Olli-Pekka Hilmola (editor)

Railway Wagon Market Analysis and New Multi-Purpose Wagon Solution for Freight Transports - Finnish Manufacturing Perspective

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Railway Wagon Market Analysis and New Multi-Purpose Wagon Solution for Freight Transports – Finnish Manufacturing Perspective

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Foreword

Nora project (Northern Rail Traffic) started during year 2006, and was originally initiated, applied and led by Prof. Anita Lukka from Lappeenranta University of Technology. However, retirement plans of her affected the execution of this project, and from late 2006 onwards development work responsibility changed to Kouvola Research Unit. During this project most of the work has been accomplished in collaboration between Lappeenranta and Kouvola as well as among manufacturers and railway logistics development bureau located in Pieksämäki. During this two year journey, number of researchers from different cultural and educational background have contributed into the results, and number of them have changed their working place to Finnish industry. However, we would like to express our gratitude for each one of them – developing new railway freight wagon concept is difficult and demanding task, but we think that this report answers some important questions regarding to this, and gives further guidance in developing logistics and business models in raw material as well as container transportation business. Thus, it should be remembered that there is no single correct answer for the type of a new freight wagon – our research group's answer is mostly that *'it depends'* from the situation. So, we advise readers to carefully examine different alternatives, and read the whole book through. We also do hope that this research supports railway's new coming in the freight world, since this mode of transport hinders potential to handle both raw material and container transports. It could be argued that intermodality, containerization and multi-purpose transportation equipment are the drivers of the future.

We are grateful for the financial support of the European Union and TEKES, the Finnish Funding Agency for Technology and Innovation. The project was also supported by the following companies and organisations (in alphabetical order): John Nurminen Plc., Kouvolan Yritysmagneetti Ltd., KPA Unicon Ltd., Naaraharju Ltd., RP-Hitsaus Ltd., Municipality of Pieksänmaa, City of Pieksämäki, StoraEnso Wood Supply Europe, and VR Cargo. During this project these different parties have shown great interest towards our research effort, and given needed support for our challenging development efforts.

During Feb.2008 in Lappeenranta and Kouvola,

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Abstract

Railway freight wagons are getting old very fast; this concerns Russian, Finnish and Swedish fleet, as well as Europe in general. It is not untypical to find wagons in use in Europe or in Russia, which have reached their maximum age. Still they are needed to be used, since there does not exist enough new wagons to replace them all. Forecasts have predicted that the shortage in freight wagons will grow at least until the year 2010. Currently newest wagons are acquired by new railway entrants or leasing firms – the latter has been very popular alternative e.g. in Russia. Demand growth will continue much longer period of time, if freight traffic flows start to favor rail instead of other transportation modes. Problems with a rather old wagon fleet in Europe and Russia have affected wagon manufacturers serving them – generally speaking European manufacturers are hardly profitable, and have sluggish sales development, Russian and Ukrainian manufacturers have been able to show a bit better performance, but only in very recent years. As we compare wagon manufacturing performance into US companies, we find that performance in terms of sales, profits and shareholder value is in much better shape in US – surprisingly, US manufacturers have been able to share dividends for their owners.

The purpose of this research work was to develop new freight wagon concept to be used in Finnish, Russian, and in some parts in Chinese railway freight traffic. This new type should be able to operate as multi-purpose wagon, being able to carry raw materials as well as containers – with this solution we could be able to balance biased transportation weight caused by the usage of different transportation modes. As a basis of our development work, we analyzed through database of above 1000 Russian freight wagon types with Data Envelopment Analysis (DEA) approach, and were able to find most suitable wagons for container transports (analyzed in more details 40 alternatives), with varying container cargo – optimization is based mostly on the length of the train as well as on its total weight (carrying capacity is rarely an issue). Thereafter, by discrete event simulation we evaluated one multi-purpose wagon in real-life transportation network (e.g. importing raw wood to Finland or China, and exporting containers back to Russia), and noticed that shorter length of a train gives cost advantage, especially in raw material transports, and also in situation, where border-crossing points are fewer. Shorter wagon is also more flexible with regard of container transports (as forty feet equivalent units are more common nowadays). In the end of our research work, we propose as suitable new wagon production approach networked philosophy, where parts of the wagon are being produced in Finland, and other parts in Russia and/or in Ukraine. This new type of wagon should be registered to Russia, since in that case it is able to serve Finnish-Russian traffic, but also with modifications Russian-Chinese traffic.

Keywords: railway wagon manufacturing, new freight wagons, logistics, raw materials, containers

Tiivistelmä

Rautateillä käytettävät tavaravaunut ovat vanhenemassa hyvin nopeasti; tämä koskee niin Venäjää, Suomea, Ruotsia kuin laajemminkin Eurooppaa. Venäjällä ja Euroopassa on käytössä runsaasti vaunuja, jotka ovat jo ylittäneet niille suositeltavan käyttöiän. Silti niitä käytetään kuljetuksissa, kun näitä korvaavia uusia vaunuja ei ole tarpeeksi saatavilla. Uusimmat vaunut ovat yleensä vaunuja vuokraavien yritysten tai uusien rautatieoperaattorien hankkimia – tämä koskee erityisesti Venäjää, jossa vaunuvuokraus on noussut erittäin suosituksi vaihtoehdoksi. Ennusteissa kerrotaan vaunupulan kasvavan ainakin vuoteen 2010 saakka. Jos rautateiden suosio rahtikuljetusmuotona kasvaa, niin voimistuva vaunukysyntä jatkuu huomattavan paljon pidemmän aikaa. Euroopan ja Venäjän vaunukannan tilanne näkyy myös sitä palvelevan konepajateollisuuden ongelmina – yleisesti ottaen alan eurooppalaiset yritykset ovat heikosti kannattavia ja niiden liikevaihto ei juuri kasva, venäläiset ja ukrainalaiset yritykset ovat olleet samassa tilanteessa, joskin aivan viime vuosina tilanne on osassa kääntynyt paremmaksi. Kun näiden maanosien yritysten liikevaihtoa, voittoa ja omistaja-arvoa verrataan yhdysvaltalaisiin kilpailijoihin, huomataan että jälkimmäisten suoriutuminen on huomattavan paljon parempaa, ja näillä yrityksillä on myös kyky maksaa osinkoja omistajilleen.

Tutkimuksen tarkoituksena oli kehittää uuden tyyppinen kuljetusvaunu Suomen, Venäjän sekä mahdollisesti myös Kiinan väliseen liikenteeseen. Vaunutyypin tarkoituksena olisi kyetä toimimaan monikäyttöisenä, niin raaka-aineiden kuin konttienkin kuljetuksessa, tasapainottaen kuljetusmuotojen aiheuttamaa kuljetuspaino-ongelmaa. Kehitystyön pohjana käytimme yli 1000 venäläisen vaunutyypin tietokantaa, josta valitsimme Data Envelopment Analysis -menetelmällä soveliaimmat vaunut kontinkuljetukseen (lähemmin tarkastelimme n. 40 vaunutyyppiä), jättäen mahdollisimman vähän tyhjää tilaa junaan, mutta silti kyeten kantamaan valitun konttilastin. Kun kantokykyongelmia venäläisissä vaunuissa ei useinkaan ole, on vertailu tehtävissä tavarajunan pituuden ja kokonaispainon perusteella. Simuloituamme yhdistettyihin kuljetuksiin soveliasta vaunutyyppiä käytännössä löytyvässä kuljetusverkostossa (esim. raakapuuta Suomeen tai Kiinaan ja kontteja takaisin Venäjän suuntaan), huomasimme lyhemmän vaunupituuden sisältävän kustannusetua, erityisesti raaka-ainekuljetuksissa, mutta myös rajanylityspaikkojen mahdollisesti vähentyessä. Lyhempi vaunutyyppi on myös joustavampi erilaisten konttipituuksien suhteen (40 jalan kontin käyttö on yleistynyt viime vuosina). Työn lopuksi ehdotamme uuden vaunutyypin tuotantotavaksi verkostomaista lähestymistapaa, jossa osa vaunusta tehtäisiin Suomessa ja osa Venäjällä ja/tai Ukrainassa. Vaunutyypin tulisi olla rekisteröity Venäjälle, sillä silloin sitä voi käyttää Suomen ja Venäjän, kuten myös soveltuvin osin Venäjän ja Kiinan välisessä liikenteessä.

Avainsanat: rautatievaunuvalmistus, uudet vaunutyypit, logistiikka, raaka-aineet ja kontit

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1 INTRODUCTION

Global economic growth has been achieved with increased merchandise, and eventually significant amount of international transports (United Nations 2005). In most of the cases high valued, and low weight as well as small sized products have been transported primarily by air (e.g. growth forecasts and past performance could be concluded from Airbus 2006; Boeing 2006), and other items by sea transports (Platou Report 2006). In this situation road transport has been favored as final connecting link (described in Woxenius 1998 as well as in Batisse 2001), and altogether railways have lost their market share in global scale (e.g. European Union 2005), and volumes have at best remained at same level through decades (only exceptions are the countries having applied strict deregulation and privatization programs for rail, like US, Sweden and UK). However, as we deal with emerging economies of east, like Russia, Ukraine and China, road transportation is rarely the right answer for hinterland transports. Due to historical reasons, railways e.g. in Russia and Ukraine are in much better shape as compared to road (see Figure 1 below), and in other countries have sustained their infrastructural quality level as compared to roads (except US and Singapore, but the level of infrastructure is relatively high anyway). As we think about Finnish-Russian-Chinese axel in transports, it becomes evident that Russia is supplying raw materials for both of the countries by rail (e.g. Terk et al. 2007), and from these countries e.g. trucks or sea transports and trucks are trying to take case of imports to Russia (e.g. Hilmola, Tapaninen, Terk & Savolainen 2007; Märkälä & Jumpponen 2007). Therefore, it is not surprising to find out that from Russia to Finland there was 16 times more train tonnes coming to Finland as transit, and correspondingly nearly 32 times more truck transported tonnes from Finland to Russia (Hilmola, Tapaninen, Terk & Savolainen 2007: 67) – situation has only worsened during the years, and as volumes increase continuously, situation becomes unsustainable in economic and environmental terms. We would need increasingly transportation solutions, which would be multi-purpose, flexible and able to combine unbalance caused by transportation modes. This is the main motivation behind this research report – to suggest alternatives for current situation for both medium-distance two country based transportation as well as international landbridges connecting different continents to each other.

However, it should be emphasized that railway competitiveness over road is not that evident in freight transports – passenger transports is often, e.g. in Europe, Japan and also in Russia, having higher priority than freight (e.g. concluded in Hilmola, Ujvari & Szekely 2007, see also Obermauer 2001: 26 for Japan). Quite often this has resulted in a situation, where freight waits, while passengers flow through the transportation system. In US, where railway freight has gained increasingly volumes and share from road transports, there has been applied opposite policy – freight flows, while passenger trains wait (Rhoades et al. 2006). As waiting means longer transportation times, and un-competitiveness, this factor connected on other routes used for freight transports, leads into a much undesired situation. For Table 1 we have built comparison of railway freight and road transport distances between Finnish city Kouvola (could be considered as most important east-bound traffic point of railways) and 25 largest Russian cities in European side – for example to Moscow traveling time takes nearly 28 % higher amount of time as compared to road transports (if time is only distance dependent). Adding up waiting times due to frequent passenger traffic into this, and we are easily in a situation, where travel time is un-competitive with respect of transportation lead-time. However, it should be emphasized that in cost comparison only, railways could still hold in this case advantage, since longer than 500 km transportation distances within nearly any situation (e.g. without taking into consideration efficiency and productivity) are more efficient than road transports (although, longer distances from A to B are caveat for rails). Thus, in generally within trade among Russia and other eastern countries, distances are rather long, and solutions for more responsive and cost efficient railway connections are demanded, if sustainable system performance is the aim. This note concerns also connection to northern Asia through rails – although, railways hold significant distance advantage over sea transports to connect e.g. North-European economies with this high growth area, advantage is easily lost with uncompetitive pricing (as occurred on Trans-Siberian Railways recently, e.g. concluded in Hilletofth et al. 2007 and Hilmola, Tapaninen, Terk & Savolainen 2007: 28), and mal-functioning overall transportation system.

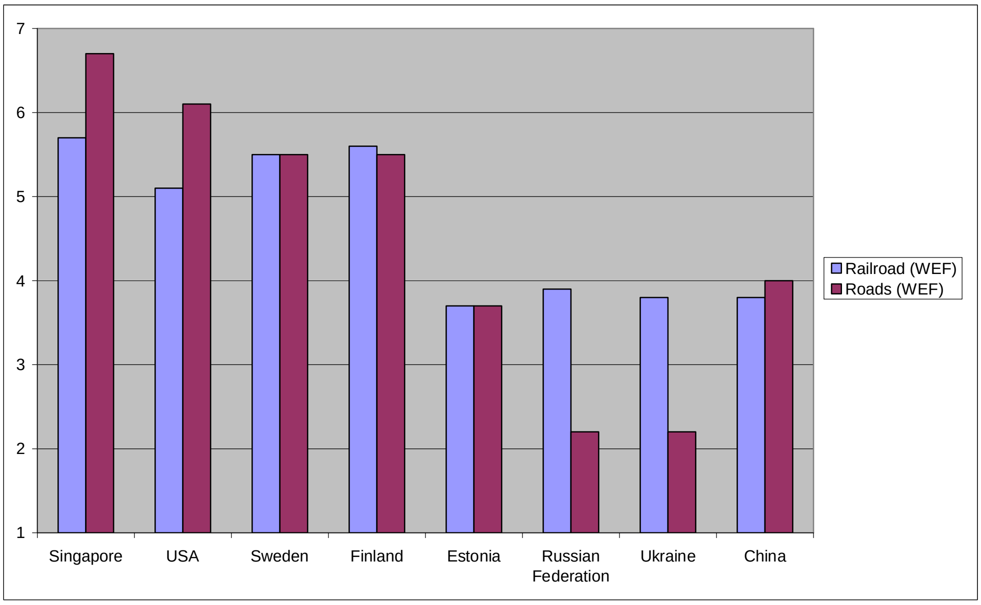

Figure 1. Comparing state of infrastructure in eight selected countries of interest (WEF denotes to World Economic Forum, and is measured with 7-point Likert scale). Source: World Economic Forum (2007).

Table 1. Absolute and proportional difference between road and rail freight from Kouvola (Finland) to TOP 25 largest cities in European part of Russia.

European City	Railway distance (km)	Road distance (km)	Difference (km)	%
Astrakhan	2827	2361	466	16 %
Chelyabinsk (U)	2662	2727	-65	-2 %
Izhevsk	2344	2096	248	11 %
Kazan	1951	1794	157	8 %
Krasnodar	2823	2222	601	21 %
Lipetsk	1720	1407	313	18 %
Moscow	1358	980	378	28 %
Naberezhnye Chelny	2594	2022	572	22 %
Nizhniy Novgorod	1515	1395	120	8 %
Orenburg	2667	2432	235	9 %
Penza	1965	1626	339	17 %
Perm	2093	2202	-109	-5 %
Rostov-on-Don	2540	1950	590	23 %
Ryazan	1353	1178	175	13 %
Samara	2274	2045	229	10 %
Saratov	2171	1823	348	16 %
Simbirsk (Uljanovsk)	2082	1847	235	11 %
St. Petersburg	272	272	0	0 %
Tolyatti	2221	1974	247	11 %
Tyumen (U)	2684	2896	-212	-8 %
Ufa	2662	2333	329	12 %
Volgograd	2389	1951	438	18 %
Voronezh	1807	1509	298	16 %
Yaroslavl	1090	1034	56	5 %
Yekaterinburg (U)	2348	2571	-223	-9 %

This research report is structured as follows: In the following Section 2 we will review the literature related to transportation infrastructure investments in macro economic scale, and their implications on economic growth. Based on our analysis, road investments dominate in number of countries, but their further growth potential is in large-scale rather questionable, and situation dependent, since road investments e.g. in rural areas of China are preventing more poverty than creating high impacts on Gross Domestic Product. However, for railways investments are always having higher magnitude, and therefore hard to objectively evaluate a priori whether they are beneficial or not. As wagon investments are part of infrastructure policy (railways are still influenced greatly by governmental policies and ownership), we identify that renewal of wagons, and applying of new technical innovations is being hindered by small scale investment decision on railway network, and cross-border licensing inactivity. In Section 3 we will review railway transportation market in Russia, which is policy level issue, and has numerous connections on our literature review. The regularity environment is described and the main market players are defined. Generally it could be concluded that Russian railway transportation market is highly monopolistic and dominated by RZD OJSC.

However, the number as well as the influence of independent railway operators is constantly growing. Section 4 describes the current state of freight wagon fleet in Russia. The challenges of freight wagon age in Russia as well as in the EU (especially in Finland, Estonia and Sweden) are further discussed in Section 5. In general, it can be stated that freight wagons in Russia and Europe are fairly old and need to be replaced. The future need in freight wagons in Russia, Finland and Estonia is being analyzed in details in the following Section 6. Section 7 describes the situation in wagon manufacturing industry of Russia. Special attention is paid to the capability of Russian manufacturers to meet the growing demand of wagons. The comparative analysis of Russian, Ukrainian, European and American manufacturers is provided in Section 8 – generally we conclude that US manufacturing is in better shape than the rest of the countries, however, some Russian and Ukrainian manufacturers have followed their success, and are showing indications from sustainable performance. Section 9 is devoted to the thorough analysis of the Russian and Finnish freight wagons suitable for container transportation – in here we also complete Data Envelopment Analysis (DEA) for currently available container transport wagons registered for Russian markets. Our analysis shows cargo specific optimal wagons as well as generally most suitable container wagons from currently available wagon database. In this section is also being analyzed recently introduced wagons for container sector transportation purposes. In Section 10 we are completing discrete event simulation for another type of wagon, which is capable to transport raw materials (e.g. wood, steel bars, pipes etc.) as well as containers – we also present analysis from Chinese wood imports from Russia, interestingly volumes are rather similar to Finland, and this transport also uses mostly rail. Our simulation analysis concludes that multi-purpose wagon is workable alternative for real-life transportation network between Finland and Russia, and container transports seems to be competitive with respect of marginal costs incurred by additional wagons in overall system and additional travelling distance. In Section 11 we present networked production approach for the production of this multi-purpose wagon, this could be applied in the production of long-distance container wagons. In the final Section 12 we conclude our research work, and propose avenues for further research.

2 LITERATURE REVIEW – INVESTMENTS ON TRANSPORTATION INFRASTRUCTURE AND THEIR ECONOMIC IMPACTS

Theories related to economics assist to see the macroeconomic effects that infrastructure investment have in general on the economy as a whole. The linkages between the two groups of issues have been target of considerable debate since the 1940's. The foundations were laid down by Rosenstein & Rodan with introducing the theory of "Big Push". The central message behind their explanations states that simultaneous industrialization in many sectors of the economy leads to the process to be profitable, despite the fact that all of these sectors might not break even. In addition as a consequence of improved income level in the basic industries, new demand for goods is induced, which in turn increases means of expansion scope for transport services. This line of reasoning is the basis for the existence of positive externalities. In particular transport infrastructure enhancements helps other industrial sectors to lower production and transaction costs and governments must contribute to the development with an aggregate approach to optimize or correct the impacts on the economy (Holzner et al. 2006).

From the viewpoints presented above the key issue for officials is to close out the negative forces deteriorating the interactions between physical, institutional infrastructure, market competition and market entry. This is a challenge especially in the view that sustainable transport development scenarios, while often involve tradeoffs between objectives of economic efficiency, safety level considerations, ecological compatibility and these aspects should be reflected in an effective system of tariffs and pricing legislation annually. Towards the future in the theme of intensified integration and structural change of economies, the role of transportation infrastructure will become even more crucial in line with growing demand from customers to be flexible.

Further it could not be demonstrated so far that transport infrastructure investments have direct impacts on GDP growth neither that these initiatives would raise the productivity of investments of other type of capital. Instead it has been emphasized that it may be more valuable of exploring how well countries exploit the available infrastructure for them, and so spotting the relevance of infrastructure quality and its dimensions. Through quality improvements it is possible to reduce waste of manpower, time of provision of service and cut out mistakes (, in so increase output with less effort). The essence is to measure the cost-of-quality until it becomes higher than costs caused by failure. Besides cost-benefit considerations, investments in infrastructure generate more intensive cross-border cooperation within a larger region enhancing the level of economic and political integration. Poor cohesion of political efforts poses on the implementation of infrastructure investments even bigger threat than the one resulting from market failure.

In international projects multiplicity of actor, scenarios for revenues and in general the existence of objectives that limit the achievement of optimal outcomes make it inevitable for intervention of a party from outside, that is on often at higher level: EU or equivalent transnational organization can close the gap of information asymmetry. This in many cases requires the liberalization of service sector so that proper innovative activities could be triggered though competition of service providers. Despite the well known importance of transport infrastructure investment decisions, planning and financing these initiatives can be regarded as failure in some extent when the process comes to the state of implementation. Nationally practices are highly different and this sheds a light on the increasing complexity of decision processes in an international context (Gines 2006). The welfare effects on counties with divergent history and economic policy along the same transnational corridor are not well known though many studies in the past have been carried out. Nevertheless the underlying reasons behind the gaps between planning and implementation are well diagnosed.

These days there is still lack of reliable and verifiable data to be analyzed. Systematic procedures are needed to be improved further and data on large scale project has to be collected on a real time basis. The data is most often not analyzed as in-depth as it could be and as a result arguments can be raised on the correctness of resulted information with regard to allocation of investment to different modes in particular (Short & Kopp 2005).

At the same time national methodologies for planning decisions have great amount of defects, insufficient transparency being the fault number one. As a consequence at the international level the results might include even more errors, circumstances under which malfunctioning takes place are not well scrutinized and the adaptation of these methods are therefore not precise. Official bodies in many cases still do not appraise the possible choices beforehand, but evaluation is not conducted even afterward either and so strategic implications are troublesome to draw. In addition, research concerning transnational transport corridor investment schemes is still scarce. The cause behind these abnormalities are often due to the fact that institutional changes of the transport sector makes the quality of data vague and thus there is no development toward a set of “best practice” (Short & Kopp 2005).

2.1 Trends of infrastructure investments in Europe, Russia and in the USA

In general it can be stated that transportation infrastructure investments have been rising since 1980’s all over the world, but their magnitude and patterns of impact are increasingly different. One of the problems is that currently financing and planning of these projects are becoming more and more controversial from the political point of view, while globalization renders the decision context even more cumbersome.

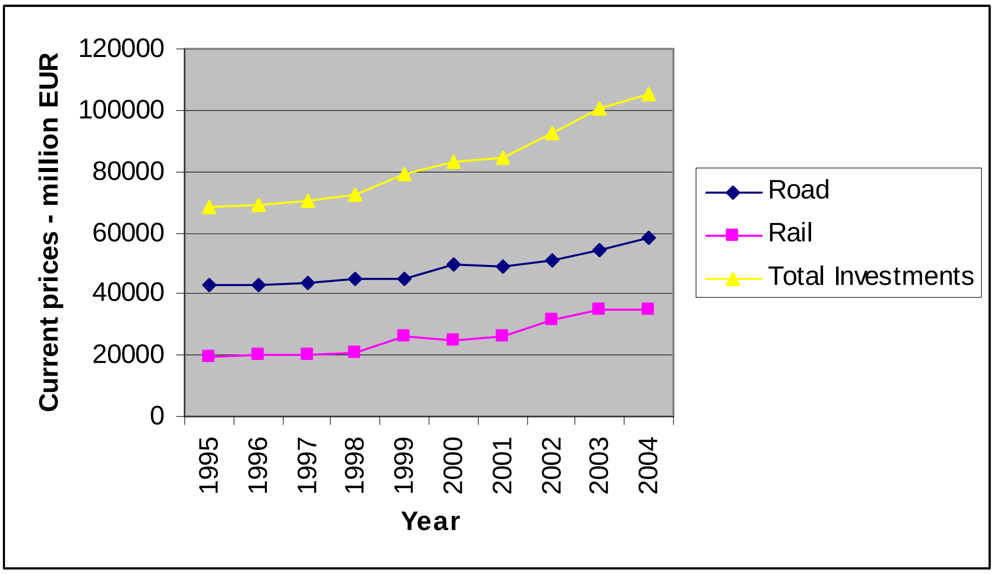

Figure 2. The volume of transport infrastructure investments by mode in Europe between 1995 and 2004. Source: International Transport Forum (2007)

The data on which the curves in Figure 2 are based on those collected by International Transport Forum and are available from its website. This organization itself admits that the reliability of the set of data gathered is not guaranteed completely: The absence of harmonized definitions and methodologies make interpretation vague into a certain extent. It is also stated that data does not reflect that the real scale of private investments or that of by local authorities. Also there are some countries that were excluded from the study, for example: The Netherlands, Ireland, Belgium, Hungary, Bulgaria and Ukraine. Data on the year of 2005 could not be interpreted as there was no information on the volume of investment from many significant countries such as the UK or Italy. While interpreting the results it has to be mentioned that the share of pipelines investments were left out from the sample. The core message from Figure 2 is that in Europe road investment projects have been preferred to the ones of rail for a long time.

The situation in Russia is somewhat different. From Figure 3 it can be concluded that the importance of railway investments seems to be bigger in comparison with the ones of road. However, the relative significance of railways from the total amount of capital injections is rather small: During the years being examined, based on the sample of data pipeline investments surged being the major input to the transportation infrastructure development (Rosstat 2006). The most significant limitation comes from the fact that the interval of time of examination is only four years, so there might be a scale difference between the elements when they are seen in a ten-year perspective.

