982]):

$$M^t\left(y^{t+1},x^{t+1},y^t,x^t\right)=\frac{D^t\left(y^t,x^t\right)}{D^t\left(y^{t+1},x^{t+1}\right)} \qquad [4]$$

$M^t > 1$ indicates that the productivity of period *t + 1* is higher than that of period *t*, since the reduction of the input vector of period *t + 1* to reach the frontier of period *t* is higher than that applicable to the inputs of period *t*. But $M^t < 1$ indicates that productivity has decreased between period *t* and *t + 1*.

Alternatively, it is possible to define the Malmquist productivity index by taking the technology of period *t* + 1:

$$M^{t+1}\left(y^{t+1},x^{t+1},y^t,x^t\right)=\frac{D^{t+1}\left(y^t,x^t\right)}{D^{t+1}\left(y^{t+1},x^{t+1}\right)} \qquad [5]$$

In this case the interpretation is similar. *Mt* > 1 indicates that the productivity of period *t* + 1 is higher than that of period *t*, since the reduction necessary in the inputs of the period *t* + 1 for the observation to be feasible in *t* + 1 is lower than that applicable to the inputs of period *t*.

In all the above definitions only two periods (*t* and *t* + 1) have been considered, and the definitions have been made taking as reference the technology of period *t* or *t* + 1. However, when we wish to analyse the productivity change for a longer time series, the use of a fixed technology may cause problems the further away we are from the base year. Also Moorsten (1961) shows that the choice of base year is not neutral in the results. To attempt to solve these problems two methodologies are offered. The first consists of calculating two indices based on pairs of consecutive years which take as base the technology of the two periods *t* and *t* + 1 and calculating the geometric mean of the two, thus allowing the technology of reference to change, minimising the problems caused by the change (Färe et al. 1994).

Another procedure, used by Berg et al. (1992) to solve the above-mentioned problems is to consider two frontiers of reference corresponding to the initial and final years and to take the geometric mean of the two Malmquist indices.

In this study we will use the first of the alternatives:

$$M(y^{t+1},x^{t+1},y^t,x^t)=\left[\left(\frac{D^t(y^t,x^t)}{D^t(y^{t+1},x^{t+1})}\right)\left(\frac{D^{t+1}(y^t,x^t)}{D^{t+1}(y^{t+1},x^{t+1})}\right)\right]^{1/2} \qquad [6]$$

Rewriting the above expression, it is possible to break down the Malmquist productivity index into the catching-up effect and technical change or movement of the frontier:

$$M(y^{t+1},x^{t+1},y^t,x^t)=\underbrace{\underbrace{\frac{D^t(y^t,x^t)}{D^{t+1}(y^{t+1},x^{t+1})}}_{\textit{Catching-up effect}}\underbrace{\left[\left(\frac{D^{t+1}(y^{t+1},x^{t+1})}{D^t(y^{t+1},x^{t+1})}\right)\left(\frac{D^{t+1}(y^t,x^t)}{D^t(y^t,x^t)}\right)\right]^{1/2}}_{\textit{Technical change}}}_{\textit{Productivity change}} \qquad [7]$$

The catching-up effect or change in relative efficiency between periods t and $t + 1$ is represented by the first ratio, which will be higher than unity if there has been an increase in efficiency. Similarly, the geometric mean of the two ratios between brackets measures the change or movement of technology between periods t and $t + 1$.

Recent developments in the Malmquist productivity index have included an additional component to measure the contribution of the output bias on Total Factor Productivity (Färe et al. 1997).