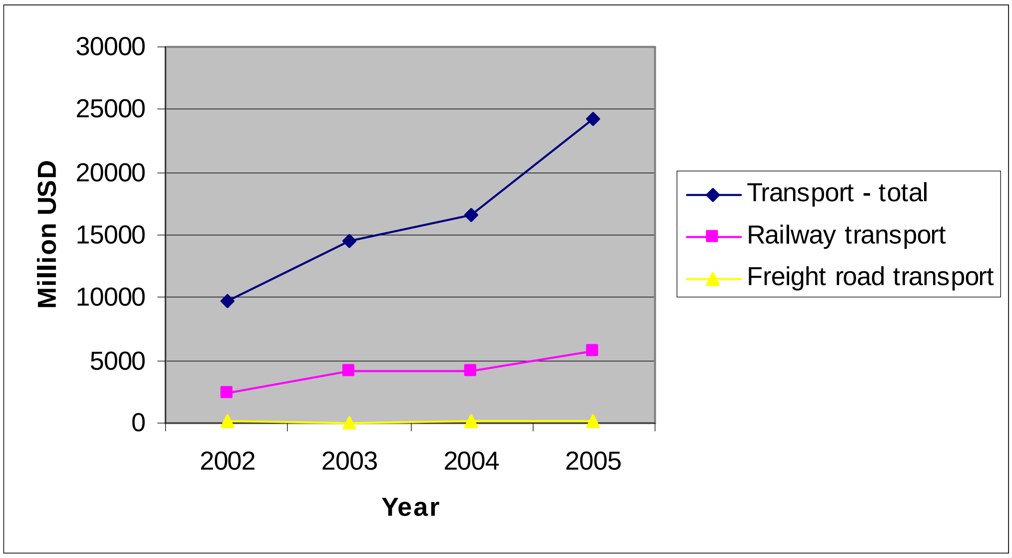

Figure 3. Investments into fixed capital in Russia by transport mode between 2002 and 2005. Source: Rosstat (2006).

Based on the available data it can be said that the overall importance of road (highways) infrastructure investments in the USA has been stable from 1977 till 2000, while the magnitude of railroad inputs decreased significantly: More than 60 % disappeared out of the starting level during these 24 years, if infrastructure investments are seen as a %age from the GDP (Bureau of Transportation Statistics 2004). Recent reports reveal that the situation has not changed much since the end of the 1990's: Railways are still suffering from underinvestment and there is not enough freight rail capacity with regard to the prospected needs of the future (American Railroads 2007; American Association of State Highway and Transportation Officials 2007).

2.2 Detailed analysis of the road and railway industry in relation to infrastructure investment and economic growth

It can be stated that *road investments* in general are the most popular kind of transport development target of governments all over the world, and especially in Western Europe. This is mostly the result of the fact that road transport is seen as the backbone for freight services of trade both on national and international level. For example, in the Northern Dimension Region of Europe according to the forecasts up to 2013 road will capture a share of 57 % out of the total amount of investments in contrast to rail receiving only 28 % (Ojala 2007). Many arguments back up the role of road: The vast majority of inland freight transport currently within the EU is carried out by trucks and in many cases road is the only available way of reaching specific towns and location of companies hidden in countryside in rarely inhabited regions of a country. In addition truck is the most appropriate for transport of sensitive items quickly, in small batches, and in a frequent manner.

On the other hand as road infrastructures are the densest out of all transport modes in Europe, they require attention for regular update and maintenance. All this is the consequence of increasing customer expectations: Growing flexibility requirements in terms of production rhythm, and detailed scheduling systems. At the same time road investments in many occasions can't relieve the problem of congestion and in the end extended traffic produces more pollution and other non-desirable environmental effects. From the longer time perspective it can be argued that environmental and other non-monetary values and norms increase their share in the overall umbrella of transportation costs, but on the average the rate of return road investment projects provide are becoming smaller. In this respect there is a difference in the role of these investment initiatives: In the developed world, road system enlargement is seen as a contributor to the economic growth, whereas in the developing regions of the world these projects help governments in reducing poverty. These arguments can be justified when looking the examples of China and Great Britain: In the former the emphasis is to be put on rural infrastructure whereas in the latter investments on the countryside is not seen to economically viable.

The primary message from the articles below in Table 2 indicates that there is a strong link between road investments and overall economic development of a country. At the same time it has to be noted that the nature of this relationship is elusive: Most of the time the case for road investment is definitely a context sensitive one and the rate of return is not guaranteed in any way. The final outcome might even produce negative effects for the economy as a whole in case of impacts of specific interrelated externalities. These can be for example last minute changes during the implementation phase of a huge updating project inducing massive cost overruns in relation to the frame set in original budgets. It is this dimension, which poses a great deal of difficulties to policy makers: In the end increased level of project capital costs may lead to foreign borrowing or setting up extra tax schemes that induce other negative chain reactions so that final effects will not be even determinable.

Table 2. Article analysis on the link between road transport infrastructure investments and economic growth

Brown, Patric (2006). Road Pricing and Road Investment	The economic justification of building new roads would not disappear, even if pay-as-you drive charging system is introduced. From the viewpoint of rural community there is no economic argument for expanding the road network.	In certain suburb areas in Britain the income from charges could excess 10 times the costs of adding capacity of those roads; so new tunnels could be considered to be created. Inter-city motorways are economically relevant.
Shenggen Fan & Connie Chan-Kang (2005). Road Development, Economic Growth, and Poverty Reduction in China,	Investment into rural low-quality road produces much higher marginal return. These investments are much more important from the point view of poverty reduction than in terms of economic growth.	The emphasis in China between 1988 and 2002 was mainly on building express highways: The annual growth was 44 percent, while rural network increased only by 3 percent during the same period.
Dutz, Mark (2005). Road Freight Logistics, Competition and Innovation: Downstream Benefits and Policy Implications	Innovative road freight services induce a significant cost savings and increase of sales revenues for user companies. Generating extensive competition in the freight road sector should be of primary aim.	Competition policy in Central Eastern and Europe (CEE) should concentrate on eliminating barriers of access to key resources with the view on supply side. There is not enough support for innovation in the business environment.
Kopp, Andreas (2005). Aggregate Productivity Effects of Road Investment	Road infrastructure investments in Western Europe do generate positive macroeconomic effects in terms of productivity. Nevertheless the return rates are in most cases low. Some local road project can still provide extremely high returns.	In certain cases external costs – for instance time, environmental damage – may have profound negative effects on a road infrastructure project. External cost analysis is to be considered all the time.
Joynt, Hubert (2004). Maximizing the Economic Returns of Road infrastructure Investment	The extent of return from a road infrastructure investment project is dependent on the real estate market the scale of land development, the urban economic environment and the infrastructure service providers.	The general characteristics of road investment project are indivisibility, long gestation interval, lumpiness and high costs. The four causality components must be compiled simultaneously for being able to generate profit.
The Allen Consulting Group (2004). Benefits of Investing in New Zeland's Road Infrastructure	The rates of fatal accidents and congestion are a compatible measure for the adequateness of road infrastructure investments. The main areas of improvements are accident cost reductions and travel time decreases.	On a national level increased project capital costs and financial effects may lead to foreign borrowing. Travel times shortening most likely to lead less incentive to use public transport – bus or/and train services.

From the above it can be seen that the emerging social marginal costs coming from road network investments are significant, but in a way out of control. In practice everything is dependent on the behaviour of the parties involved in the construction investment, but because of lengthiness of the project and the level of uncertainty involved in the decision making processes, calculations as to the profitability of the investments are sometimes not even sensible to be created.

The rate of fatal accidents and congestion percentage might be in certain cases better measurement tools. One might even claim that from certain point of view negotiation skills outweighs rational decision making procedures. Key success factors thus may correlate with the way of constructing the method of measuring success: Some governments prefer to include substantial amount of non-monetary factors over cost reduction ones whereas others may do it vice versa. Some countries may even set very low level of discount rate with long project life for calculations, while others may determine high discount rate with shorter project duration. It might be the case that some policy makers see it important to evaluate the increase of value of human life as a result of these investments. Therefore, in general the core problems of measuring the outcome of these road infrastructure investments are in relation to the fact that there are no generally worldwide approved standard procedures for these issues.

It seems that in Europe and well developed economies road investment are targeted more on densely inhabited city-regions mainly to revitalize and optimize the allocation of traffic flows, whereas in Asia the main emphasis helping people to reach the target location they want to go in rural areas. The rate on return on capital invested is low in average and going to be even lower in the near future, whilst in Asia rural investments carry bright prospects of increasing marginal returns. Still it might be the case that some local initiatives in Europe are better established in terms of profitability than similar kinds of in Asia due to highly better positive economic externalities in the former compared to that of the latter. In Europe such profitable project might be found on the Balkans or in Ireland for example. In Asia the direction taken is just the right: Central Asia is to be focused in the near future.

Rail investments are far more capital intensive, lengthy including greater level of uncertainty than those ones in the case of road. Since the density of road system is substantially greater than that of rail, trucks can effectively compete with services of railway operator both on short and long routes: this affected the policies of giving much more reliance on promoting road infrastructure development – the case of China reflects this point well. As noted above the rate growth of express highways linking large cities was 44 % between 1988 and 2002. It can be suggested that during this period there were not much capital left in the budget frame of the State for extending rail network in China.

For the same token it has to be mentioned that from the economic point of view as road takes over 1 % of market share, the decrease is equal in terms of annual revenue almost EUR 1 billion for the rail freight industry of Europe (CER 2007). These financial effects entail destructive elements for rail in the near future: As customers have ever wider chances of choice to select from different options of transport services and as logistics processes are turning to be more complex, it is obvious that parties ordering transport services will put the freight service providers more heavily compete against each other and the importance of price as a component of quality will rise. At the same time it has to be noted that there are signs that indicate bulk items to loose importance to high value goods in the transport sector. Therefore, as international trade continues to grow at significant rate, transit time reliability and available capacity considerations will be emphasized even more in the process of decision making of route selection.

Since the capital intensity of rail infrastructure investments is higher than those of roads, most of the projects were managed under governmental control, but because of uncompetitiveness of state administrative activities, the initiatives became unjustified from economical point of view and officials started to prefer even more the choice of road transport. As a result rail infrastructure begun to deteriorate more and more, so companies started to emphasize the use of trucks: Thus a domino effect took place favouring road over rail.

In US the rail industry had similar symptoms, but it can be stated that over there the railways were saved with massive deregulation measures, and Class I railroads firms are already profitable being able to share increasing dividends. Shareholder value creation has been good in a decade perspective (Hilmola et al. 2007) In the EU similar schemes are under way, but still many former incumbent company produce huge losses and the level of viability of business is far more prone to fluctuation depending on the region of Europe. In addition, large scale investments are most probably to decrease in terms of number to be implemented, as recently the budget of Trans-European Transport Network (TEN-T) investments were cut by two thirds, decreasing the amount of capital available from EUR 20.35 to 13.75 billion (Ludewig 2006). Despite these factors there are already signs available that the overall development is going on to the right direction: The conference on rail logistics held in Brussels in March 2007 showed that during the last year the rate of growth of rail transport bypassed for the first time that of road.

Table 3. Article analysis on the link between rail transport infrastructure investments and economic growth.

Author & Title	**Major arguments**	**Other information**
Association of American Railroads (2007). The Importance of Adequate Rail Investment	New investments are inevitable to meet well rising demand: New rail capacity is to be created. This must be achieved through deregulated legal framework either via tax incentives or extensive new public-private partnership.	The railroads are an extremely capital intensive industry. In 2006 railroads still were not able to cover their cost of capital. The commitment of the US government in assisting the sector financially is not appropriate.
van Wee, Bert (2007). Rail Infrastructure: Challenges for Cost-Benefit Analysis and other ex ante Evaluations.	Though CBA is the most often used method to evaluate ex ante benefits and cost of rail infrastructure investments, the accuracy of this method is doubtful since many relevant aspects are disregarded.	Cost overruns are very common in transport infrastructure projects, the average for rail initiatives being 44 percent. Strategic behavior of parties being involved is a major cause for cost being underestimated.
Filina, V.N. (2006). The Investment Policy of Railroad Sector Under Reform	The focus is on complex large scale traffic projects and rolling stocks. Contractual relations would create more opportunities to improve infrastructure as they define responsibilities better.	Transit freight traffic via Trans-Siberian Main Railroad increased in 2003 by 40 percent. With the contribution of North-South corridor traffic is estimated to climb by 60 percent by year 2010.
Grimes, Avery, George & Barkan, P. L. (2006). Cost-effectiveness of Railway Infrastructure Renewal Maintenance	Through a large scale quantitative data analysis it was shown that emphasising large replacement type of maintenance over ordinary small scale update projects is justifiable.	Between 1994 and 2000 also in Europe the dominance of large renewal maintenance activities increased their share in capital spending of railway companies.
Holzner, Mario & Edward Christie & Vladimir Gligorov (2006). Infrastructural needs and economic development in south-eastern Europe: the case of rail and road transport infrastructure	There is no evidence whether additional investments in infrastructure lead directly to the growth of GDP or to the efficiency of investments of other types of capital.	The question of whether increasing income leads to increasing demand of infrastructure is still an open one. The quality of existing infrastructure is of primary importance.
Dementiev, Andrei (2005). Reforming Russian Railways Introduction of Competition and New Regulatory Challenges	The level of deterioration and obsolescence of infrastructure cannot be evaluated. The state of rail infrastructure is not sufficient and may soon hinder the overall economic growth of the country.	The infrastructure monopoly in Russia has the possibility of discriminating potential competitors in terms of charging the access to infrastructure. There is lack of investment into infrastructure.

The overall picture of these articles above on railways infrastructure in Table 3 envisages an enormous need for adequate scale for investment in physical railroad network, but indicates scarcity of resources to implement these plans. Effects on economic development are clearly identifiable, but they are weaker including greater uncertainty with respect to profitability than those in the case of road projects. Regional interoperability and productivity enhancements are more troublesome to achieve since as a consequence of historical development: Railway industry possess more country specific technical standards compared to road infrastructure.

The aspects presented above can be clearly seen in the slow progress in the harmonization of the regulative environment in the EU targeted for large scale economic integration. Infrastructure pricing system and the organization of funds for rail investments are prohibiting further development of the sector to be able to compete effectively with road. For large countries, such as Russia, the need for update railways is more evident and projects on development of infrastructure tend to be a prerequisite for economic development. Knowing that the density of railroads in Russia is currently significantly lower than e.g. in US, even when taking into consideration the larger area of former Soviet Union and that the length of specific industrial railroads decreased by 25 % from 1992 to 2004, it is obvious that the situation is serious (Filina 2006). In Russia currently the biggest problem is therefore, how to attract further capital input for infrastructure enlargements to build new capacity. Long pay-back periods, long lead times compounded with the lack of universal price charging system on rail infrastructure are the essential reasons behind the theme of underinvestment.

United States solved these problems by letting the rail industry on their own and waited intra-modal competition and demand to render private operators to take on investment programs. In terms of capacity for volumes freight railroads are doing currently well there, but since enormous rise of demand is expected in the near future the density of the network is to be significantly enhanced (Association of American Railroads 2007). The big boom for constructing network for Class I railroads took place in the 80's and recently large scale renewal upgrading become the number one format for projects indicating that the amount of capital spent on investment schemes will rise in the short run. It might be possible that in the future US railways will have to borrow capital in order to be able to fund the necessary initiatives.

In Europe the focus was still now on smaller inter-regional schemes whereas in particular in the last five years the centre of attention has turned to cross – country large TEN-T networks projects. To be able to advance further the productivity of railways freight services, notice should be given also to direct lines between industrial sites.

In Russia the situation is currently clear: The rail network is underdeveloped and deteriorating all the time and immediate action is needed to facilitate the proper utilization for example the Northern Corridor. The volume carried by rail freight has dropped by 25 % from 1640 to 1221 millions ton between 1992 and 2004 (Filina 2006). The most urgent problems are related to intermodal interface connection: ports on the side of Russia need to establish frequent and reliable connections to Asia and traffic flow on the rail has to be improved so that there would not be variations concerning lead time (Hilletofth et al. 2007). These bottlenecks have already been taken into consideration by the Russian Railways, as during the first phase of investments the main targets were set to reconstruct Eastern Siberian, Transbaikalianl and railroads in the Far East. Another primary region is the one of Olya port: The construction of 50 km new railroad approaching the harbor will complete the formation of North-South International Transport Corridor. According to Russian governmental sources this novel transit path will facilitate overall cost to be reduced by 15-20 %, while shortening delivery time by 10-15 days (Filina 2006).

One of the finest options to find the way forward would be to benchmark the North American landbridge that is the most productive existing transport corridor in the world at the moment (Hilletofth, et al 2007). During the last year Russian Railways (RZD) took a move into this direction by acquiring shares of ports controlled by private owners in Russia and nearby the border of North Korea (in the city of Rajin) to be able to open the route to waterway in South East Asia. It seems that these projects can only be implemented through sufficient public-private partnership arrangements with project oriented approach organization, where the focus is on private capital. The platform of the arrangements should be outlaid on well detailed contractual setting as to minimize risk involved, and increase the motivation of parties to implement the construction as soon as possible in a profitable manner. To help the procedure further, the guidelines created by the United Nations for developing inter-modal transport solutions between Europe and Asia is certainly valuable (United Nations 2007).

The significance of *rail car investment* initiatives is growing all the time in parallel with the management innovation research for rail infrastructure. The situation is about to become crucial in the least developed part of Europe and Asia, and in Southern Russia in particular, where infrastructure is in such a bad condition that without immediate measures the utilization level of railway corridors will totally collapse.

It can be argued that the main competitive advantages of railway transport compared to road are related closely to the usage and utilization of wagons and locomotives: No need to load and unload freight frequently with a high level load capacity, speedy and cheap transport of mass bulk items is possible. Significant productivity improvement steps can be achieved only, if novel way of employing automation and information technology is deployed to make locomotives, wagons, terminals more intelligent and increasing their uploading volumes. This is where additional costs may render the investment unprofitable as usually these projects are compounded with immediate infrastructure update needs for example as a result of brand new regulations imposed by the EU.

Table 4. Article analysis on the link between rail wagon investment activity and economic growth.

Author & Title	Major arguments	Other information
Oksana, Ivanova (2007). Wagon Manufacturing Industry in Russia: Current Status and Challenges for Tomorrow	The unclear role of Russian state makes it more difficult for independent wagon manufacturers to engage in investments. There exist need and demand for wagon investment, but RZD does not emphasize this dimension.	The average rate of deterioration of rolling stock assets in Russia is above 80 percent. 18 percent of this kind of obsolete rolling stock exceeded already their time for service.
Ching-Chung Kuo & Gillian M. Nicholls (2007). A mathematical modeling approach to improving locomotive utilization at a freight railroad	The main factors that are to be improved with investments to make railroad more competitive are mobility, flexibility and speed. Productivity growth enhances economic wealth.	This study concerned Class 1 railroad settings with operations on a small geographic area. Hub yard or several satellite yards were targeted by this scrutiny.
Hilmola, Olli-Pekka (2007). European freight transportation and adaptation to demand decline	Productivity advancements in the short run are mainly rail wagon related.	International cross-border scheduled routes and the inability to link rail in a flexible manner to other types of transport are core factors affecting the decline in demand for rail freight transport.
Rothengatter, Werner (2006). Issues of Interoperability in the European Railway System	Negotiations on standards for train control systems are the most decisive. Through intra-modal competition higher productivity, lower prices and better quality of services can be reached.	Licensing wagons in the are of EU is widespread (80 percent of wagon fleet are included) whereas licensing of locomotives is a matter for future.
Bo-Lennart Nelldal (2005). Efficient train systems for freight transport: A systems study	Wagonload traffic in a linear way should be developed, with higher loading gauge. These changes require investments in the infrastructure. In some cases these can be of small scale.	The impact of measures could lead to the decrease of transportation costs by 10-20 percent. Rail transport volume could increase up to 35 percent whilst road would face falling trend up to 23 percent.
Giannettoni, M. & Savio, S. (2004). Fleet management in railway freight transport	The diversity of actors in rail transport and old multinational agreements are core obstacles today for European wide wagon management investments.	It is common that essential wagon information is not documented and fleet managers are not even able to make the best decisions concerning daily operations.

The outcome of the articles on railway wagons in Table 4 suggests that rail car development is not seen in several cases as essential mean for economic growth in the long run: High level policy reforms are prioritized in many places over rail car management issues and this fact leads to the lack of international cross-border scheduled route connections. Rail fleet development should be seen as an inevitable component of railways reform policies and as a result significant productivity improvements could be reached via small scale infrastructure adaptation projects. In fact because of the importance of interoperability and standardization efforts on regulative measures, one can claim that wagon investment schemes are about to take the priority in large scale reorganization initiatives in the near future. As these kinds of specially oriented rail car investment programs entail huge amount of technical data, extensive information exchange and computerized mathematical models could optimize resource allocation leading to further reduction of transportation costs pertinent to rail vehicles.

By now several technical innovations have been put into practice and some market share has been recaptured by the railways from road and sea transport. The most relevant developments are related to computerized train scheduling, routing optimization, and upgrading procedures of equipments, terminals, and novel solutions with regard to rail wagon identification systems. (Kuo & Nicholls 2007)

Liner approach in some places may be preferred over the one composed of nodes, so large scale downsizing and/or adaptation of networks is needed. Hungary is worth of mentioning here as an example. Another potential obstacle is coming from the fact that in Europe infrastructure and management operations of rail activity is to be separated according to the EU regulations: It can be argued that this kind of development would be easier under an integrated umbrella of infrastructure and management. As in these situations the parties participating in these investments are of great cultural and technical diversity, transaction cost involved in setting up a contractual framework might amount to sky high level. In the end one can claim that investment programs for wagons may entail more financial and regulatory barriers than technical ones.

Until now the focus of research projects in Europe was on the determination of profitability of the ranges of rail freight traffic on the Primary European Freight Rail Network (PERFN): According to these, long distance full block trains segments constitute the most competitive and capable of generating revenue. Inter-modal solutions in most cases only break even and the efficiency level of service provided is below to that of the block trains. Single wagon service proved to be the least competitive and unprofitable segment of business. The problem is that in Europe the share of loss producing services such as trains made up of several wagons and single wagon services constitute up to 70 % of the existing business activities. At the same time the margins of profitability of full train services are decreasing rapidly and this segment represents only 30 % of the existing set of service offering (CER 2007).

Prototypes of intelligent coordination systems for wagons and locomotives are already under testing and Internet as a means for efficient data management tool is explored. From these days on the attention is even more on the exploitation of online data transfer systems. In particular, currently the focus is on the optimal deployment of “The Telematic Applications for Freight (TAF) as part of the standardization package of Technical Specifications for Interoperability (TSI).

Nevertheless the most urgent issue arguably is to standardize train control systems: Around the EU there is still approximately 20 different solutions are in use while being incompatible with each other. Today this is one of the reasons why international haulage delay so much having speed of 18 km/h on the average – it was stated that this speed is slower than the one of an ice breaker creating new shipping route choices (Rothengatter 2006).

Community of European Railway and Infrastructure Companies (CER) suggested that longer trains should be the focus of investment in the future, especially those ones carrying light items. Together with improved facilities for real-time information transfer, future could entail prospect for better financial performance of these investments (CER 2007): In case of reaching 90 % of transit time reliability for wagons substantial increase of revenue generated through operations would be possible. Productivity would also improve as a consequence of reliable online coordination mechanisms among the actors of rail freight sector. These effects would be multiplied in a case of successful utilization of tri-plan-capability.

In Asia, and in Russia particular, railway wagon investment schemes were not of high priority importance of transport policy until now. Currently it is even difficult in some of the countries to evaluate the level of obsolescence of infrastructure components. Only very recently e.g. RZD took a notice about the real state of matters and embarked on reconstructing initiatives: The majority of current investments are targeted to the renewal of infrastructure and traction power.

As transport investments serve both as an input to basic production process of providing services and can be seen derived as a result of economic growth, the actual positive externality effects will be much larger. In addition RZD is in a process of establishing two new subsidiaries in the belief that in the near future new private capital can be raised by selling some % of the shares of the privatized operators. It has been showed recently that in a case that country along a multi-modal transport corridor invests into enlargement of available capacity, it forces the country next to it also do the same (De Borger et al. 2007). Along these lines it can be put forward that as the EU and China put emphasis on capacity extensions it makes Russia to take a move that balance the situation. Based on this argumentation it can be claimed that the markets for wagon and locomotives might become overheated at some point necessitating the need for governmental intervention.

In any case plans in Russia are optimistic: As a result of modernization efforts completed by 2010, the fleet size should be extended by 24 %. The level of update and the increase of fleet size still might not be sufficient when taking into consideration the positive externalities imposed by external railway corridor development rate, such as the one of the Trans-Chinese Main Railroad. Boosted by the German technical knowledge input this pathway might attract over 60 % increase in volumes in the near future between Shanghai and Paris. (Filina 2006).

On the other hand, given the fact that already now the traffic over the railway network of China is 1.5 times bigger when compared to the indicators of Russian Railways, there is a danger that in the long run more and more volume will be lost to lines not even reaching the Russian borders. This is essential knowing that one of the main characteristics of transportation network in Russia is the highly uneven regional development level.

To make strategic steps easier to take, it would be a sound move to set up a specific international research group to investigate the current state of Russian fleet to be able to choose from the existing networks of primary rail freight lines. The idea could be similar to the one in the EU: To be able to raise productivity by further investment these has to be targeted and followed up in a right way.