The above breakdown can again be illustrated using Figure A5.1.

$$M(y^{t+1}, x^{t+1}, y^{t}, x^{t}) = \underbrace{\underbrace{\frac{OD/OB}{OE/OC}}_{Catching-up\ effect} \underbrace{\left[\left(\frac{OE/OC}{OE/OF}\right)\left(\frac{OD/OA}{OD/OB}\right)\right]^{1/2}}_{Technical\ change}}_{Productivity\ change} = \qquad [8]$$

$$= \underbrace{\underbrace{\frac{OD/OB}{OE/OC}}_{Catching-up\ effect} \underbrace{\left(\frac{OF}{OC}\cdot\frac{OB}{OA}\right)^{1/2}}_{Technical\ change}}_{Productivity\ change}$$

If the observation has not varied its efficiency between t and $t + 1$, the first term will be equal to 1 and the productive change experienced between the two periods (M) will be explained only by the movement of the frontier.

However, if the second term is 1 (the frontier has not moved), the changes in productivity estimated by M will be explained only by the changes in efficiency of firms in the two periods (catching-up). In other cases, the productive changes reflected in M will be a mixture of changes in efficiency and movements of the frontier.

The Malmquist productivity index can be calculated in several ways (Caves et al. 1982). In this study, as noted, we calculate the Malmquist productivity index using DEA, a non-parametric technique of linear programming.

Suppose that in each period t there exist $k = 1,...,K$ firms which use $n = 1,...,N$ inputs (x^t_{nk}) to produce $m = 1,...,M$ outputs (y^t_{nk}). The calculation of the Malmquist productivity index for a firm j requires calculation of four types of distance function: $D^t(x^t, y^t)$, $D^{t+1}(x^{t+1}, y^{t+1})$, $D^t(x^{t+1}, y^{t+1})$ and $D^{t+1}(x^t, y^t)$.
Making use of the property whereby the input distance function is equal to the reciprocal of the Farrell input-oriented efficiency measure (Färe & Lovell 1978), we have that for $D^t(x^t, y^t)$,

$$\left[D^t\left(x_j^t, y_j^t\right)\right]^{-1} = Min \quad \vartheta_j^{t,t}$$
$$s.t.$$
$$\sum_{k=1}^{K} \lambda_k^t y_{mk}^t \geq y_{mj}^t \qquad m = 1,...,M$$
$$\sum_{k=1}^{K} \lambda_k^t x_{nk}^t \leq x_{nj}^t \vartheta_j^{t,t} \qquad n = 1,...,N$$
$$\lambda_k^t \geq 0 \qquad k = 1,...,K \qquad [9]$$

Note that we assume constant returns to scale (Caves et al. 1982; Cantos et al. 1999, Färe et al. 2008). Also note that this efficiency measure is radial and therefore can leave slacks, which constitute a non-radial form of inefficiency. This fact led some authors such as Grifell-Tatjé et al. (1998) to develop a non-radial efficiency measure which incorporates the slacks. Replacing the conventional radial efficiency measure with this new measure generates what the author calls the 'quasi-Malmquist productivity index'.

The calculation of $D^{t+1}(x^{t+1}, y^{t+1})$ is obtained in a similar way but substituting *t* for *t* + 1. Finally, the calculation of the first of the distances referred to two different moments in time $D^t(x^{t+1}, y^{t+1})$ is done in the following way:

$$\left[D^t\left(x_j^{t+1}, y_j^{t+1}\right)\right]^{-1} = Min \quad \vartheta_j^{t,t+1}$$
$$s.t.$$
$$\sum_{k=1}^{K} \lambda_k^t y_{mk}^t \geq y_{mj}^{t+1} \qquad m = 1,...,M$$
$$\sum_{k=1}^{K} \lambda_k^t x_{nk}^t \leq x_{nj}^{t+1} \vartheta_j^{t,t+1} \qquad n = 1,...,N$$
$$\lambda_k^t \geq 0 \qquad k = 1,...,K \qquad [10]$$

Note that the observation (x^{t+1}, y^{t+1}) is compared with the technology in *t*, formed by the set of observations existing in *t*, and so it may occur that the observation is not feasible, given the technology current in *t* (*Ft*) and the solution is greater than unity.