Statistical information available could also be more intensively scrutinized in order to be able to determine the most cost effective solutions allocating wagons and locomotives to yards and routes. Evidence of investments into these kinds of optimization models can be referenced from Canada: Conrail Corporation enacted researchers for helping to find the way of cutting costs from using locomotive fleet assets. There is scope for enormous productivity development, if one takes into the consideration the fact that nowadays the state of applying mathematic models to investment decisions is still in the stage of infancy. This is especially true with regard to calculations based on Net Present Value (NPV): These tools ignore the impacts on economic development, constraints of financing, or the existence of uncertainty and are applied in different countries with no consistent set of parameters (Quinet & Vickermann 2004).

The EU could help Russian authorities to gather more specific disaggregated data on market development concerning rail freight traffic flows. In particular statistical data on traffic flows between industrial hubs and large cities could be valuable. In this way the forthcoming need for investments level on road and rail could be more precisely estimated and effects on modal split would be possible to draw. In turn this would make it easier to impose a common infrastructure pricing system on operators using tracks in Russia. Setting up tolls is a difficult issue for the EU too as in many cases those can have more negative effects on transport infrastructure investment than positive ones (Ludewig 2006). Recent research on this topic even suggests that it is not a proper instrument to use toll charges on transit traffic along an international transport corridor (De Borger et al. 2007).

Still one other study of EU level points directly to the opposite direction: It was already demonstrated by Community of European Railways and Infrastructure Companies (CER) that the placing an optimal price strategy (applied by Switzerland) on EU wide road network and using the charges received to finance rail investment, would trigger rail freight demand up by 17 % (Ludewig 2006). In any case cooperation with Russian government and private transport service providers over there would give the EU deeper insight into the prospects of development of intermodal transport corridor from the EU across Russia ending up to east coast industrial area of China.

3 RAILWAY TRANSPORTATION MARKET IN RUSSIA

3.1 Regulatory environment

Russian Railways OJSC (often referred to as RZD OJSC) is 100 % government-owned rail monopoly with full state backing and guarantee. RZD OJSC is one of the biggest railway companies in the world, which is partly due to the large size of the country. Only the US has more railway kilometres than Russia. RZD OJSC was set up in accordance with Russian Government Decree dated May 2001: The Structural Reform Program on Rail Transport and is the main company in Russia providing railway transportation management and control. As a large monopolistic company of vital strategic interest, RZD OJSC is regulated by four government bodies, each carrying out different aspects of the regulatory function. Railway sector management in Russia is shown in Figure 4.

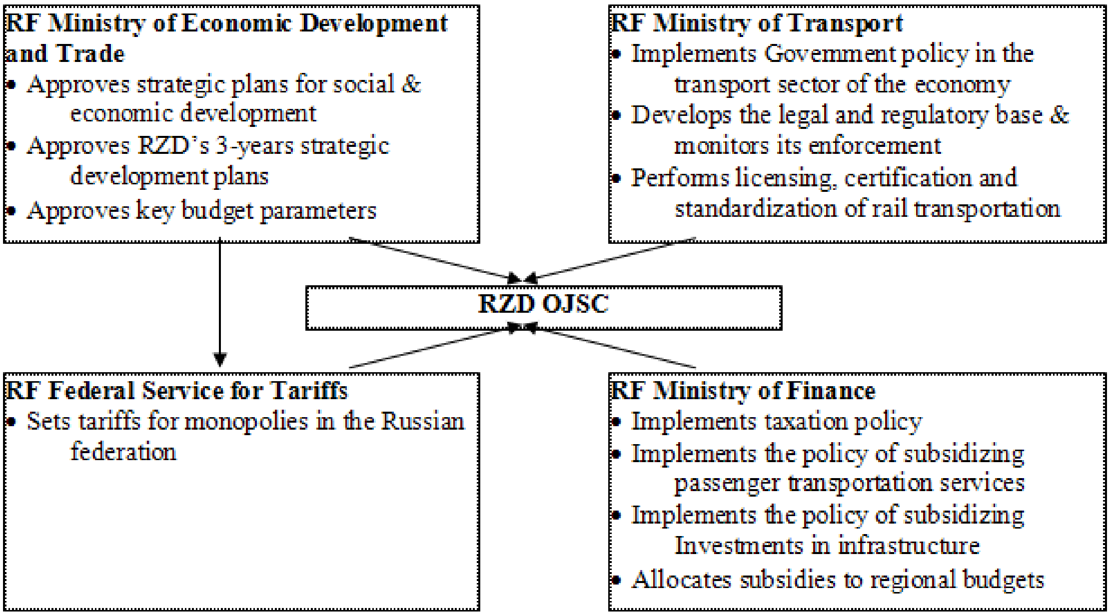

Figure 4. Railway Sector Management in Russia. Source: RZD OJSC

As it can be seen from Figure 4, the Ministry of Transport and Communications is responsible for the supervision, regulation and licensing of the railway industry in general. The Ministry of Economic Trade and Development approves Russian Railways' strategic development plans and key budget parameters. In addition, it has an oversight responsibility for the Federal Tariff Service (see below). The Ministry of Finance is responsible for taxation and subsidies (principally in support of the passenger segment) and funds transfers to regional budgets. The Federal Tariff Service is the government body responsible for setting tariff policy in the monopoly sectors of the Russian economy. Tariffs are also applied in railway services, and these eventually determine significant part of the total costs of transportation in rails. Total costs of producing service by governmental organization could be related to tariff billed from customer, but it could also be the case that paid amount is several times higher due to political (transportation or general policy) reasons.

3.2 Russian Railways vs. independent operators

Russian Railways OJSC is the sole owner and operator of the public railway infrastructure in Russia. Its assets include e.g. track, depots, stations, switching facilities and dispatch centers. RZD OJSC is also the largest owner, operator and leaser of freight rolling stock, the exclusive owner and operator of all passenger service rail assets and the largest owner of locomotives. In a process of railway reform and with the aim of assets unbundling, two Russian Railways' subsidiaries, namely TransContainer OJSC and Refservice OJSC, were founded to serve container and refrigerator transportation correspondingly. Refservice OJSC got from parent company refrigerator rolling stock, while TransContainer OJSC received containers and flat cars. In the near future RZD OJSC plans to establish one more subsidiary Cargo Company to provide transportation of the rest types of cargo. According to estimations of the RF Federal Antimonopoly Service, that subsidiary will possess about 60 % of the total rolling stock operated on Russian railways.

Private participation in the industry is currently limited to the ownership, leasing and operation of rail cars and limited ownership of locomotives; and is restricted to the freight segment only. The total number of private freight rolling stock owners in Russia is about 2.5 thousand. However, the major part of that rolling stock belongs to 90 private rail operators. Rail operator is a company that has concluded an agreement with RZD OJSC on the use of railway infrastructure and provides cargo transportation using own or rented rolling stock. There are two main groups of private rail operators: transportation subdivisions of raw material companies, i.e. captive operators (e.g. Fintrans, LUKoil-Trans) and independent operators (e.g. Severstaltrans, Eurosib SPB, DVTGroup, Transgarant). Separate group of private rail operators is presented by companies created with participation of both private and state capital (e.g. Russian Troika). The interaction between the participants of railway transportation in Russia is shown on Figure 5.

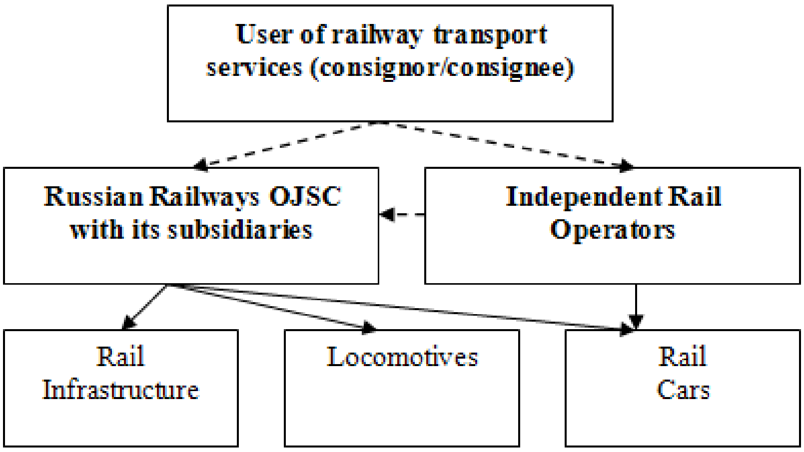

Figure 5. Interaction between participants of railway transportation in Russia

As Figure 5 shows, the necessary condition for rail transportation service is availability of rail cars, locomotives and access to rail infrastructure. The user of rail transportation service has two options: to contact RZD with its subsidiaries or to address independent operator. In first case, RZD that is the sole owner and operator of the railway infrastructure as well as the largest owner of rail cars and locomotives in Russia provides the full range of services. In second case, independent operator that owns rail cars (and in a very rare case locomotives) takes responsibility to agree with RZD on provision of locomotives and access to infrastructure. In both cases RZD is necessary participant of rail transportation process. However, currently RZD has some plans to establish own independent freight operators (latest information is that they have plans for two, namely the First Cargo Company as well as Second Cargo Company), which would be affiliated companies to RZD, and would be listed to stock markets (Guryev 2008). Gathered initial public offering funds would be most probably used in purchasing new rolling stock and invested in other railway cargo transports related infrastructure development.

4 FREIGHT WAGON FLEET IN RUSSIA

By the beginning of 2006 the total number of freights wagons operated on the Russian railways has reached 902 thousand, from which 628.4 thousand (or 69.7 %) belong to RZD OJSC and 273.6 thousand (or 30.3 %) – to independent rail operators. At the same time, since 2001 the private freight wagons fleet has been demonstrating an impressive growth rate (see Table 5).

Table 5. Number of wagons owned by RZD and private companies. Source: RZD OJSC

Wagons owned by:	2000	2001	2002	2003	2004	2005	2006
RZD, thousand	639.8	639.7	625.2	621.3	634.5	624.1	629.7
-annual growth rate	-	-0.1	-14.5	-3.9	13.2	-10.4	1.3
Independent operators, thousand	162.9	161.0	173.6	195.3	222.5	252.3	280.7
-annual growth rate	-	-1.9	12.6	21.7	27.2	29.8	7.1

As it can be seen from Table 5, lately the demand for the new wagons is mainly created by private companies. It is expected that by 2010 Russian freight wagons stock will be equally distributed between RZD and independent operators. The structure of freight wagons stock operated on the Russian railways is shown on Figure 6.

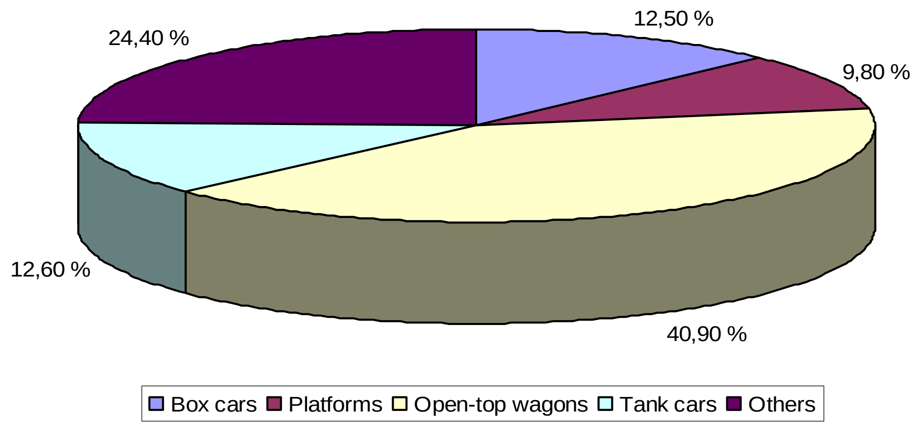

Figure 6. Freight wagons operated by RZD. Source: Federal Antimonopoly Service of the RF

As it can be seen from Figure 6, open-top wagons dominate in RZD freight fleet (40.9 %). Almost the equal shares belong to tank cars (12.6 %) and box cars (12.5 %). The share of platforms is less than 10%. As container platforms are of special interest for the purpose of our research, their structure is analysed in details.

As a result of the Structural Railway Reform, in March of 2006 the responsibilities for container transportation were placed on the RZD subsidiary TransContainer OJSC, which got from parent company about 24 thousand platforms. Figure 7 shows the structure of container fleet operated by TransContainer OJSC.

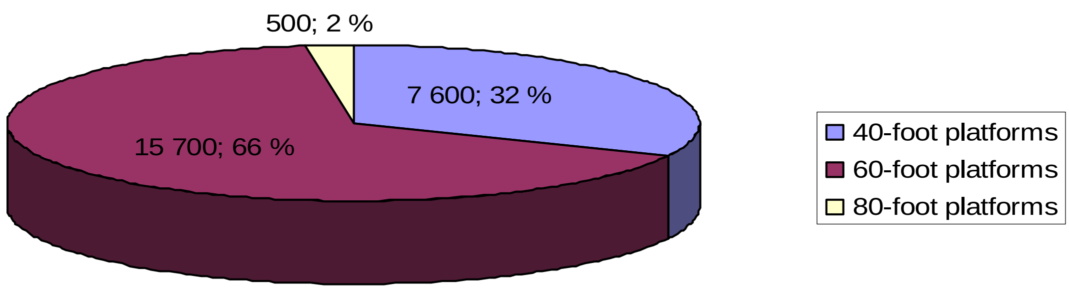

Figure 7. Container wagons in service of TransContainer OJSC. Source: TransContainer OJSC

As Figure 7 shows, over two thirds of the wagons used by TransContainer are 60-foot platforms, one third are 40-foot platforms and only a tiny portion (2 %) are 80-foot platforms. TransContainer seems to have somewhat improper equipment, since the 80-foot platforms would seem be the most efficient method of transporting containers (VR 2006).

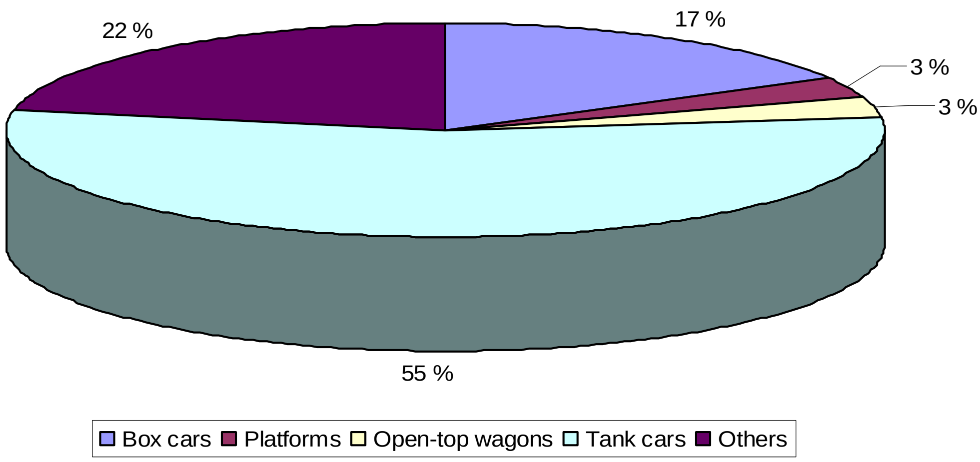

Figure 8. Freight wagons operated by Independent Operators. Source: VKM Leasing, 2004

Figure 8 shows the structure of freight wagons belonging to Independent Operators. In contrast to the structure of RZD freight fleet, the major share of private wagons belongs to the tank cars (55 %), followed by the box cars (17 %). Both open-top wagons and platforms take only 3 % of the total private fleet. It means that to win in competition with RZD for transportation of other than liquid freight independent operators should make significant investments into the purchase of non-tank wagons. Flat cars could be one of the valuable alternatives. The current level of containerization in Russia is low – 30 %, compared to 60-70 % of the world average. It means that Russian container market has significant growth potential. Already now its annual growth rate is more than 20 %, compared to 8-10 % of the world average. Rail operators should be ready to respond to the growing demand in container transportation.

5 THE CHALLENGES OF FREIGHT WAGON AGE: SITUATION IN RUSSIA, FINLAND, SWEDEN AND ESTONIA

5.1 Age distribution of Russian wagons

Statistics witnesses that wagon manufacturing in Russia have been increasing until the year 1987. The dissolution of the Soviet Union and the followed recession of Russian economy determined the reduction in the demand for the railway transport services in Russia. In 1998 the volume of the railway transportation was 2.5 times lower than in 1990. The surplus of wagons reached about 0.5 million (30 % of the total freight fleet) and thus investments into the new rolling stock lowered significantly. The age distribution of freight wagons in Russia is shown on Figures 9 and 10.

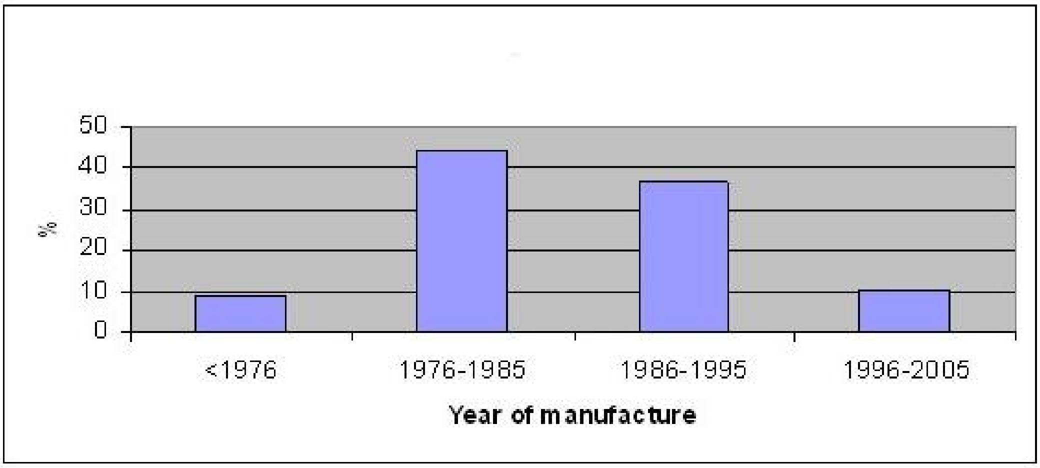

Figure 9. Age distribution of Russian freight wagons. Source: RZD OJSC

Approximately 80 % of the wagons are manufactured during 1976-1995 and only 10 % of the wagons are less than ten years old. Almost the same amount (~10 %) of the wagons are older than 30 years, which also attests that there are wagons in use that have passed their service life. Since most of the wagons are really old, the next ten years will most definitely be filled with new investments. Figure 10 shows the distribution of wagons owned by RZD according to the year of manufacturing.

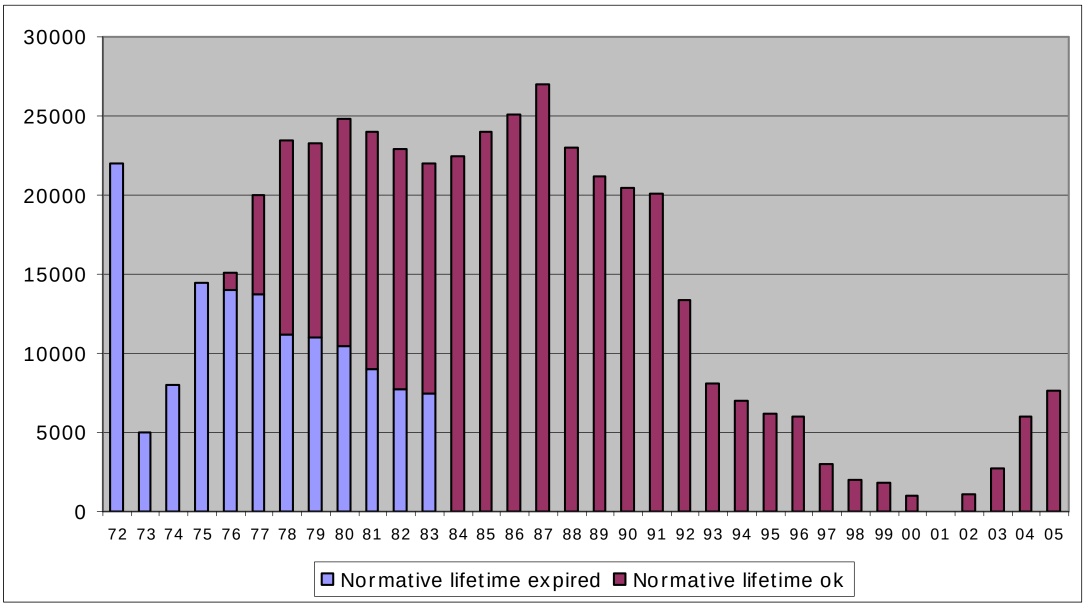

Figure 10. Distribution of wagons owned by RZD. Source: Federal Antimonopoly Service of the RF

Figure 10 shows that wagons manufactured in 1983 and earlier should not be used, since they have already passed their normative lifetime. RZD owns very few new wagons, although its purchases have increased during the last years mainly due to the enormous shortage in different wagons. Figure 11 shows the average age of different wagon types operated by RZD.

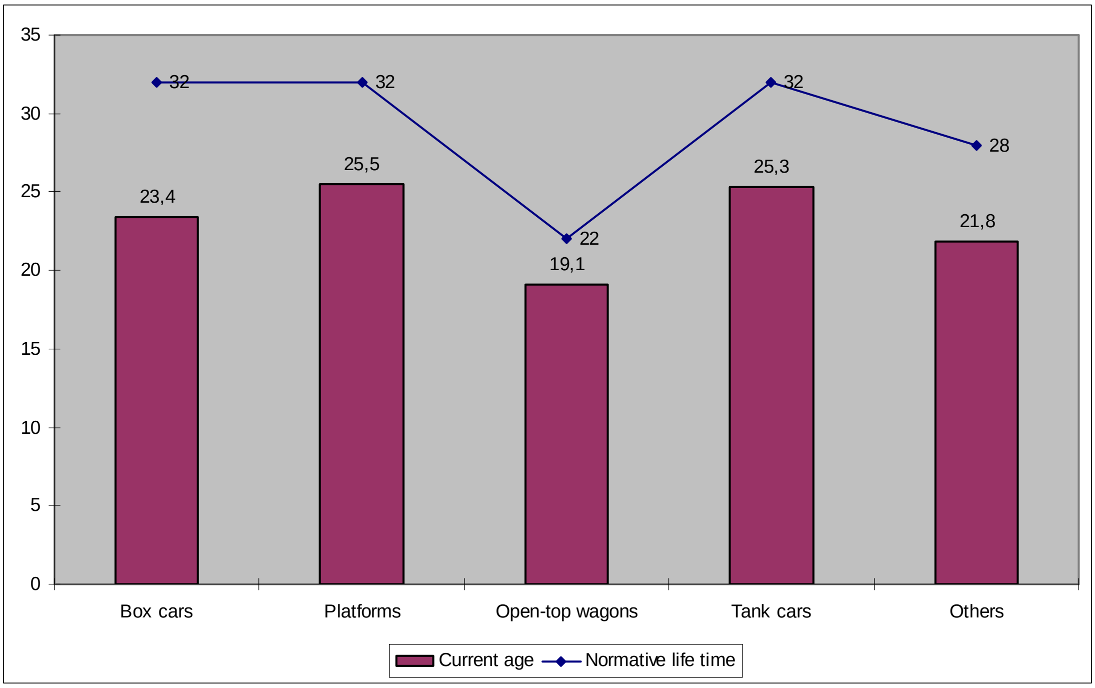

Figure 11. Average age for RZD freight wagons in Russia. Source VKM Leasing (2004)

The line on Figure 11 shows the normative life time for freight wagons and it varies from 22 to 32 years. The average age for wagons in use varies from 19.1 to 25.5 years and especially the average age of open-top wagons seems to be almost as high as their normative age. Similarly, flat cars have passed on average 76 % of their service life, tank cars – 72 % and box cars – 70 %.

In 2005 the wear factor for those wagons has reached 85.9 %. The average age of freight wagons belonging to RZD is 20.9 years. About 18.7 % of them have passed their service life. According to RZD, the number of wagons taken out of service in 2006 – 2010 will exceed 143 thousand and in 2011-2015 – 158 thousand. It means that to keep the current size of its freight fleet RZD should annually purchase about 30 thousand wagons. However, the reality is somewhat different (see Figure 12).

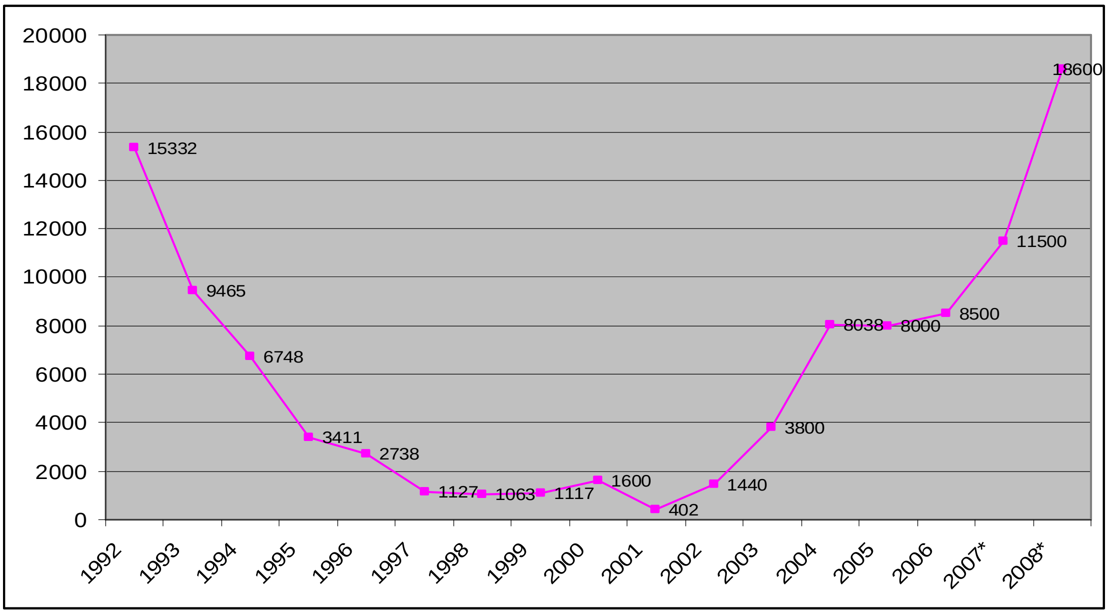

Figure 12. RZD purchases of new wagons in 1992-2008, items. Source: RZD OJSC

Figure 12 shows that since 1992 RZD purchases of new wagons were constantly declining up to 2001, when they reached the lowest level of 402. Beginning from 2002 RZD investments into new wagons have been growing. However, even the highest level of purchases planned for 2008 are only 62 % of the amount needed to replace the retired wagons.

The rolling stock deficit will be partly compensated by the growth in a number of wagons belonging to independent operators. The average age of freight wagons belonging to their fleet is about 14 years. Unlike RZD, they do not need to invest heavily in the replacement of retired wagons and thus have more possibilities for the new wagon purchasing. According to statistics, nowadays about 75 % of freight wagon produced in Russia is being consumed by independent operators. However, those purchases are not sufficient enough to cover the differed demand having roots in 1990's coupled with the new demand created by annual increase in the volume of the railway transportation (in the nearest 5 years it is expected to grow more than 6 % annually).

5.2 Age distribution of wagons operated in the EU

In Europe, the freight wagons have almost the same age distribution as in Russia, as shown in Figure 13. Most of the wagons have been manufactured during 1970-1989 and nearly 50 % of all wagons were manufactured in the 1970's. About 20 % of the wagons are older than 36 years and only about 10 % of the wagons are manufactured during the last 15 years.

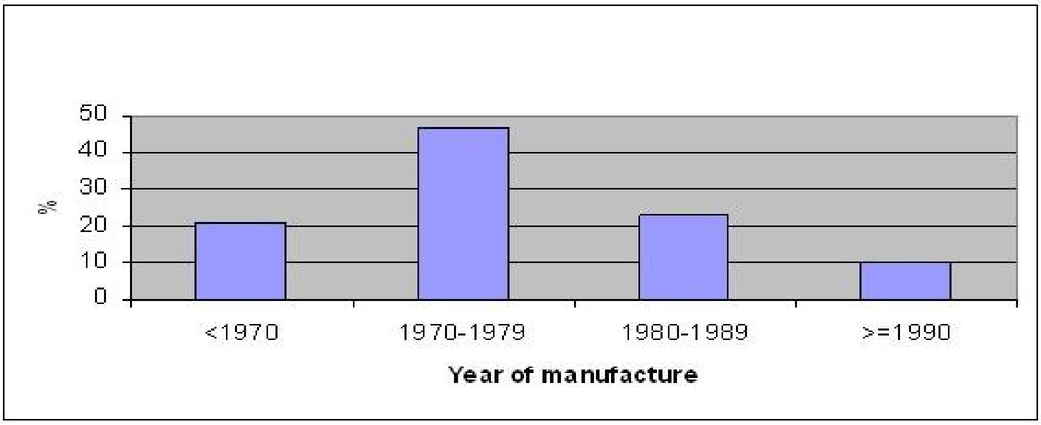

Figure 13. Age distribution of freight wagons in EU-15. Source: Kunst (2005)

According to Albert Hartmann, vice-president of marketing and sales in Thrall Europa, there were about 2 million freight wagons in Europe in 1980. The fleet is now down to about 1 million, but some of these wagons are idle. The average age is high – more than 20 years. Between 12 000 and 14 000 wagons are produced in Europe each year. If nothing is done to improve rail competitiveness, the size of the fleet will fall to about 700 000 wagons in the long term. If the average life of a freight wagon is 25 to 30 years, then Europe will need about 25 000 wagons a year. But if rail freight gets a boost politically, the railways start to work together, and others enter the market through open access, then traffic will increase. The signs are that there will be growth, so the need for new wagons will also grow (Briginshaw D., 2001**).**

The American manufacturers have already recognized the potential of European market and acquired high capacity plants in Eastern Europe.

5.3 Age distribution of Finnish wagons

In Finland, the problem of old wagons seems to be the same as in Russia and the rest of Europe. Figure 14 shows the age distribution of Finnish freight wagons by the year of manufacture.

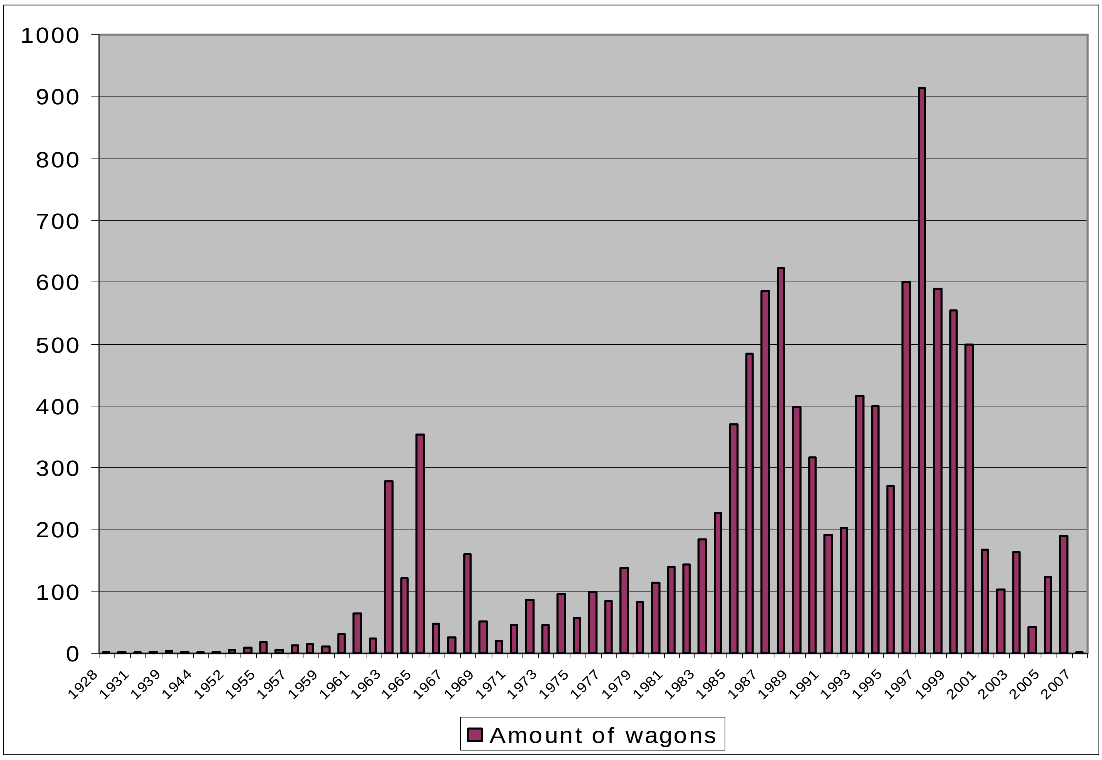

Figure 14. Age distribution of Finnish freight wagons used by the year of manufacture (year 2006 situation). Source: Finnish Rail Agency (2006)

The average age of Finnish freight wagons is 18.5 years. Most of the wagons are manufactured during 1986-2001, with the exception of early 1990's, when Finland was suffering from economic depression. Three peaks in production – 1966, 1989, 1998 and the few years around them can be observed in manufacturing years of the existing fleet. Since 1998 and until 2003 the wagon manufacturing volumes were constantly declining. The annual level of production in 2001-2006 slightly exceeded 100 new wagons, which is only a quarter of the level of the late 1980's and 1990's.

Figure 15 shows the age distribution of Finnish freight wagons that can be used for container transport and Figure 16 – the age distribution of other freight wagons.

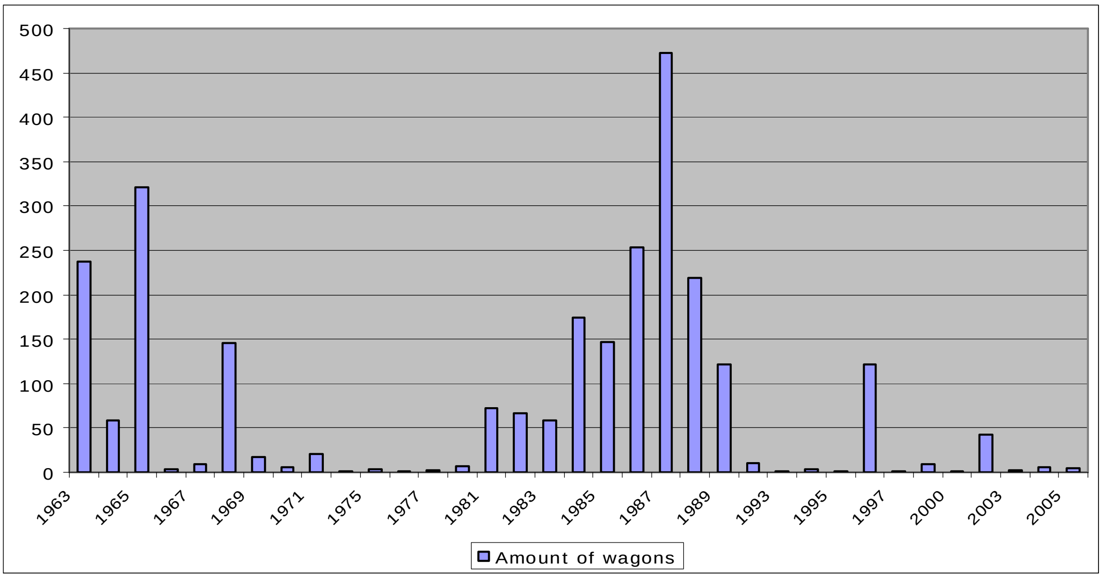

Figure 15. Age distribution of freight wagons used for container transport in Finland (year 2006): Source: Finnish Rail Agency (2006)

As it can be seen from Figure 15, the production of container freight wagons has followed the same trend as the overall freight wagons production. The highest amount of container wagons was produced in 1966, 1988 and 1997. In between those peaks the production of container wagons was very low - mostly less than 20 wagons per year. It can be noticed that the production boom has taken place approximately every ten years. The peak of production in 1997, however, can also be explained by the recovery from the depression that has been shaking Finland in the early 1990's. Among road projects, other transportation infrastructure projects are most suitable to be complete before economic take-off, not during periods of booming economy.

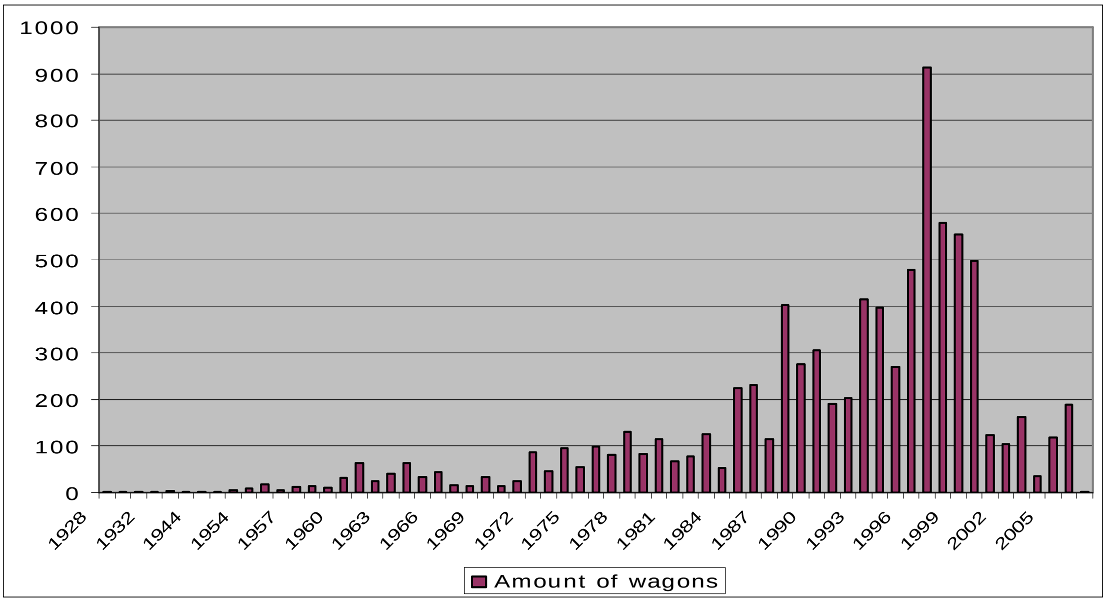

Figure 16. Age distribution of other freight wagons used in Finland (year 2006). Source: Finnish Rail Agency (2006)

As Figure 16 shows, with the production of the other freight wagons the situation is slightly different. The production volumes have been growing slowly since 1928 and reached they peak in the late 1990's (more than 900 wagons a year). After that they suddenly dropped to about 100 new wagons per year. At the same time, the production of container wagons is on the level of around 10 new wagons per year. This situation leads to one of the two options. Either the VR (Finland's leading freight and passenger carrier) is planning to reduce the wagon stock and thus the demand for new wagons is lower, or the wagon stock is kept at the present level, the need for wagons increases and the new peak in production is just about to come. The average age of Finnish wagons is shown on Figure 17.

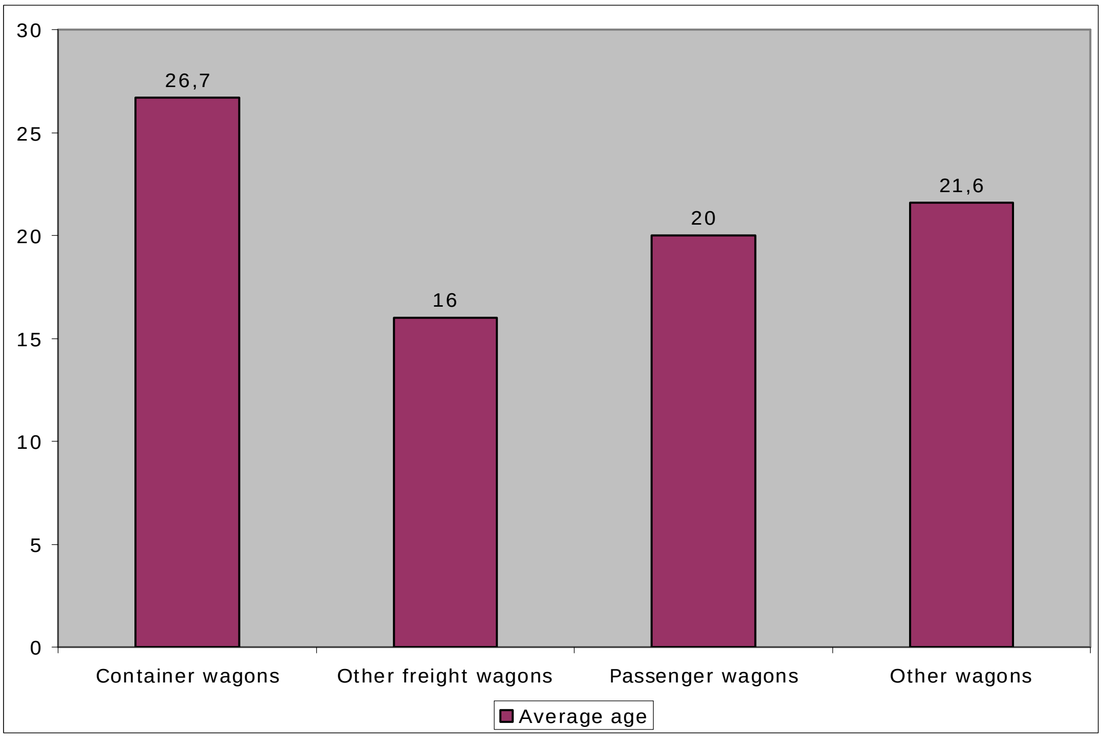

Figure 17. The average ages for different types of Finnish rail wagons (year 2006 situation). Source: Finnish Rail Agency (2006)

The wagons used for container transport are clearly the oldest with the average age of 26.7 years. Other freight wagons are the youngest among Finnish wagons. Their average age is 16 years. Passenger wagons and other kinds of wagons are nearly the same age at 20 and 21.6 years. Although, Finnish Rail Agency does not define normative lifetime for railway equipment, it can be stated that Finnish wagons are pretty old as well.

5.4 Age distribution of Swedish wagons

The deregulation of the railways in Sweden was fulfilled in 2000 – process itself started in 1988 and already during 1990's there started to appear private operators in both freight and passenger operations (Hilmola et al. 2007). The commercial authority state owned SJ was divided up into six different companies, including the goods transporter SJ Green Cargo. Most of the newest wagons in Sweden are rebuilds from frames of older wagons and these frames are often more then 50 years old. Many wagons are rented. These wagons are mostly owned by AAE, formerly named Ahaus Alstätter Eisenbahn. The intermodal fleet is not older than 25 years and the four axle wagons are mostly delivered from 1995 to 2005. The two axle intermodal wagons are generally from 1975 – 1990. Age of Green Cargos wagons can be seen in Figure 18. There are also more new cars on the way to GC. i.e Laaps wagons for log transports. Big customers also have their own cars such as SSAB have plenty of new

Shimmns and Rilns cars (see Figure 19). Privately owned railcars are often newer than the operators' cars.

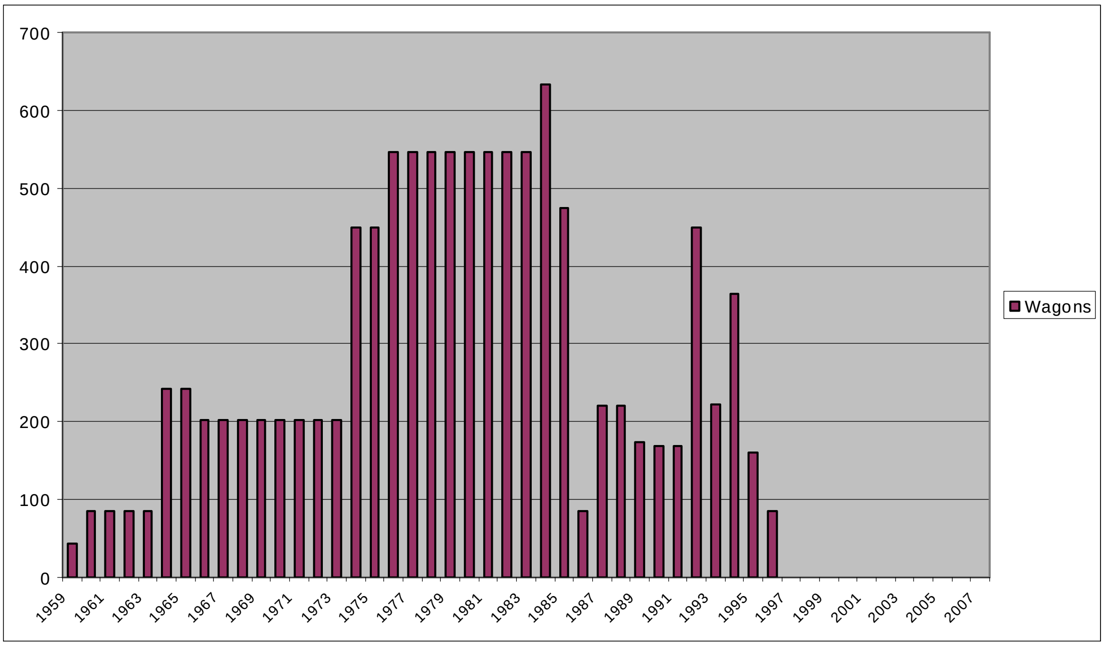

Figure 18. Age distribution of the Swedish freight wagons by the year of manufacture. Source: Communication with Swedish Railway Sector Consultants (June 2007) – indicative estimate.

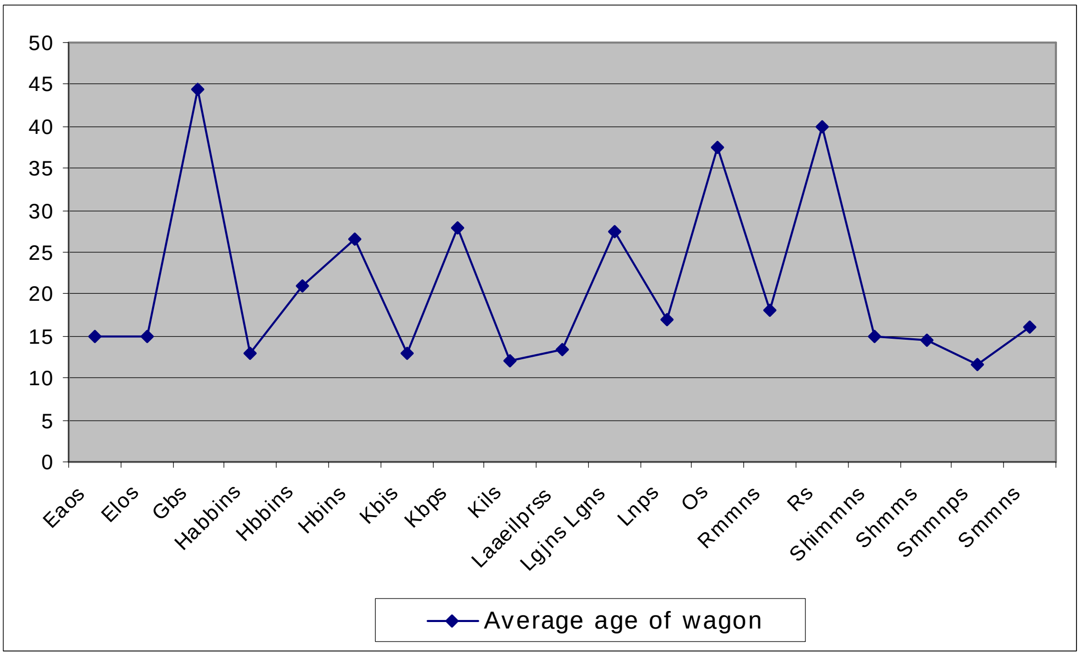

Figure 19. The average ages of different Swedish freight wagon types. Source: Communication with Swedish Railway Sector Consultants (June 2007) – indicative estimate.

5.5 Age distribution of Estonian wagons

The Estonian freight wagon fleet is on the average quite new, if compared with other countries included in this study (see Figure 20). The average age of the Estonian freight wagons is only 10 years, which is far more less, when compared with e.g. Finland, 18.5 years. The Estonian fleet is quite large, if compared with the railway network in Estonia. The railway network in Estonia is only 958 km long, so if all of the freight wagons would be at the same time in Estonia, there would be approximately 20 freight wagons for each kilometre of the railroad (wagon for every third meter).

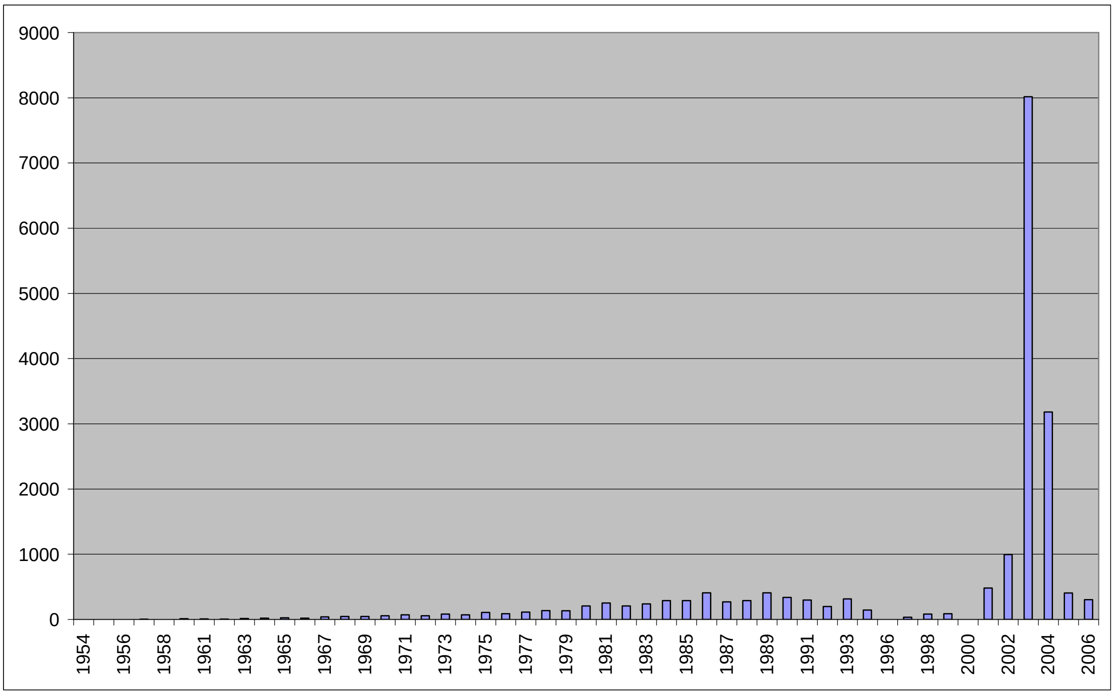

Figure 20. Age distribution of the Estonian freight wagons. Source: Estonian Railway Inspectorate (2007)

According the data given by the Estonian Railway Inspectorate, there are 19006 freight wagons registered in Estonia. More than three quarters of these wagons are tank cars (see Table 6). Why such a large amount of tank cars are needed in Estonia, which is a land without any crude oil reserves? The sharp rise in the amount of tank cars happened between years 2001 and 2005, when the price for the crude oil climbed very high and Russia started to export crude oil more heavily (e.g. analyzed in details by Terk et al. 2007: 57-71). Obviously most of these tank cars were built in Russia or in Ukraine and they were just registered to Estonia and leased back for the oil transportation purposes. Despite of the various political disputes between Russia and Estonia, the Estonian ports are still widely used to export Russian crude oil and other raw materials. This is mostly due to the reason that Russia still lacks port handling capacity, although it has invested in new ports (discussed in details in Terk et al. 2007). During year 2007, the Russian transit through Estonia declined substantially. This was obviously due to new problems in Estonian-Russian relationship caused by the moving of the statue of Bronze Soldier in Tallinn during spring 2007.