The second, $D^{t+1}(x^t, y^t)$, is done in the same way but substituting *t* for *t* + 1, and *t* + 1 for *t*.

The data correspond to a sample of 34 world railway systems from 2001 to 2008. The information was taken from reports published by the Union Internationale des Chemins de Fer and completed with data published in the organisation's statistical memoranda. Specifically, the different railway systems established in each economy are evaluated. Thus, in the first years of the sample, the systems were run by one single company with vertically integrated infrastructure and operations and horizontally integrated operating services. Over the years, as many of the railway systems began to be separated both vertically and horizontally, different companies took over their management. In this case, the data corresponding to all the companies making up a railway system are aggregated for each variable.

Two outputs and three inputs are considered. The variables selected as outputs are the number of passengers/km transported for passenger transport and tonnes/km transported for freight transport. In the case of input variables, the following are considered (Table A5.1):
Number of employees in all of the railways making up the railway system;
Two measures of the rolling stock:
  A variable indicating the number of locomotives, including light rail motor tractors; and
  A variable calculated as the annual fleet wagons and the number of coaches, railcars and railcar trailers; and
Number of kilometres of railway infrastructure in each economy.

Table A5.1: Average values for the variables (2001–08).

Economy	PKT (millions)	TKT (millions)	LLT (km)	LOCOM	WAG	EMP (,000)
Austria	8,761	18,176	5,786	1,232	20,457	46
Belgium	9,041	8,309	3,502	776	15,883	39
Bulgaria	2,538	5,041	4,215	602	14,700	35
Czech Republic	6,749	16,313	9,492	2,180	39,814	69
Denmark	5,478	1,941	2,122	57	5,294	12
Estonia	224	8,838	924	128	3,904	4
Finland	8,017	13,287	5,827	784	14,535	21
France	72,307	45,918	29,456	4,355	57,971	164
Germany	68,707	75,502	34,901	4,976	123,848	201
Greece	1,806	581	2,476	162	4,046	8
Hungary	7,000	8,127	7,951	1,034	18,894	48
Ireland	1,745	305	1,919	94	1,772	6
Italy	47,158	21,589	16,538	3,286	58,449	101
Latvia	855	16,414	2,303	217	5,962	14
Lithuania	446	11,885	1,763	249	9,857	12
Luxembourg	297	461	275	100	3,334	3
Netherlands	14,176	3,848	2,809	275	5,190	26
Norway	2,406	2,723	4,111	156	2,765	9
Poland	17,818	45,115	19,738	3,711	88,993	134
Portugal	3,591	2,474	2,840	182	4,456	9
Romania	7,895	13,656	11,007	1,966	61,314	69
Slovak Republic	2,352	9,809	3,647	1,041	18,581	38
Slovenia	778	3,239	1,229	165	4,821	8
Spain	19,888	11,820	12,853	732	19,348	23
Sweden	6,042	12,945	10,004	398	8,149	12
Switzerland	14,716	12,216	3,357	1,654	15,854	29
Canada	1,484	334,820	55,893	2,913	94,015	36
China	579,817	1,890,285	61,266	16,157	560,396	1.679
Japan	246,085	22,547	19,884	1,218	34,356	140
Korea	30,165	10,766	3,260	580	12,225	30
Russia	155,149	1,639,928	86,703	11,945	596,127	1.219
Chinese Taipei	9,285	889	1,096	323	4,692	14
USA	8,985	2,526,146	194,228	22,476	476,044	183
Viet Nam	4,142	2,898	2,804	356	5,588	42
Total	41,202	200,267	18,787	2,610	70,724	130

Source: Union Internationale des Chemins de Fer.

PKT = number of passengers/km transported for passenger transport; TKT = tonnes/km transported for freight transport; EMP = number of employees in all of the railways making up the railway system; LOCOM = number of locomotives, including light rail motor tractors; WAG = annual fleet wagons (coaches, railcars and railcar trailers); and LLT = number of kilometres of railway infrastructure in each economy.