Table 6. Estonian freight wagons divided in subtypes. Source: Estonian Railway Inspectorate (2007)

Subtype of freight wagons	Sum	Share
Hopper	180	0.9
insulated/thermos car	15	0.1
dump car	213	1.1
weigher car	2	0.0
box car	591	3.1
refrigerator car	2	0.0
Flat car for containers	80	0.4
Flat car	686	3.6
gondola car	1981	10.4
cement tank car	69	0.4
tank car	14555	76.6
Unidentified	632	3.3
All wagons	19006	100

The investments to the Estonian freight car fleet reached its peak in 2003 (see Figure 21). In that very year almost 8000 tank cars were purchased, when in the previous year the amount was only 1000 tank cars. After 2003 the investments declined very heavily, and during 2006 only some tank cars were purchased.

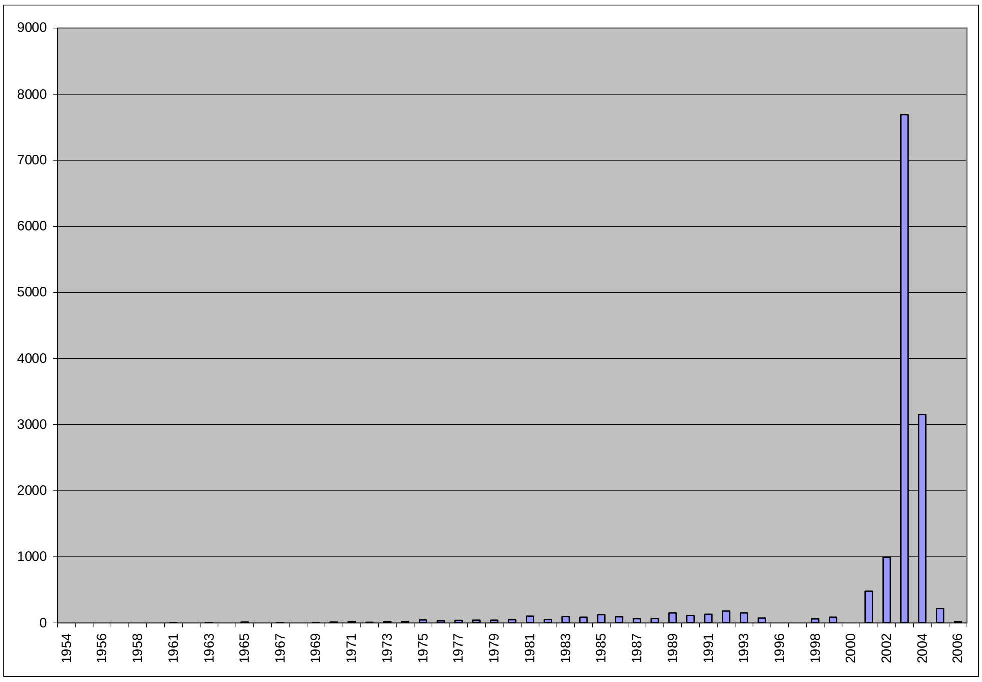

Figure 21. Estonian tank cars used divided by the year of manufacture. Source: Estonian Railway Inspectorate (2007)

As the tank cars dominate in Estonia, the figures are almost identical. Concerning the flat cars, there has been a significant rise in purchase volume during the last two years, but this has been quite modest, if compared with tank cars. Last year 200 flat cars were purchased in Estonia, which is obviously due to the rise in container transport (see Figure 22).

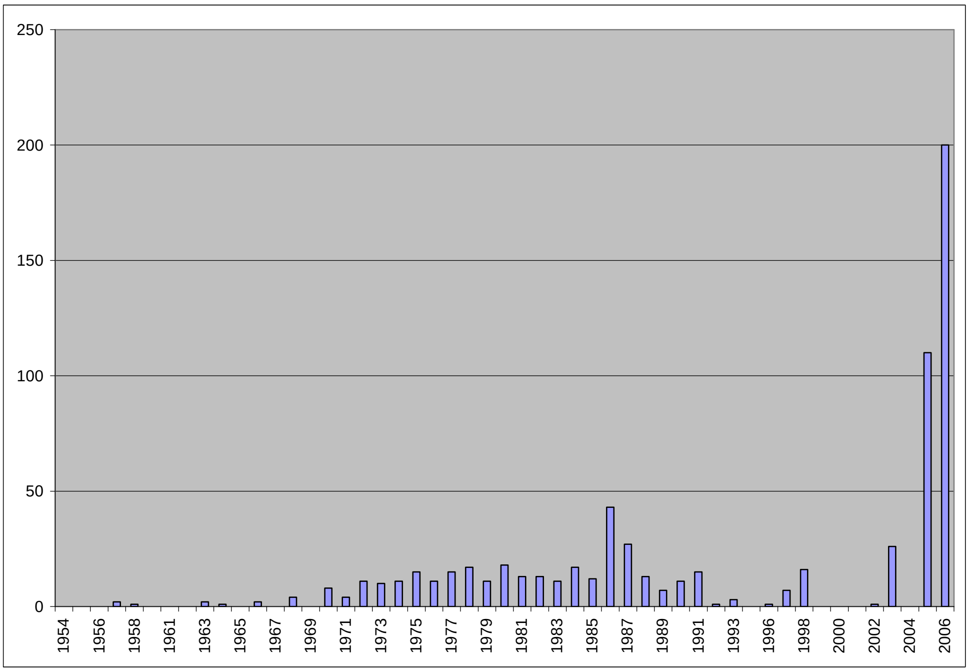

Figure 22. Estonian flat cars used divided by their year of manufacture. Source: Estonian Railway Inspectorate (2007)

6 PERSPECTIVE ANALYSIS OF FREIGHT WAGON MARKET IN RUSSIA, FINLAND AND ESTONIA

6.1 Finnish freight wagon market in 10-years perspective

In order to analyse the railway wagon market in Finland several assumptions were made. Since, the Finnish Rail Agency does not define normative lifetime for railway equipment, the normative age of 32 years was used to perform the calculations. It means that wagons exceeded 32 years were regarded as too old to be used without renovation. In the most of calculations only actually used wagons were taken into account. Wagons, which are still in stock, but are not operated any more, were discarded.

To forecast the situation on Finnish wagon manufacturing market in a 10-years perspective we created three scenarios:

1) In the first scenario the analysis of the Finnish wagon market was made with the assumption that no new wagons are manufactured during the next ten years and the wagon stock is kept at the current level (see Figure 23).

In reality, the wagon stock is not kept the same – it may increase or decrease depending on the existing demand for railway transport services and policy of railway operators. Therefore:

2) In the second scenario the analysis is made assuming that wagon stock would be reduced by 15 % (e.g. too old wagons are removed without replacement) and no new wagons would be built. It should be noted, however, that the wagon stock was reduced by the 15 % at once and the need for new wagons was calculated according to that number (see Figure 24);

3) In the third scenario the opposite situation the analysis is made assuming that wagon stock would be increased by 15 % and no new wagons would be built. The capacities of road and sea transport have restricted possibilities to expand. Railway transport gains in popularity, especially for long-distance international deliveries. The growing need in transport services may stimulate Finnish rolling stock operators to the increase wagons stock (see Figure 25).

It is very unlikely that all manufacturing of wagons would be stopped. Therefore, more realistic analyses taking into account the newly manufactured wagons were made for all three scenarios (see Figures 23, 24 and 25).

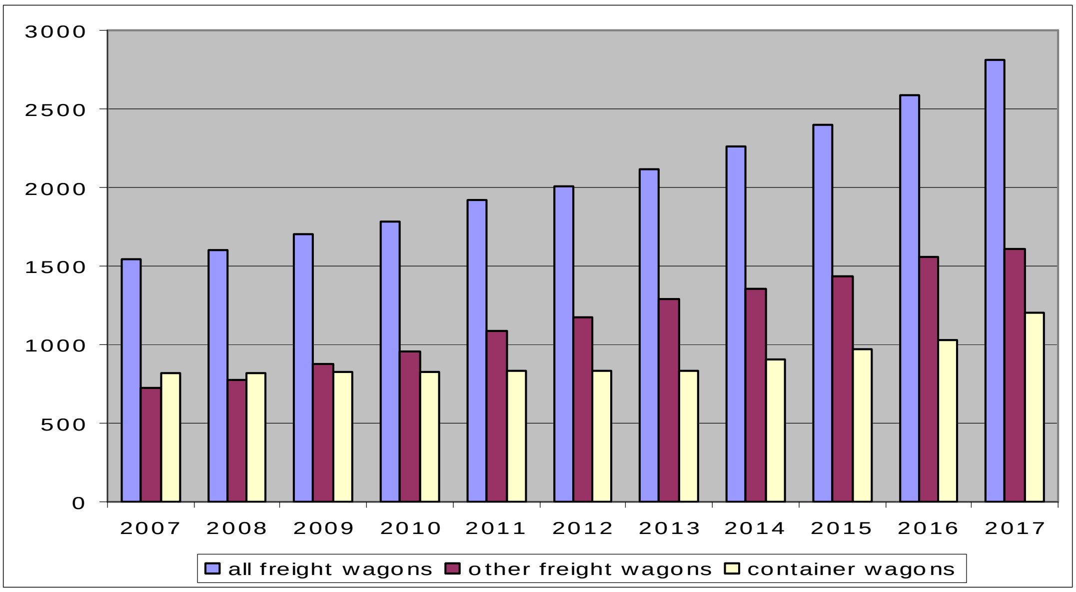

Figure 23. Forecasted need of freight wagons in Finland, if no new wagons are built during the next 10 years (cumulative).

As can be seen from Figure 23, if stock is kept on the current level and no new wagons are built, the need in new wagons will grow and in 2017 there will be a shortage of almost 3 000 wagons. At first there will be more need in container wagons, but after 2009 the need in other freight wagons will grow significantly.

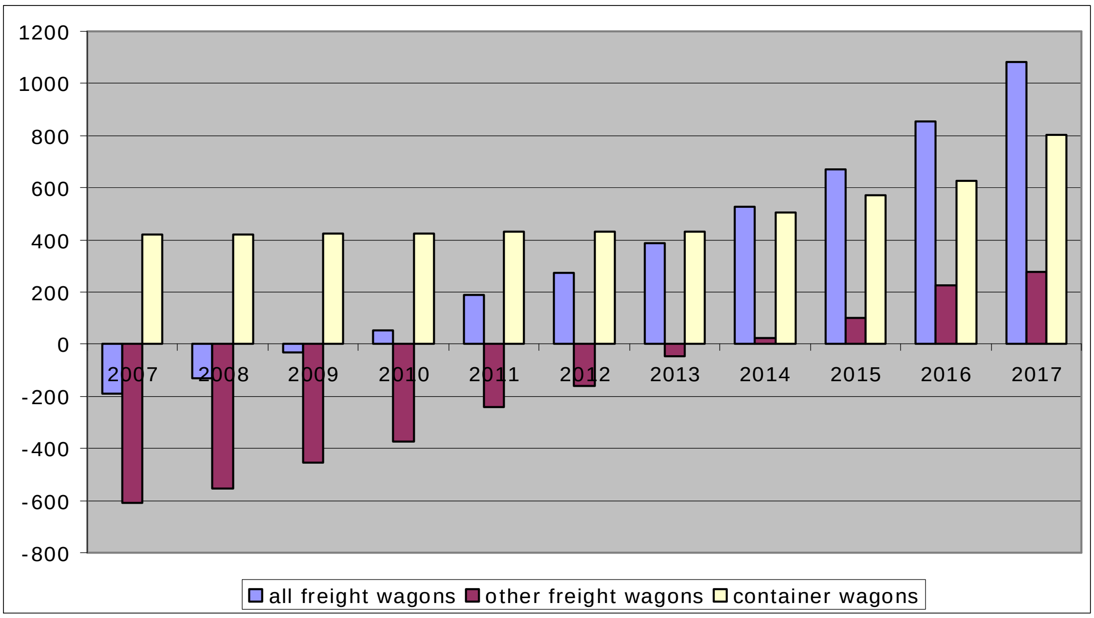

Figure 24. Forecasted need of freight wagons in Finland, if the wagons stock is reduced by 15% and no new wagons are built (cumulative).

As Figure 24 shows, if the stock would be reduced, there still would be significant need for container wagons, but the demand for other freight wagons would be diminished. Nonetheless, by the year 2017 there would be a shortage in all freight wagons.

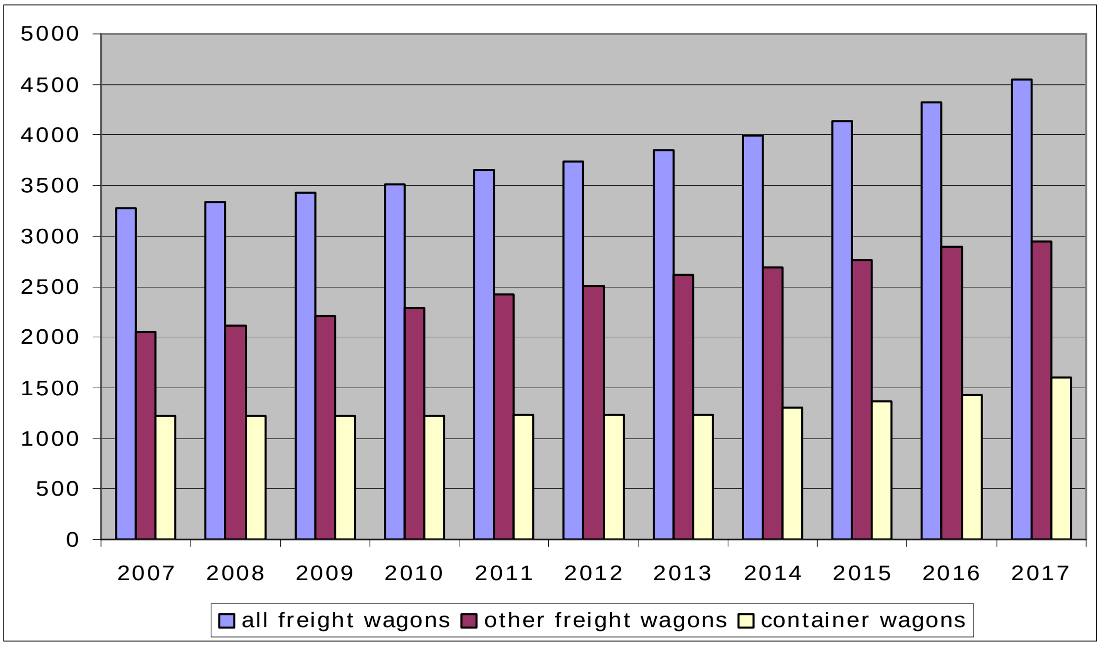

Figure 25. Forecast for the need of wagons in Finland if the wagon stock is raised by 15 % and no new wagons are built (cumulative).

As Figure 25 shows, if the wagon stock would be increased by 15 %, the need in all freight wagons would be significant instantly. Already in 2007 the estimated shortage of wagons would be over 3 000 of new wagons. If no new wagons would be built, by 2017 there would be 4 500 wagon shortage. That is over a one third of all wagons in use at the moment.

To take into account the production of new wagons the annual growth rate for wagons stock was calculated. Within the last 10 years the annual growth rate was on average 3.44 % - for all freight wagons, 0.37 % - for container wagons and 4.73 % - for other freight wagons. Thus, in the analysis the average annual growth rate of 3 % was taken into account.

If the wagon stock is kept at the current level and new wagons are manufactured at the level of 3 % of the previous year's volume, the result can be seen from Figure 26.

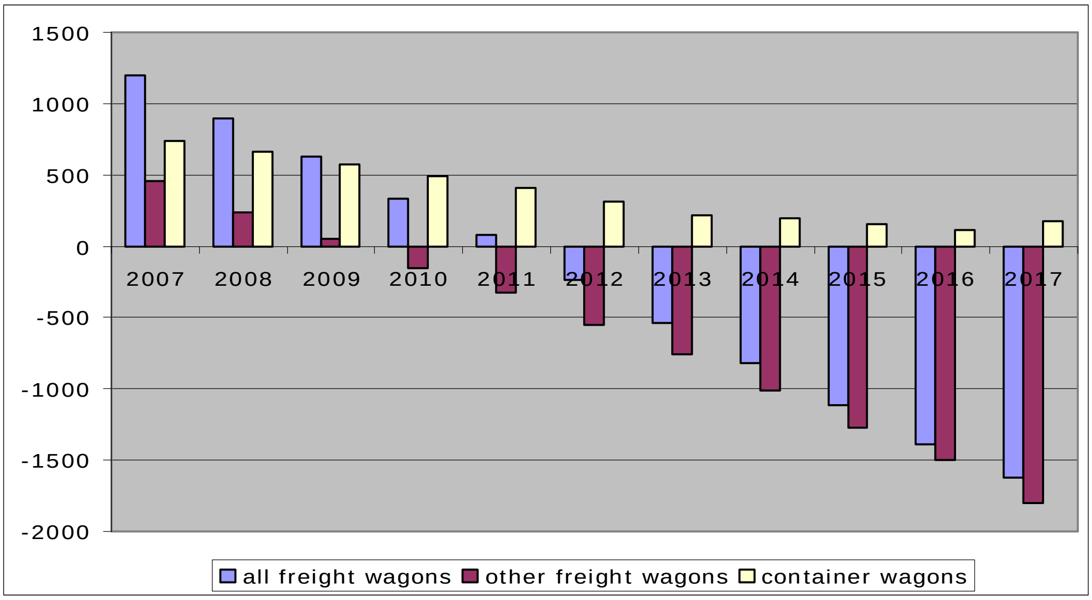

Figure 26. Forecast for new wagons in Finland, if the wagons stock does not change and new wagons are built at 3 % annual rate (cumulative).

As it can be seen from Figure 26, there still will be a need for container transport wagons at least until 2017, but for other freight wagons the demand is met in a few years and new wagons will not be needed after 2009.

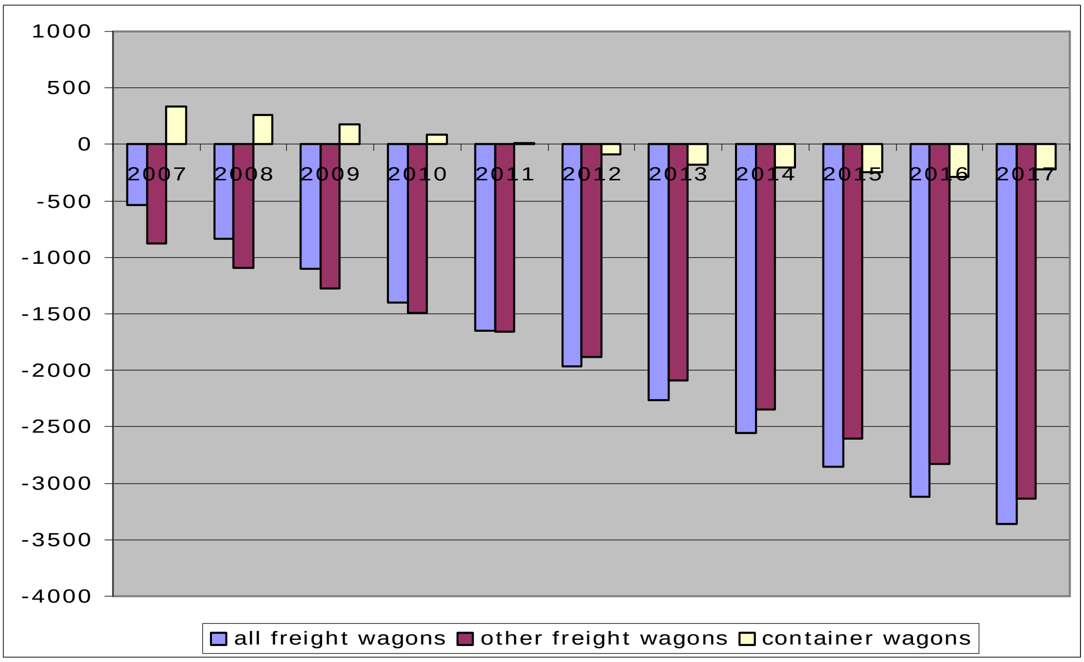

Figure 27. Forecast for new wagons in Finland, if the wagon stock is reduced by 15 % and new wagons are built at 3 % annual rate (cumulative).

Figure 27 shows that if the wagon stock would be reduced by the 15 % and the new wagons would be manufactured at 3 % annual rate, the need for new wagons would be very small. New container wagons should be manufactured more for the next four years, but other freight wagons would not be needed at all and the old ones could be removed easily from the use.

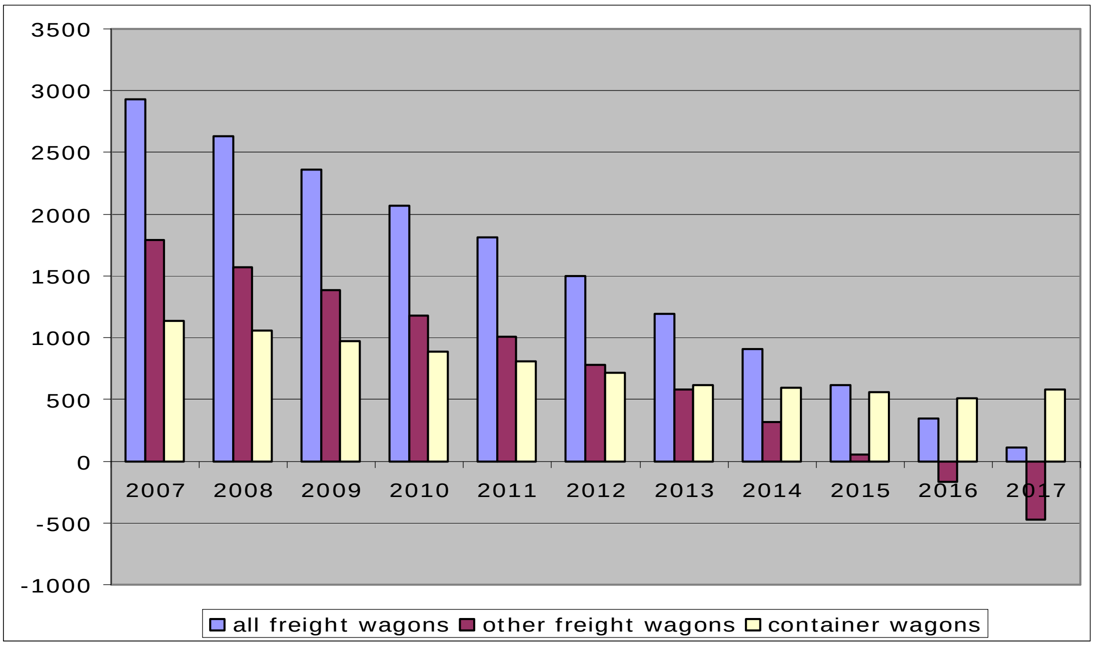

Figure 28. Forecast for new wagons in Finland, if the wagon stock is enlarged and new wagons are built at 3 % annual rate (cumulative).

As Figure 28 shows, the demand produced by the enlargement of the wagon stock can't be satisfied with the 3 % annual production rate in a short perspective. The demand for other freight wagons reduces gradually and is met by the year 2016, but the demand for container transport wagons will not be met that fast. With the annual production rate of 3 % in the container wagon sector the need for new wagons reduces quite slowly and might even increase a bit at some point beyond the year 2017.

Using the statistics information about the actual amount of wagons being in use and built in Finland during 1990 – 2005, a forecast for the production of new wagons was created (see Figure 29 and Figure 30).

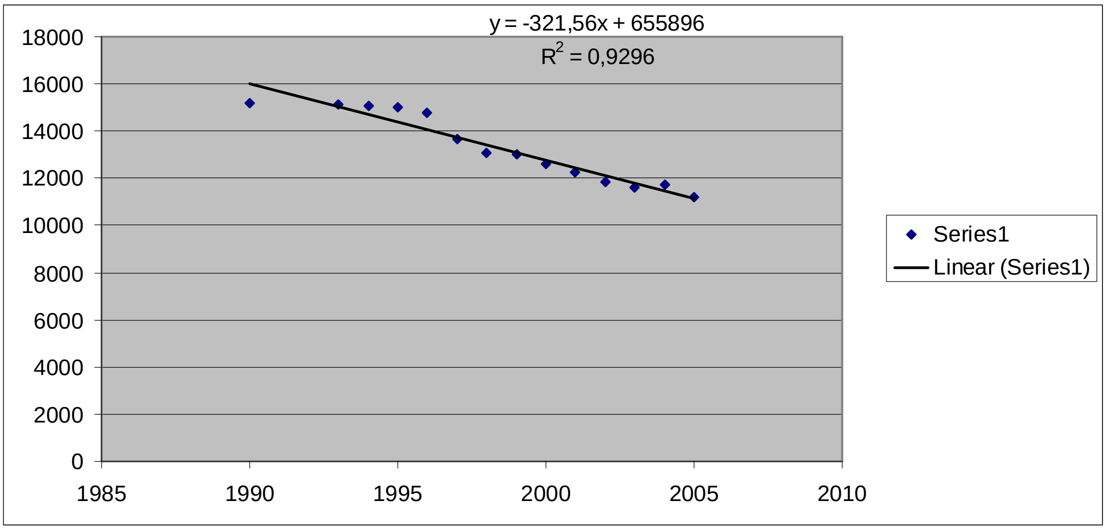

Figure 29. Regression model for Finnish freight wagons

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,964174683
R Square	0,929632819
Adjusted R Square	0,923768887
Standard Error	409,5898718
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	26596283,64	26596283,64	158,534044	2,82524E-08
Residual	12	2013166,357	167763,863		
Total	13	28609450			

	Coefficients	Standard Error	t Stat	P-value
Intercept	655896,0769	51035,89935	12,85166099	2,24455E-08
Year	-321,5606776	25,53886933	-12,5910303	2,82524E-08

	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	544698,4048	767093,7491	544698,4048	767093,7491
Year	-377,2050937	-265,9162615	-377,205094	-265,9162615

Figure 30. Regression statistics for Finnish freight wagons

As can be seen from Figure 29, the amount of new wagons has decreased steadily since 1990 and according to the forecast it will continue decreasing, if no measures are taken to prevent it. The R squared value here is quite high, which indicates strong correlation between the variables (see Figure 30). In this case, the model can explain above 92 % of the variation.

6.2 Russian freight wagon market in 10-years perspective

To forecast the situation on Russian wagon manufacturing market in a 10-years perspective the same three scenarios as in Finnish case were created.

According to the Russian railway legislation, normative age for flat wagons is 32 years and for other freight wagons 28.5 years. As due the lack of necessary data it was impossible to separate container wagons and other freight wagons (as in Finnish case), forecast is made only for the total freight wagons stock. Therefore, the average normative age for Russian freight wagons was established on the level of 28.8 years. The first scenario for the Russian freight wagon market is reflected on Figure 31.

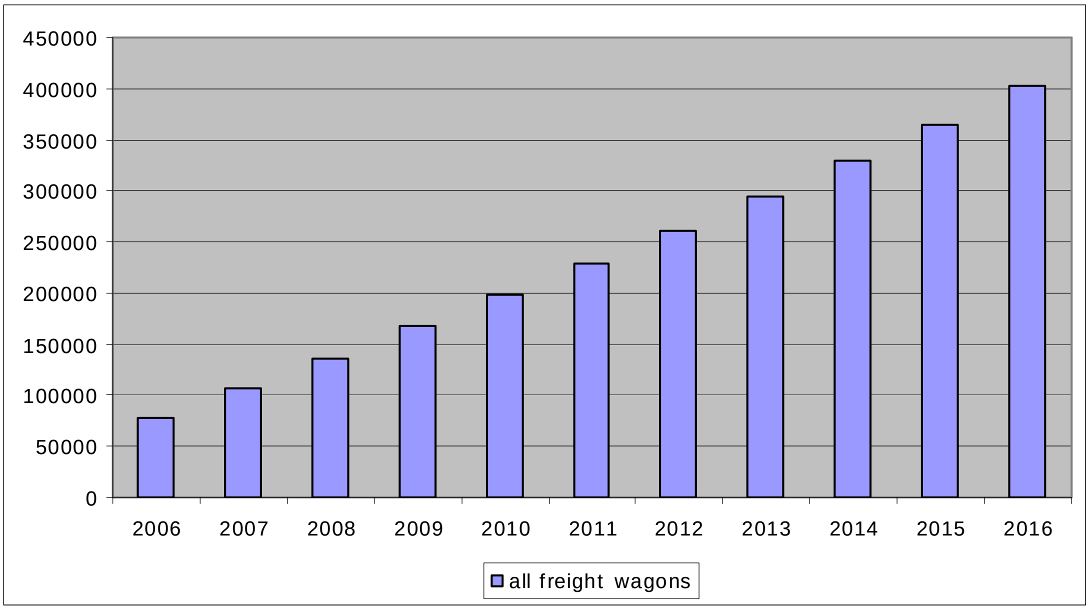

Figure 31. Forecast for new freight wagons in Russia, if no new wagons are built and the wagon stock remains on the current level (cumulative)

As it was stated in Section 4, the current number of freight wagons operated on Russian railways is about 630 thousand. If the wagon stock remains on the current level as and no new wagons are built, then by 2017 the shortage in freight wagons in Russia will exceed 400 thousand.

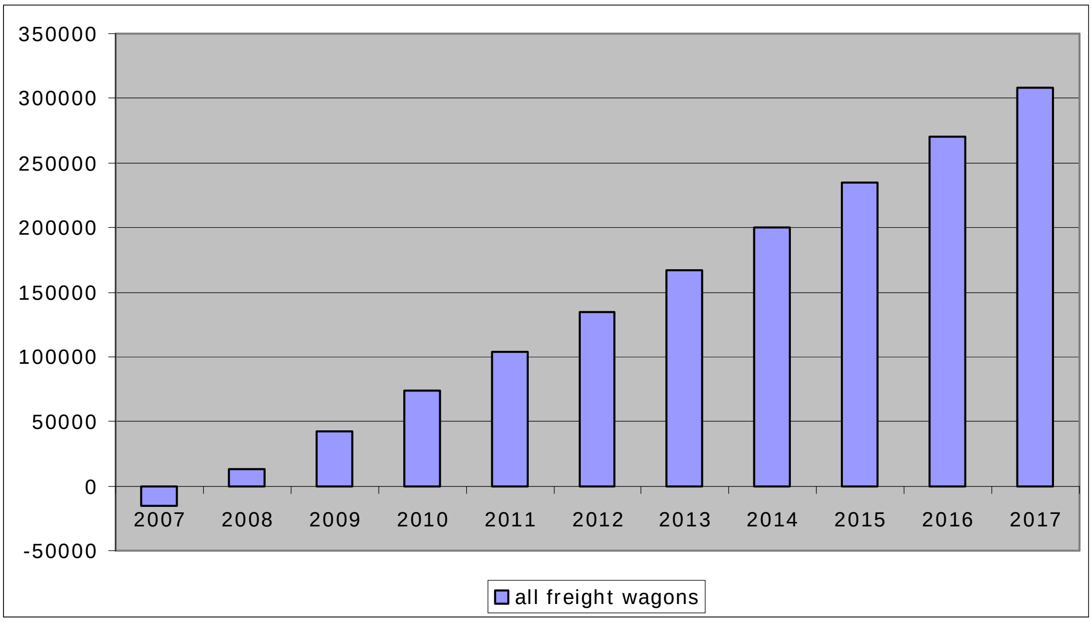

Figure 32. Forecast for new freight wagons in Russia, if no new wagons are built and the stock decreases by 15 % (cumulative).

In Figure 32 the second scenario for the Russian freight wagon market is presented. As Figure 32 shows, if no new wagons are built and the wagon stock decreases by 15 %, the shortage in new wagons will appear already in 2008 and by 2017 it will exceed 300 thousand wagons. The opposite situation in the third scenario is presented in Figure 33.

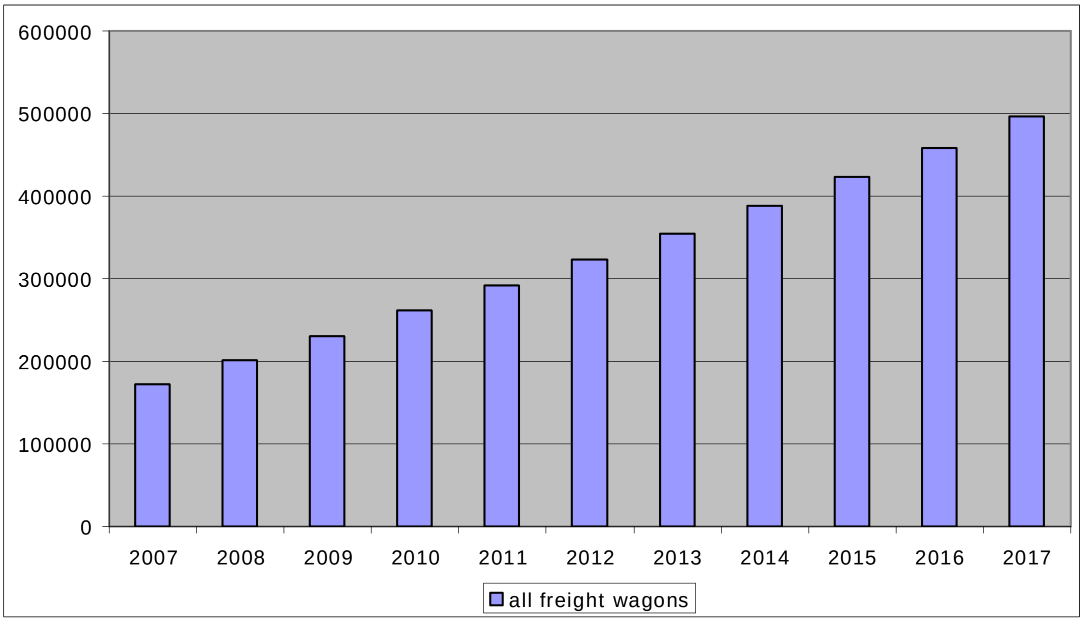

Figure 33. Forecast for new freight wagons in Russia, if no new wagons are built and the wagon stock enlarges by 15 % (cumulative).

Figure 33 shows that in case the wagon stock increases and no new wagons are built, the shortage of wagons will be even greater than in previous scenarios. By 2017 the shortage of freight wagons in Russia will reach 500 thousand.

Most probably, Russian wagon manufacturers are not going to stop their production. Moreover, manufacturers from other countries, especially from Ukraine, supply wagons for Russian market. Therefore, the additional analyses taking into account the new wagon manufacturing volumes were made.

During the last years, RZD acquired new freight wagons at the annual rate of 1.5 % of the total stock. Taking into account also purchases made by independent rolling stock operators, it was calculated that during the last decade the wagons stock in Russia increased on average by 3 % annually. Thus, further calculations were made using the annual growth rate of 3 % (see Figure 34, Figure 35 and Figure 36).

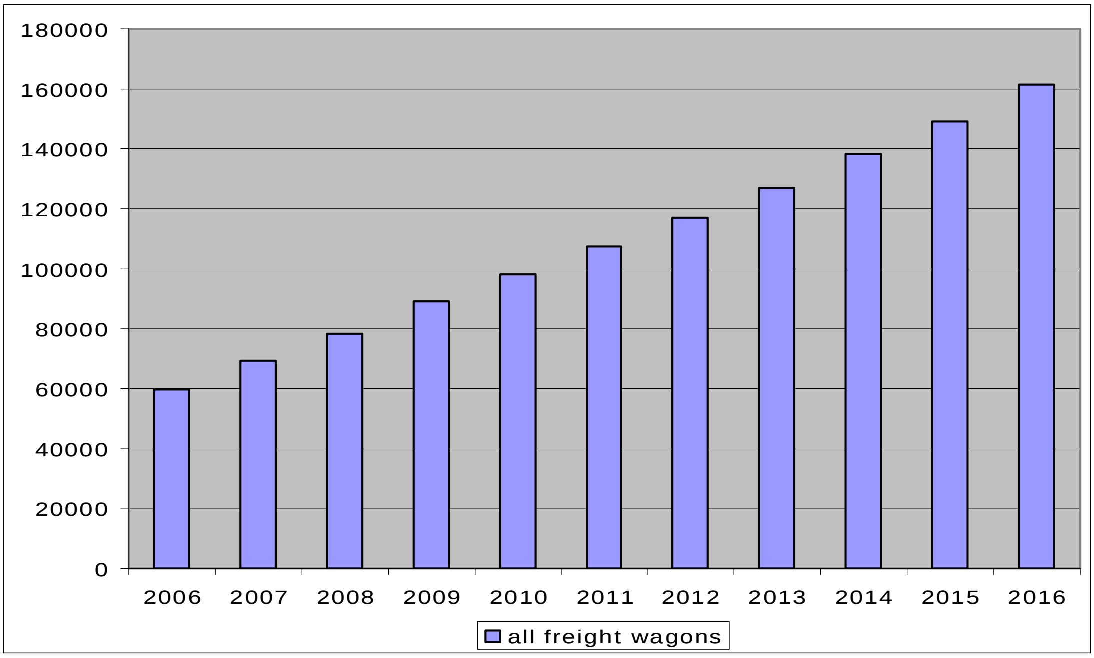

Figure 34. Forecast for new freight wagons in Russia, if the stock stays the same and new wagons are built at 3 % annual rate (cumulative).

As Figure 34 shows, if the wagon stock remains on the current level, there shortage in freight wagons will not be covered by new wagons and in 2016 it will exceed 160 000.

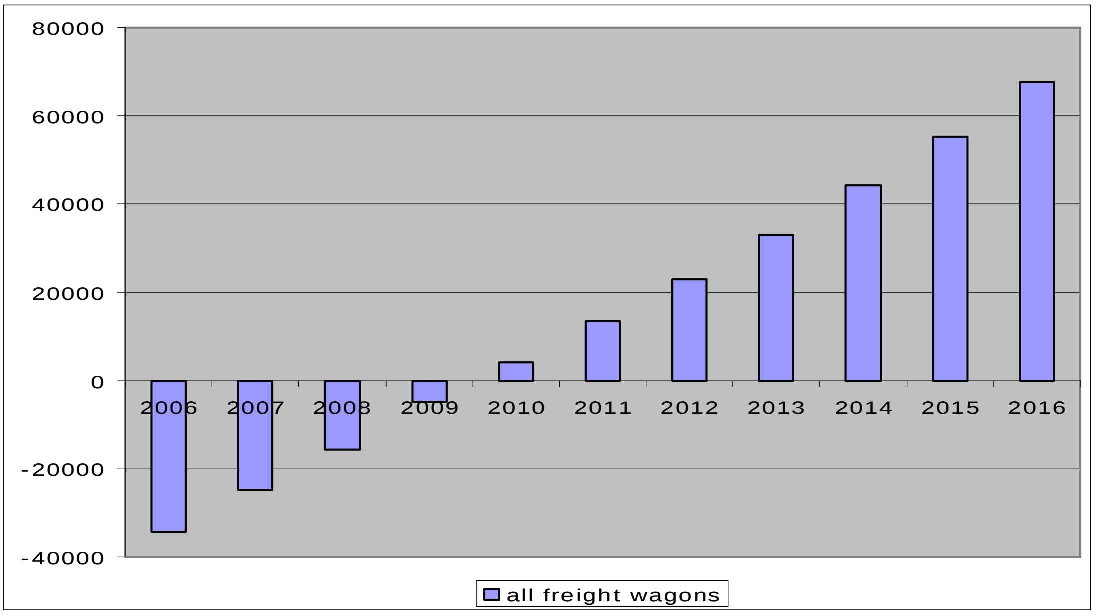

Figure 35. Forecast for new freight wagons in Russia, if the wagon stock decreases 15 % and new wagons are built at 3 % annual rate (cumulative).

Figure 35 shows that if the wagons stock is reduced by 15 %, the need in new wagons will be evident since 2010 and henceforth until at least 2016, when the shortage will exceed 65 thousand.

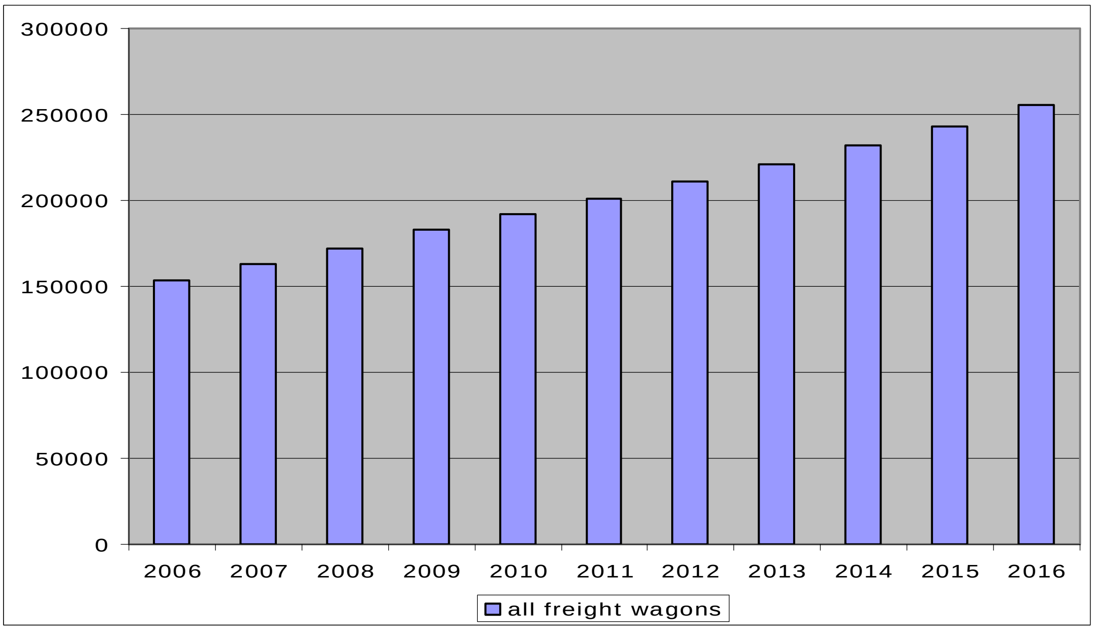

Figure 36. Forecast for new freight wagons in Russia, if the wagon stock increases 15 % and new wagons are built at 3 % annual rate (cumulative).

Figure 36 shows that if the wagon stock is increased by 15 %, the new wagons will be needed immediately. New production will not cover that need. In 2016 the shortage in freight wagons will exceed 250 000.

Using the statistics information about the actual amount of wagons built in Russia during 1990 – 2002, a forecast for the production of new wagons was created (see Figure 37 and Figure 38).

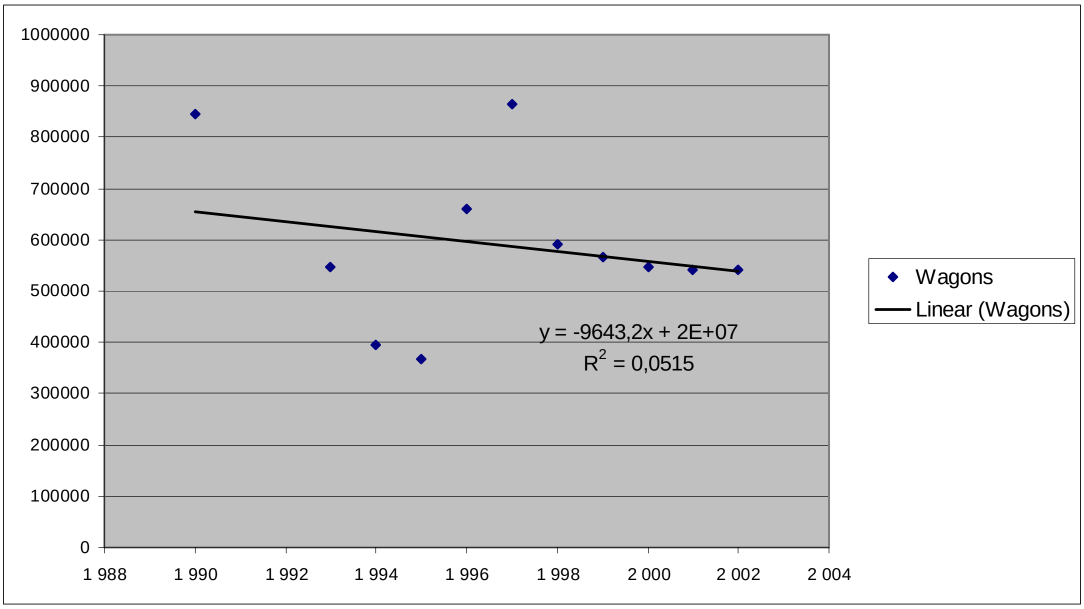

Figure 37. Regression model for Russian freight wagons.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,226913582
R Square	0,051489774
Adjusted R Square	-0,053900252
Standard Error	159486,3195
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12427058589	12427058589	0,488564013	0,502230386
Residual	9	2,28923E+11	25435886109		
Total	10	2,4135E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	19843905,88	27548648,33	0,720322306	0,489610887
Year	-9643,214966	13796,25176	-0,698973542	0,502230386

	Lower 95%	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-42475466,14	82163277,9	-42475466,14	82163277,9
Year	-40852,50465	21566,07472	-40852,50465	21566,07472

Figure 38. Regression statistics for the Russian wagons

As it can be seen from Figure 37 the amounts of freight wagons manufactured in Russia in different years differ more significantly than in Finland. However, the general trend is that the volume of annual production of wagons is diminishing in Russia as well as in Finland. At the same time the decrease rate in Russia is not as high as in Finland. It should be noted, however, that because of the dispersion in the original data, the R squared value is quite small and therefore the model can not be treated as reliable as it can explain only about 5 % of the variation (see Figure 38). The completed analysis results are similar to the ones presented by VKM Leasing (see Figure 39).

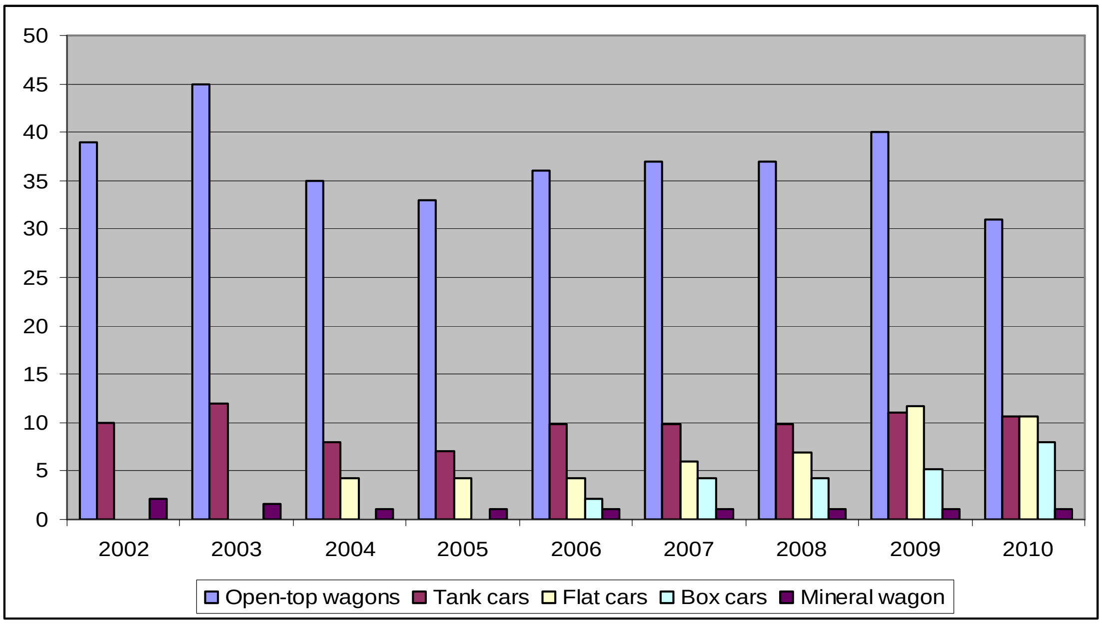

Figure 39. Deficit for different kinds of wagons in Russia, in thousands. Source: VKM Leasing (2004)

According to VKM Leasing, since in general freight wagons in Russia are quite old and need to be replaced, in the near future there will be a deficit for all kinds of freight wagons (Figure 39). The decrease in that deficit is expected only in 2010. The open-top wagons are needed the most, but tank cars, platforms and box cars will be in desperate need since their shortage will double in a few years. VKM Leasing also predicts that increasing demand will be expected mostly for tank cars due to new development in the gas industry and shortage in existing pipelines. Flat cars will represent the second most demanded kind of wagons as container transportation market in Russia is growing at a high rate (VKM Leasing, 2004).

6.3 Estonian freight wagons market in 10-years perspective

Generally speaking flat cars used for container transport are still scarce in Estonia. Like indicated before, most of the wagons belonging to Estonian companies are dedicated for transporting crude oil. The quantity of freight wagons skyrocketed during the last five years, and this creates base where forecast based on history does not give any reasonable result for the evaluation of the future of container wagon need. Obviously we will see a peak of some hundred wagons during year 2007 (and during following one). As earlier mentioned, freight wagons in Estonia are relatively new and rightly allocated to the needs of the current situation. There will be no need for tank cars, since during year 2007 transportation volumes of the crude oil through Estonia decreased (scenario presented in Figure 41 corresponds to this situation better). Obviously there will be no increasing need for flat cars, but there may be a need to invest in the other type of wagons (see Figure 40). If the quantity of Estonian wagons will diminish in the future, there will be very little demand for new wagons, since the existing wagons are on the average relatively new.

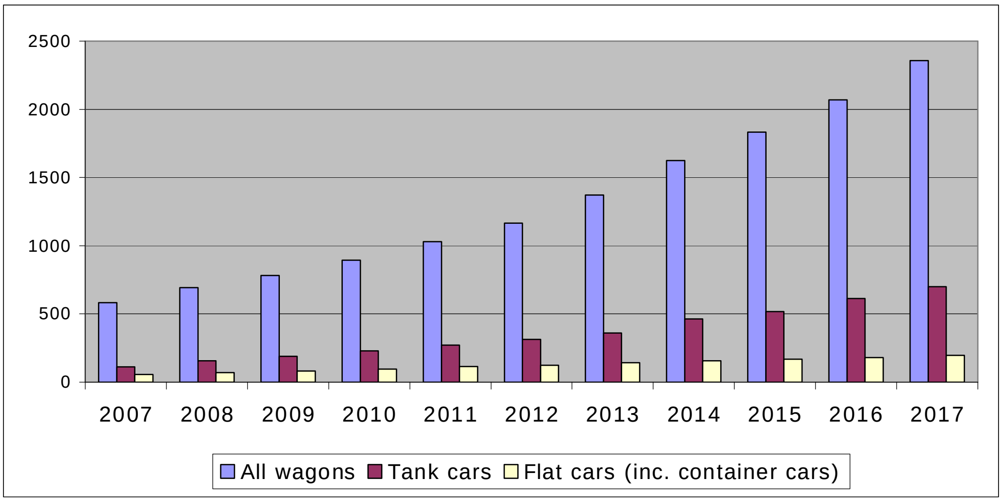

Figure 40. Forecasted need of freight wagons in Estonia, if no new wagons are built during the next 10 years (cumulative).

If the number of wagons will reduce by 15 %, there will be almost no need for new wagons during the next 10 years. Only some flat cars will be needed (Figure 41). More optimistic scenario is presented in Figure 42.

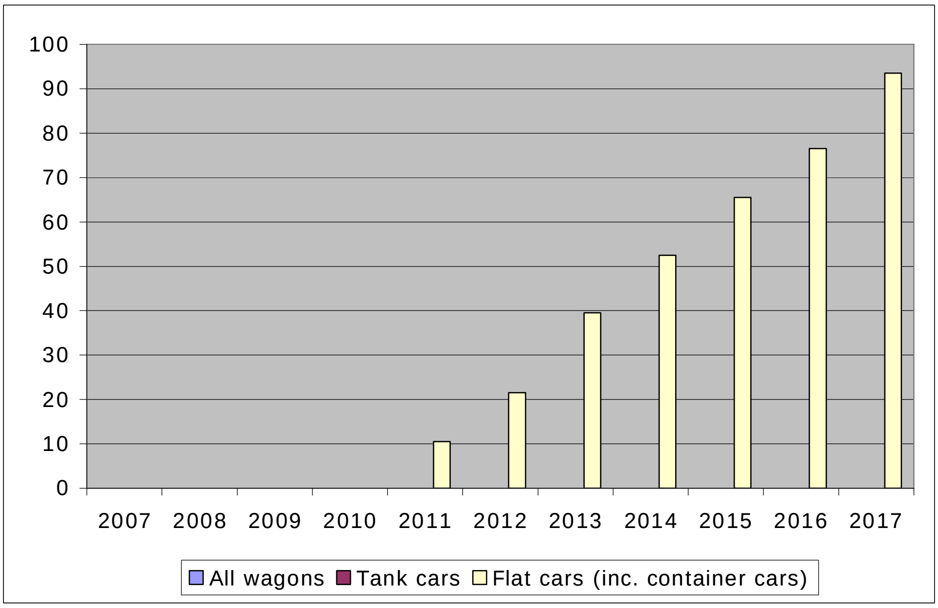

Figure 41. Forecasted need of wagons in Estonia, if wagon stock is reduced by 15 %, and no new wagons are being built (cumulative).

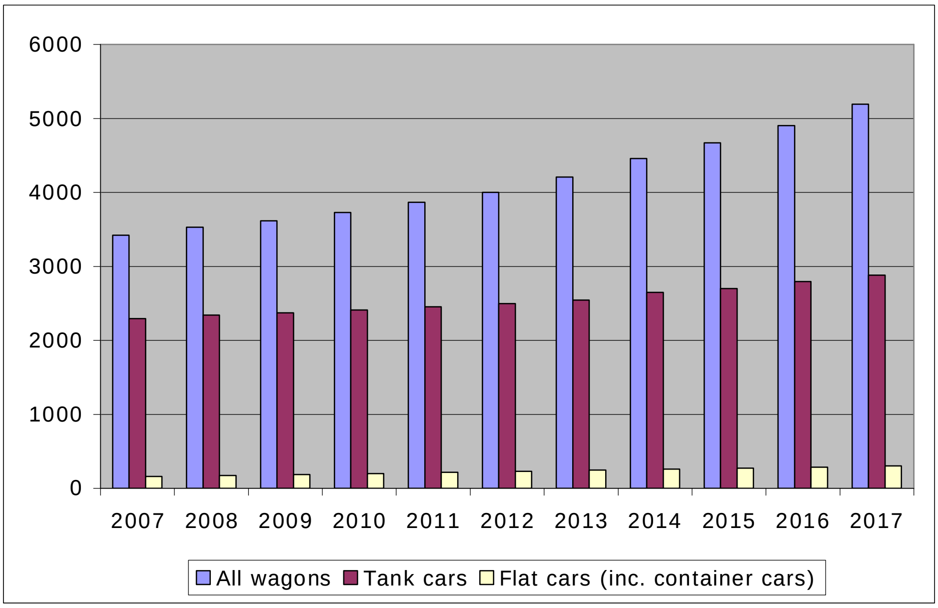

Figure 42. Forecasted need of wagons in Estonia, if wagon stock is increased by 15 %, and no new wagons are being built (cumulative).

7 RAILWAY MACHINE BUILDING IN RUSSIA: HISTORY AND CURRENT TRENDS

7.1 History of railway machine building in Russia and Soviet Union

Prior to the reign of Nicholas I, very little consideration had been given to railroads in Russia. A few mines and factories in the Urals used tramways already in the 19th century to move ore or products, but they used horses or men to pull the carts over short distances. Several proposals were made to build railways, but none were accepted until the Austrian engineer Franz Anton von Gerstner pushed through his proposal to build the St. Petersburg-Tsarskoe Selo Railway in spring 1836. The railroad was built quite quickly and the first locomotive was tested on it already in November that year. This was the first public railway and already in that year a first railroad for industrial use was taken in use. This inaugurated the start of railways in Russia, and set the pattern for subsequent government attitudes about and policies on railway development (Fink 1991).

Railway machine building has even a bit longer history in Russia and in the Soviet Union than the railways intended for steam locomotives have. The locomotive building started already in 1833 when father and son Cherepanov, having previously built steam engines for pumping water in the mines, started the construction of the first locomotive in Russia.

The collapse of the Soviet Union almost 20 years ago divided the multiple Soviet manufacturing plants between different countries, mainly between Russia and Ukraine. It can be explained by the fact that railway manufacturing plants were most often (but not always) constructed close to the production of iron and steel – like in the Urals and in the eastern Ukraine.

The market of railway machine building in Russia and in the CIS has a remarkable growth potential. Lately, the demand from the state railway monopolies of Russia and the CIS and also from emerging independent rolling stock operators (potentially up to 50 % of all demand) is constantly growing at a high rate. It is estimated that by 2010 the market of railway machine building (production, modernization and repair) in Russia and in the CIS will almost double and will make up about 15-20 % of the world market (TransCreditBank 2005).

Railway machine building consists of four sectors (TransCreditBank 2005):

- Locomotives manufacturing;

- Freight wagons manufacturing;

- Passenger wagons manufacturing;

- Production of track equipment.

In this study we are focusing on the freight wagons manufacturing sector of Russia.

7.2 Current situation and trends

The railway manufacturing industry in Russia is characterised by the high concentration of production. Freight wagon manufacturing is not that monopolistic as locomotive manufacturing or passenger wagons manufacturing. Still, the share of three leading plants (Uralvagonzavod FSUE, Altaivagon JSC and Ruzkhimmash JSC) is about 90 % of the total freight wagon production. The share of Uralvagonzavod FSUE exceeds 60% - in 2004 it produced 21 168 wagons. In 2004 Altaivagon JSC and Ruzkhimmash JSC produced 6 084 and 6 072 respectively. Earlier there was forth big player – Abakanzavodmash JSC with annual capacity of 2 000 wagons, but in 2004 its production decreased significantly. Three leaders control the production of box cars, open-top wagons, tank cars and flat cars. The only sector, which is out of their control, is production of self-unloading cars and hopper cars, which are mainly produced by Bryansk wagon manufacturing plant belonging to Transmashholding CJSC group. The production of freight wagons in Russia in 2003-2006 is shown in Table 7.

Table 7. Production of freight wagons in Russia in 2001-2006. Source: Rosstat, companies' data

	2003		2004		2005		2006	
	items	%	items	%	items	%	items	%
Altogether	26 973	100.0	35 358	100.0	35 200	100.0	33 700	100.0
Tank cars	15 579	57.7	11 174	31.6	n.a.	n.a.	n.a.	n.a.
Open-top wagons	5 250	19.5	13 706	38.8	n.a.	n.a.	n.a.	n.a.
Box cars	1 248	4.6	4 704	13.3	n.a.	n.a.	n.a.	n.a.
Flat cars	4 654	17.2	5 022	14.2	n.a.	n.a.	n.a.	n.a.
Dump cars & hoppers	258	1.0	752	2.1	n.a.	n.a.	n.a.	n.a.

As it can be seen from Table 7, the total production of wagons grew up to 2004 and since then it has been quite stable. The most significant growth was evident in 2003, when the total output of freight wagons production was about 2.5 times higher than in previous 2002 year (not shown in table). It was a result of the huge increase in the demand from private companies created by introduction of 15 % tariff discount for transportation in private wagons. However, already in 2004 the growth of production was significantly lower - 31%. In the following 2005 and 2006 a small decrease in the volume of freight wagon production could be observed. This situation is partly explained by the fact that independent operators placed their orders on Ukrainian plants, production of which is about 10-20% cheaper.

If we analyse the general situation in the railway manufacturing in Russia, it can be noticed that Russia is a net importer of the railway manufacturing production and Ukraine is the main exporter to the Russian market (Figure 43 and Figure 44). Russia is mainly exporting railway machines to several CIS countries, as can be seen from Figure 45.

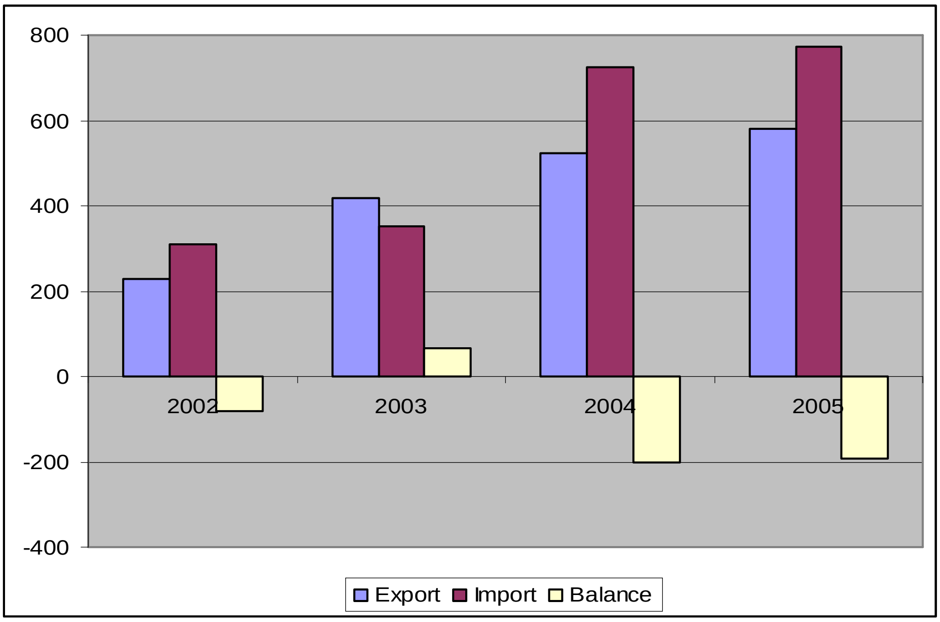

Figure 43. Balance of Russia's foreign trade of railway manufacturing production, USD million. Source: Rosstat, Minpromenergo

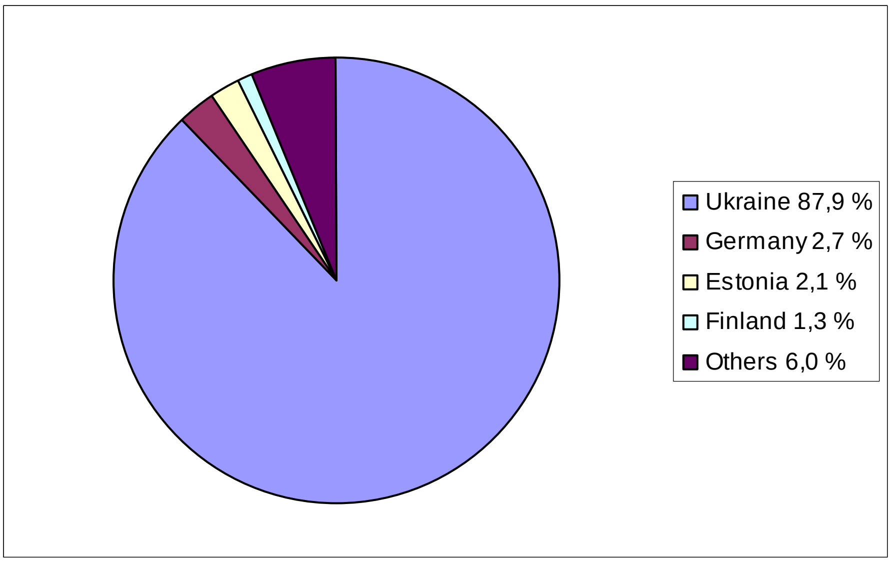

Figure 44. Main import partners of Russia in railway manufacturing trade. Source: Rosstat, Minpromenergo

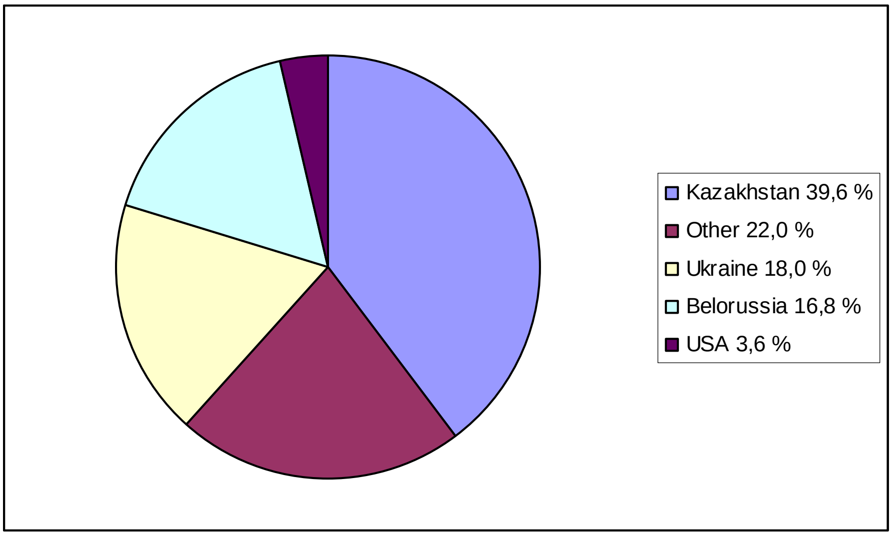

Figure 45. Main export partners of Russia in railway manufacturing trade. Source: Rosstat, Minpromenergo

As Figure 43 shows, in 2002-2005 Russia had the trade deficit in the railway manufacturing production. Only in 2003 small trade surplus could be observed. During that period import from Ukraine has grown from USD 190.5 million in 2002 to 679.1 million in 2005. Freight wagons take about 50 % of that import. The share of Ukrainian wagons in Russian freight wagon market is about 25 % (Zaiko, A., 2006).

To a certain extent Russian-Ukrainian collaboration could be explained by historical reasons. In Soviet Union time (in 1980's) Ukrainian wagon manufacturing plants annually produced 72 000 of freight wagons satisfying 60 % of the total demand of all Soviet Republics (Verner N., 2006). Immediately after the dissolution of the Soviet Union and the division of Soviet assets Russia could satisfy only 50 % of the internal demand for the railway manufacturing production. The followed sharp drop in transportation volumes and thus in the demand for new wagons decreased investment possibilities of Russian manufacturers. As a result, by the start of economy revival the Russian railway manufacturing plants have lost 30 % of their production capacities. Remaining capacities are characterized by 65-70 % depreciation and technological inferiority of 15-20 years. That is why existing production capacities of the Russian railway manufacturers can't be fully utilized to meet the growing demand (see Figure 46).

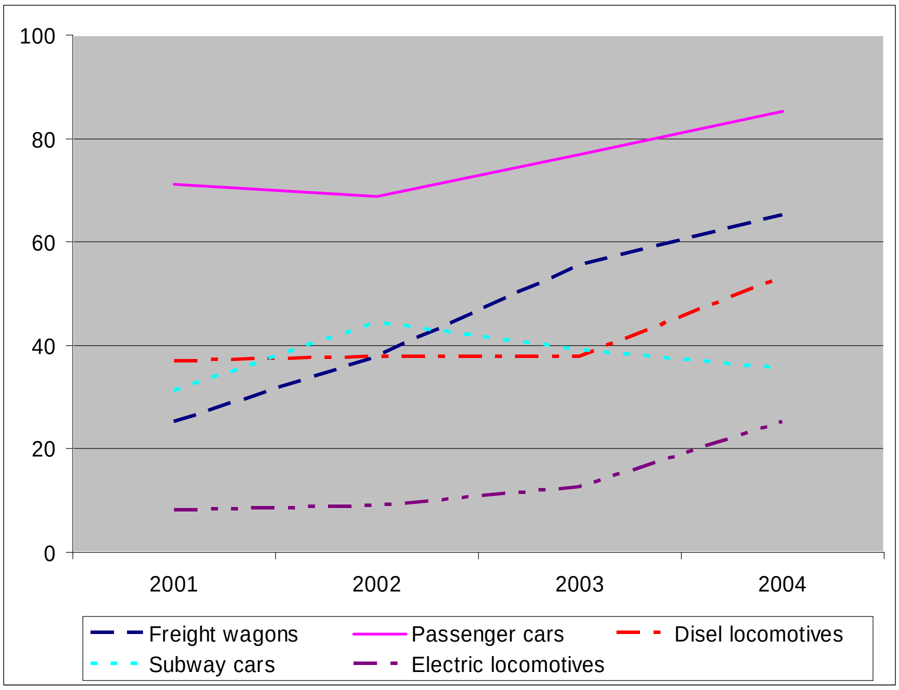

Figure 46. Utilization of production capacities in Russian wagon manufacturing in 2001-2004, %. Source: Minpromenergo

As it can be seen from Figure 46, the situation in the railway manufacturing sector is improving. In 2001 the average utilization rate of production capacities was about 35 % and in 2004 it increased to almost 55 %. However, it is not enough to satisfy the growing demand. The utilization of freight wagon manufacturing capacities in 2004 was on the level of about 65 %. It is no wonder that Russian manufacturers are unable to cut prices for their products and win the competition with Ukrainian manufacturers. Moreover, it becomes evident that in case Russian companies find money to cover the existing deficit in freight wagons, Russian manufacturers will hardly be able to produce the necessary amount of wagons. According to experts estimations, in 2005-2010 Russian companies will need 230 000 wagons (differed demand is not included). If nothing is changed, Russian manufacturers are able to produce at maximum 200 000 wagons.

Experts from the RF Ministry of Industry and Energy analysed the performance of Russian transport manufacturing market, compared to the world leaders (see Table 8).

Table 8. Performance of Russian transport manufacturing market, compared to the world leaders. Source: Minpromenergo

		2005	2006	Target	Leading countries					
					Group average	USA	Japan	Germany	France	Great Britain
Share of Russia on the world market	%	10,00	12,00	20,00	12,40	13,60	8,90	16,30	15,40	7,80
	USD billion	3,50	4,50		5,02	5,20	3,70	7,20	6,50	2,50
R&D expenditures/sales ratio, %		0,01	0,25	10,00	11,92	13,30	14,60	12,10	10,70	8,90
Exports, USD billion		16,50	19,00		4,12	4,60	3,30	5,80	5,10	1,80
Fixed capital investments/sales ratio, %		2,60	4,80	14,00	11,88	13,30	11,40	10,70	11,90	12,10

Table 8 shows that in general Russian transport manufacturing plants have unacceptably low level of R&D expenditures and fixed capital investments. While the average level of R&D expenditures in leading countries is 11.92 %, in Russia it is only 0.25 %. Similarly, the level of fixed capital investments in leading countries is 11.8 %, in Russia – 4.8 %. To improve the situation in the industry, the level of R&D expenditures in Russia should be at least at the level of 10 %, fixed capital investments correspondingly at 14 %.

The necessity in modernization of wagon manufacturing capacities as well as the need in the rolling stock innovation is evident. However, according to Viktor Litvinov, expert of the Institute of Natural Monopolies Research (INMR), wagon manufacturers find the massive implementation of new technologies to be disadvantageous (Zaiko, A., 2006). The leaders of freight wagon manufacturing – Uralvagonzavod FSUE, Altaivagon JSC, Ruzkhimmash JSC, Transmashholding JSC – are not ready to the sharp change of the technology due to the deficit of financial resources for modernization of production capacities and lack of sufficient solvent demand. According to another expert of INMR Vladimir Savchuk, neither independent operators, nor RZD make long-term agreements with manufacturers (Zaiko, A., 2006). Moreover, RZD usually pays its own price for rolling stock, which is equal to the cost of production (manufacture provides detailed information with “open books” principles about it to RZD) plus premium. According to Valentin Gapanovich, Engineering Manager of RZD, premium paid to the manufacture is very small. RZD does not let prices to increase higher than inflation rate (Barsukova, A., 2006).

8 COMPARATIVE ANALYSIS OF RAILWAY WAGON MANUFACTURERS IN RUSSIA, EUROPE AND USA

In the USA, Russia and Europe railway manufacturing market is highly consolidated and dominated by several corporations, which are recognized as world leaders. Consolidation on Russian market is not so high and correspondingly the production volumes (monetary value) of Russian railway manufacturers are lower compared to the US and European competitors. Only one company from Russia is included in the top-10 list of the world railway manufacturing companies (see Table 9).

Table 9. Largest companies involved in railway machine building and their turnover of the railway machine building. [Dementiev A., 2007]

Rank	Company	USD billion
1	Bombardier (Canada)	7.6
2	Alstom (France)	6.8
3	Siemens (Germany)	5.9
4	LORIC (China)	4.0
5	Hitachi/Kawasaki (Japan)	3.7
6	GE (USA)	3.2
7	EMD (former part of GM, USA)	2.1
8	Transmashholding (Russia)	1.5
9	Vossloh (Germany)	1.4
10	Finmeccanica TS (Italy)	1.4
…	Uralvagonzavod (Russia)	0.8

American railway manufacturing business has been performing very well during the past few years. All freight wagon manufacturers have increased sales and profits for the last two years and were able to pay dividends for their shareholders. However, their machinery seems to be fairly old and no new investments have been made recently. Russian manufacturers are also doing well, since there is a growing demand for new wagons. In contrast to the success of American and Russian manufacturers, European ones have not performed well lately. Only one of the analysed European companies has been able to increase its profits during the last six years. The performance of Russian, European and American companies is analysed in details in the following sub-sections.

8.1 Railway wagon manufacturers in the USA

Figure 47 shows the sales and profits made by American wagon manufacturers during the last six years.

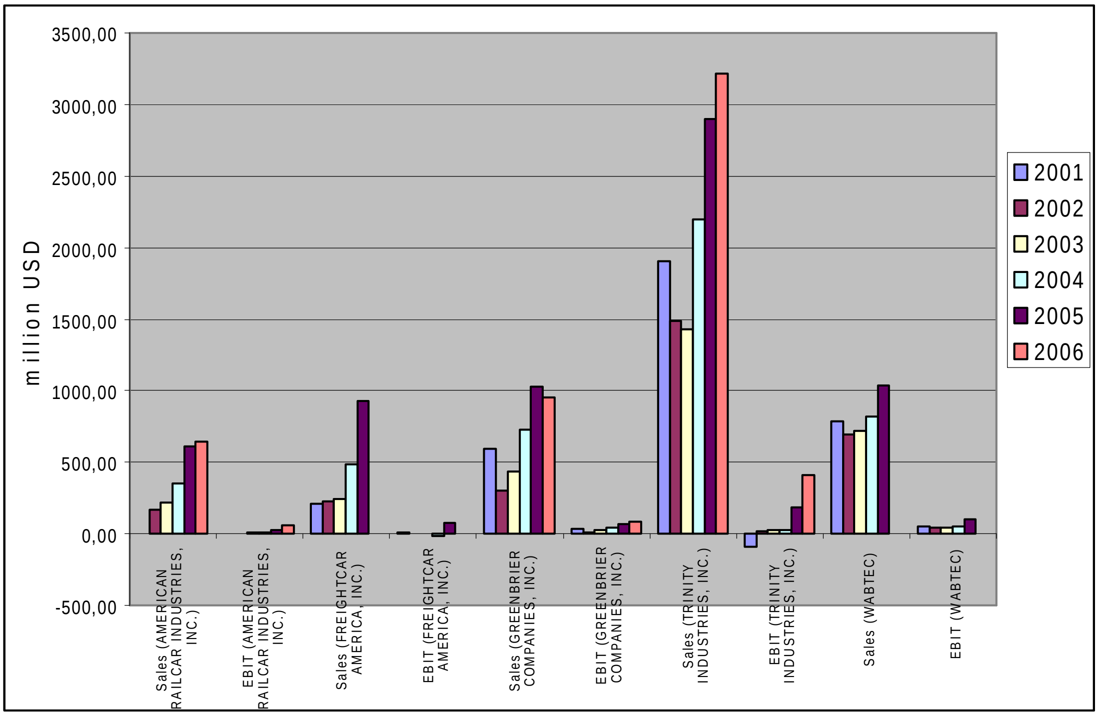

Figure 47. Sales and profits of American wagon manufacturers. Source: Thomson One, 2007

As shown on Figure 47, sales of each manufacturer have been growing rapidly since 2003. Yet only a few manufacturers have increased their profits considerably in relation to the past years. There can still be seen a slight climb in EBIT (Earnings Before Interest and Tax) for each manufacturer in the year 2007.

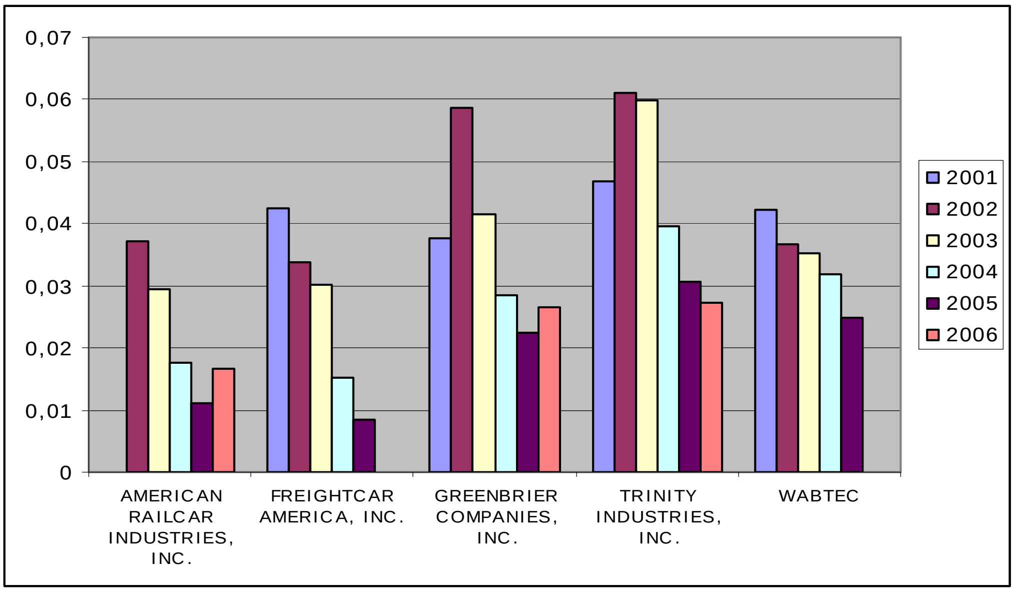

Figure 48. Amount of depreciations in relation to sales in the USA. Source: Thomson One 2007

As can be seen from Figure 48, that depreciation of investments for each manufacturer in USA has mostly been decreasing during the last five years. This means that no new investments have been made, or the investments have been rather small. Although so far American manufacturers were able to meet the growing demand using the old equipment, the further increase in sales will be hardly possible without significant investments.

Figure 49 shows the dividends paid by American freight wagon manufacturers during the years 2001-2006.

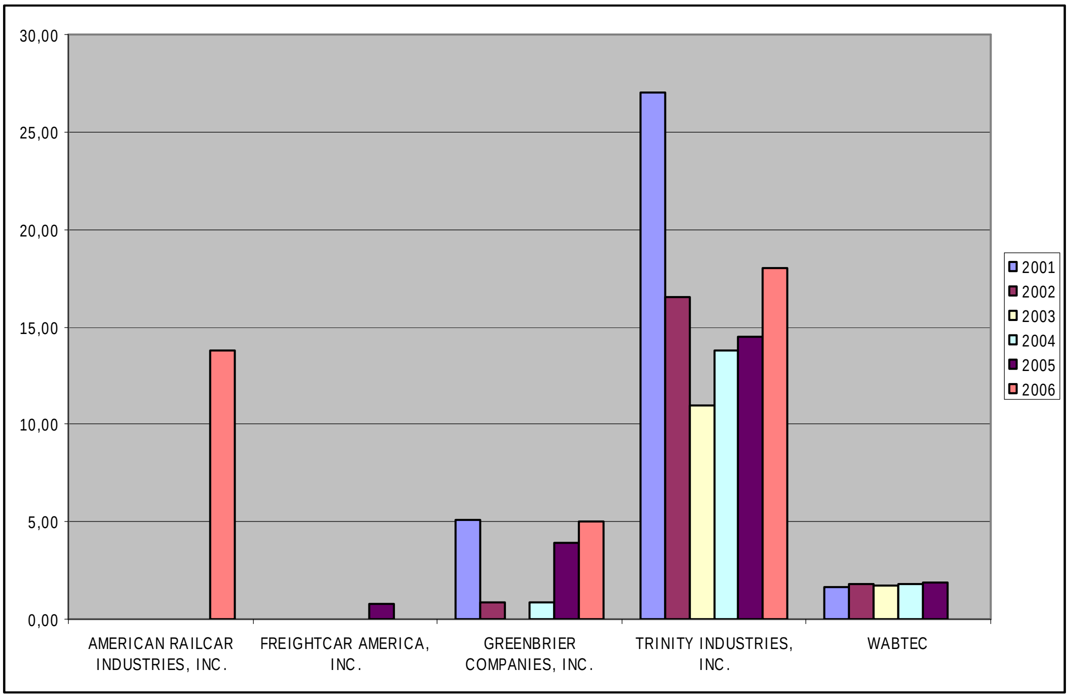

Figure 49. Paid dividends in American wagon companies during 2001-2006. Source: Thomson One, 2007

As it can be seen from Figure 49, only Trinity Industries, Inc. has decided to pay substantial dividends compared to other manufacturers. All other manufacturers show growth in paid dividends during the last few years. It is not surprising considering that all of them have also increased sales and EBIT.

The share price for American freight wagon manufacturers Wabtec and Trinity Industries is shown on Figure 50.

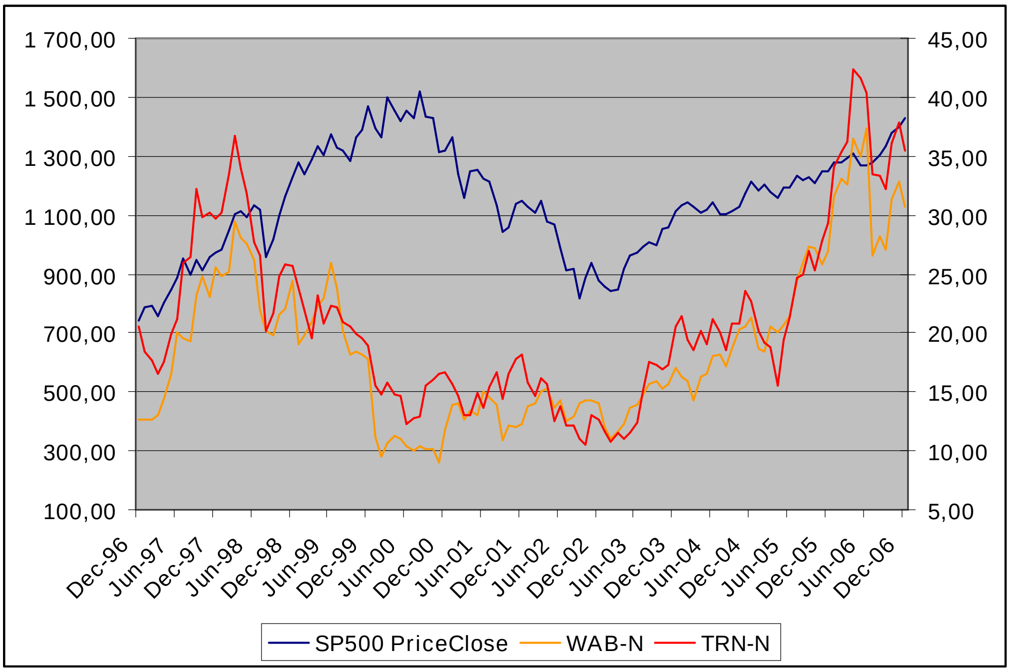

Figure 50. Wabtec and Trinity Industries Inc. stock exchange 1996-2006. Source: Thomson One (2007)

Figure 50 shows, that both companies show growth during the last three years and a rapid climb during the last year. The climb creates shareholder value for the companies, but since this branch of industry is very old the rate indicates that the owner-value is fluctuating. During the observation period these two wagon manufacturers have performed similarly with SP500 index. So, it could be concluded that investing funds on these companies have not been poor decision, and they have performed similarly as markets on the average.

8.2 Railway wagon manufacturers in Russia

It is difficult to analyze the performance of Russian companies, since only for one Russian railway manufacturing company, Nizhniy Tagil Iron & Steel Works (NTMK), could be found public listing status, and therefore data for share price changes is available. NTMK does not manufacture entire wagons, but makes parts, like wheels, for them. It has shown substantial growth, and has made a 9000 % shareholder value increase during the period of 2003-2006. NTMK was privatized from the state in 1992 and transformed into a joint-stock company. After this, large technological renewals were made, and the first stage of the reform was completed in 2000. This has clearly had an impact on the production and hence helped in the economically viable recovery of the company. Now the sales of the company is around EUR 72 million (RUR 72003.48 million), which is nearly 26 % more than the year before (NTMK, 2006).

Figure 51 shows the share price for Nizhniy Tagil Iron & Steel Works – showing impressive shareholder value increase, as have Russian markets showed overall.

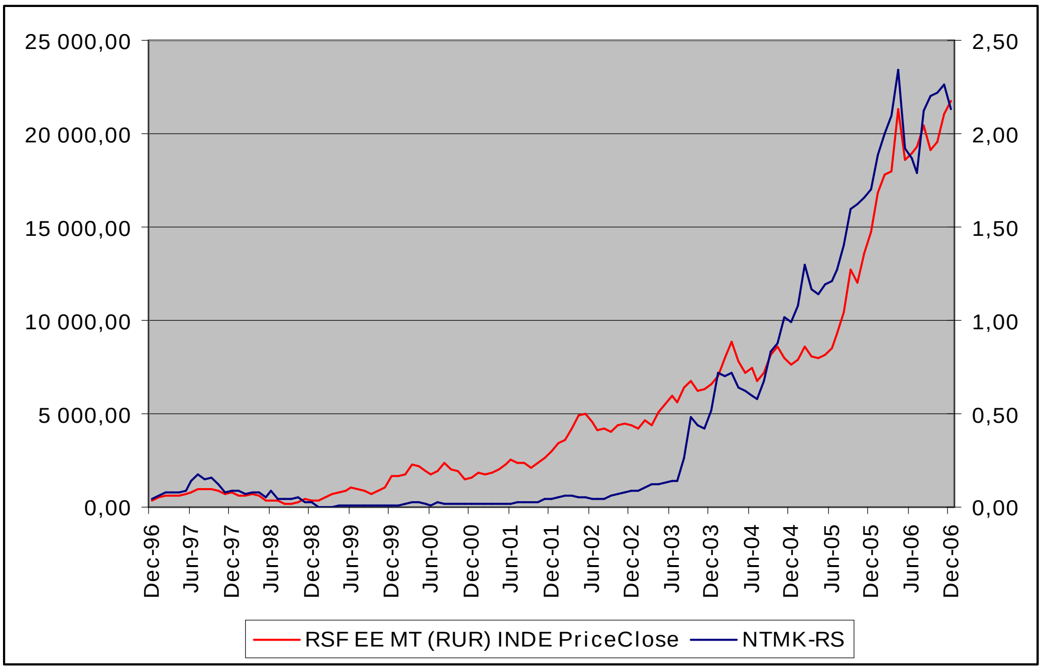

Figure 51. Nizhniy Tagil Iron & Steel Works stock exchange 1996-2006. Source Thomson One (2006)

The main freight wagon manufacturers operating on Russian market are shown on Figure 52.

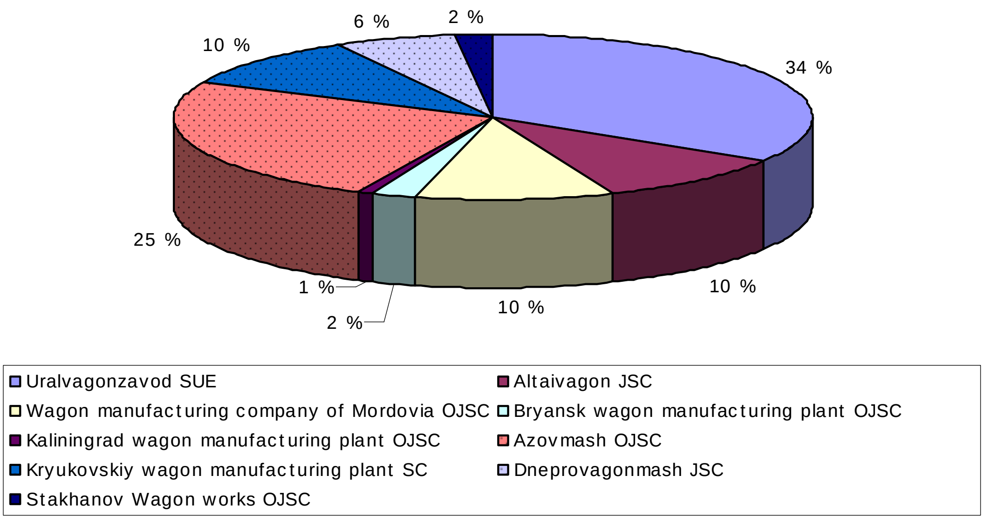

Figure 52. Freight wagon manufacturers present on the Russian market

The first five companies (from Uralvagonzavod SUE to Kalingrad wagon manufacturing plant OJSC) shown on the Figure 52 are Russian and the last four companies (Azovmash OJSC – Stakhanov Wagon works OJSC) are Ukrainian. Thus, it can be stated that Russia market is divided between freight wagon manufacturers from Russia and Ukraine. The Russian market leader is Uralvagonzavod SUE and the Ukrainian market leader is Azovmash OJSC. Together they have almost a 60 % market share while the other seven manufacturers together have about 40 % market share.

8.3 Russian freight wagon manufacturers

Federal state unitary enterprise Uralvagonzavod

The largest wagon manufacturer in Russia, FSUE Uralvagonzavod (UVZ) produces freight wagons in Nizhniy Tagil, Sverdlovsk region. Apart from freight wagons, the company produces also various products, such as furniture and tanks, for which it has been famous since the WWII. Concerning railway machine building FSUE UVZ produces tank cars, hoppers, flat cars, open-top cars and bogies.

FSUE UVZ entered already in 2002 the territory of the EU by establishing a joint Russian – Estonian company UVZ&AVR Ltd with Estonian transport company AVR Transservice Ltd. Their production plant is located in Ahtme, in north-eastern Estonia utilizing the proximity of the Russian border. This company is specialised mostly in railway wagon assembly and repairs & painting of different wagon types. Company is also willing to get more orders from other EU-countries, but this hope is hampered due to the fact that the Russian wagons are not accepted in most of the EU 25 countries. They are allowed in some countries, but only in transport from/to Russia (Uralvagonzavod 2007).

JSC Altaivagon

The history of the plant began on October 7, 1941, at the very beginning of the World War II when Dneprodzerzhinsk Wagon Works, located in that time in Ukrainian SSR, was evacuated to the Altai Region.

Today JSC Altaivagon is one of the main national and the only one company located over the Urals manufacturing freight wagons. For several years in row the company has been among the most rapidly developing Russian enterprises.

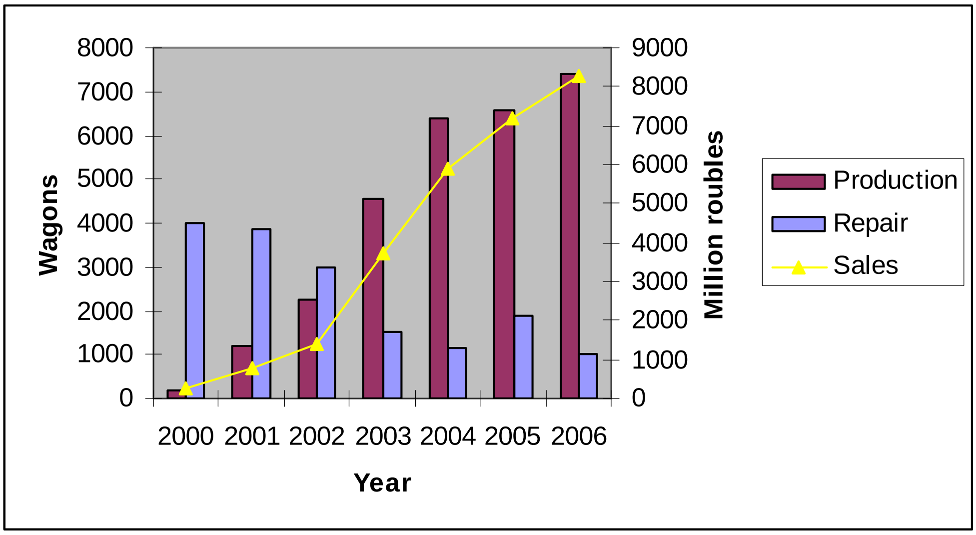

Figure 53. Number of wagons repaired and produced and the amount of sales of JSC Altaivagon in 2000 – 2006. Source: JSC Altaivagon, 2007

Sales of the company were very low when the upturn in the railway machine building in Russia started in 2000 (presented in Figure 53). Last year the company produced about 40 times the amount of wagons that were produced in 2000. The sales of the company exceeded more than RUR 8 billion in 2006.

Main products of Altaivagon include around 20 models of wagons (flat cars, tank cars, gondola wagons and covered wagons) designed to carry large scale of freights (JSC Altaivagon, 2007).

JSC Ruzkhimmash

JSC Ruzkhimmash (usually called also as OJSC Car manufacturing company of Mordovia) was established in 1961 in the city of Ruzaevka, Republic of Mordovia. Nowadays it is one of the key plants of chemical and petroleum machine building. Concerning railway machine building the company produces several types of tank cars for petroleum products, hydro carbonate gases, acids etc (JSC Ruzkhimmash 2007).

OJSC Bryansk wagon manufacturing plant

OJSC Bryansk wagon manufacturing plant, established already in 1873, is nowadays part of the CJSC Transmashholding, which was established in 2002. In the course of its activity the holding has carried out large investment projects aimed at the development, reconstruction and modernization of its enterprises as a result of which favourable conditions have been created for their stable and efficient operation. Two major shareholders of the company are

OJSC HC Kuzbassrazrezugol and TransGroup AC, one of the leading Russian railway operators (OJSC Bryansk wagon manufacturing plant, 2007).

In 2006 the sales of products and services of the Transmashholding were RUR 55 billion (approximately USD 2 billion). Investment programs by CJSC Transmashholding in the areas of R&D and technical re-equipment were RUR 3 billions. Transmashholding has altogether 55 thousand employees. Apart from OJSC Bryansk wagon manufacturing plant, CJSC Transmashholding includes production plants such as Novocherkassk Electric Locomotive Plant, Kolomensky zavod, Bryansk Engineering Plant, Bezhitsk Steel Foundry, Metrowagonmash, Tver Carriage Works, Demikhovsky Engineering Plant, Penzadieselmash, Oktyabrsky Electric Railway Car Repair Plant, Industrial Group KMT, Transconverter and Tsentrosvarmash.

CJSC Transmashholding, like Uralvagonzavod, has already invested in EU by buying a German company, FTD Fahrzeugtechnik Dessau AG, a company producing vehicles and subsystems in Dessau (CJSC Transmashholding 2007).

Also a German company Knorr-Bremse and CJSC Transmashholding have signed a letter of intent for the setting up of a joint venture in Russia. The plan is for the new company, which will be responsible for the manufacture, sale and servicing of complete braking systems for rail vehicles in Russia and the CIS states, to be based in central Russia (News-ticker.org 2007).

OJSC Kaliningrad wagon manufacturing plant

Kaliningrad (formerly Köningsberg) was the capital of the German province of East Prussia. During the WWII Soviet Union occupied this area and since the collapse of Soviet Union Kaliningrad has been an exclave of the Russia, now totally surrounded by the enlarged EU. The OJSC Kaliningrad has produced railway wagons there since 1946**.** Nowadays company is producing different types of dump cars (OJSC Kaliningrad wagon manufacturing plant 2007).

8.4 Ukrainian freight wagon manufacturers

OJSC Azovmash

The history of OJSC AzovMash dates back to the mechanical engineering origination at the metallurgical plants Nicopol and Russian Providens built with an attraction of foreign capital in Mariupol at the end of the 19^{th} century. Large-scale mechanical engineering complex had been derived from the metallurgical plant named for llyich and was separated from the plant under the name Zhdanov heavy engineering industry works in 1958.

The production of the railway wagons dates back to 1945, when at the metallurgical plant named by Ilyich, on decision of State Committee of Defence, were manufactured the first 25 two-axles tank cars of 25 t load carrying capacity for transportation of petroleum products (OJSC AzovMash 2007).

Nowadays OJSC AzovMash is a large Ukrainian machine building enterprise. The company is a CIS leader by tank car production. Besides that, the plant produces box cars, hopper wagons and flat cars and a large scale other products of machine building. The main customer countries of the enterprise are Russia, Iran, Kazakhstan, and Uzbekistan.

OJSC AzovMash includes joint stock companies such as Mariupol Plant of Heavy Machine Building, AzovObscheMash, Mariupol Thermal Plant and AzovElectroStal. OJSC AzovMash has also become a partner and stockholder of Armavir Plant of Heavy Machine Building in southern Russia. According to expert data, the enterprise’s output in 2005 embraced 3,900 tank cars, 4,200 open-top cars, 200 box cars, 5 hoppers, and 2 flat cars.

Present day OJSC AzovMash supplies its products to more than 20 countries of the world, among them traditionally the CIS countries - Russia, Kazakhstan, Uzbekistan, and Hungary, India, Yugoslavia, Pakistan, Algeria, Egypt, Turkey among the others (National Exhibition of Ukraine in the USA 2006).

OJSC AzovMash is state-controlled with 50 % + 1 share belonging to state. One quarter of the shares belongs to companies affiliated to System Capital Management, which is controlled by a famous Donetsk-born businessman Rinat Akhmetov (Verner 2006).

OJSC Kriukov Car Building Works

The history of the OJSC Kriukov Car Building Works (often named also as Kryukovskiy Wagon-Building Plant, later in this text JSC KCBW) started in the 1874 with the small car repair shops of the Kharkov - Nikolayev railway, specializing in the freight-car repairs. With the industrial manufacture development since 1924, some repair works of the railway field, including the Kriukov car repair shops, had changed their profile into the railway technical equipment release. At that very time the staff of the enterprise had received an important production assignment – to adjust the output of 16-ton covered cars with the metal frame. During the years of the WWII the plant was evacuated to Perm, where the manufacture of the defensive production (demolition air bombs) was arranged.

Later the plant was moved back to Ukraine and nowadays JSC KCBW is second largest enterprise in Ukraine by the number of wagons produced. The plant is the only company in the CIS to engineer passenger and cargo wagons (open-top cars, hopper cars, tank cars, flat cars, combined railway cars, wide assortment of spare parts and component parts for freight cars). The plant manufactures more than 30 types and models of cargo wagons. The output is shipped to more than 20 countries worldwide. Ukrzaliznytsia is the main client of the plant concerning freight wagons (JSC Kriukov Car Building Works 2007).

JSC KCBW is owned 27 % by Estonian company Skinest Finance (which is controlled by Russian Steel giant Severstal), 24,9 % by Transbuilding Service Limited from UK, 20 % by TEKO-Dneprometiz and 20 % by private investors (14 % owned by the management of the company) (Verner 2006).

OJSC Dneprovagonmash

OJSC Dneprovagonmash is one of the leading Ukrainian and CIS enterprises in projecting and producing of cargo wagons for main railways and various industrial segments. It currently employs over 4000 people. Significant part of its production (75 %) is being exported, and largest export country is Russia. The wagons are also shipped to other CIS countries, Baltic States, China, India, Pakistan, Iran, Bulgaria, Slovakia, Yugoslavia, Cuba, Egypt, Algeria, Guinea, and Nigeria. Engineering licenses were sold to China, Germany, and South African Republic.

Besides to export sales, the enterprise is searching for other forms of cooperation with foreign customers. Thus, Dneprovagonmash has recently bought the Plant of Metal Structures (located in Engels, Saratov region, Russia) facilities of which will serve for production of Dneprovagonmash range cars (JSC Dneprovagonmash 2007).

Dneprovagonmash is owned by the group Privat – 25 %, group TAS – 38 % and LLC Bearn – 19, 8 % (Verner 2006).

OJSC Stakhanov Wagon Works

In June 1965 the 1^{st} phase of the plant was put into operation producing metal constructions for tower cranes, walking excavators, cat-heads and other kinds of equipment. In December 1969, the works was repurposed to produce freight main-line railway cars. Already in the beginning of 1970 the Works gates left the first railway flat-car with 63 tons, mastered production of the wheel sets and railway bogies. In 1976 the works has started manufacture of cars for mineral fertilizers.

In subsequent years the design office of the plant developed technical documentation for railway cars of different purposes and specialized transport means with carrying capacity 63-400 tons. Producing hopper cars, open-top cars, tank cars, flat cars, railway carriers, pneumatic discharge cars, dump cars, undercarriages of cars. The company is owned by holding company AvtoKraz (JSC Stakhanov Wagon Works 2007, Verner 2006).

Ukrainian manufacturers that were studied have improved their financial performance lately. Figure 54 shows the sales and EBIT of the leading Ukrainian wagon manufacturers.

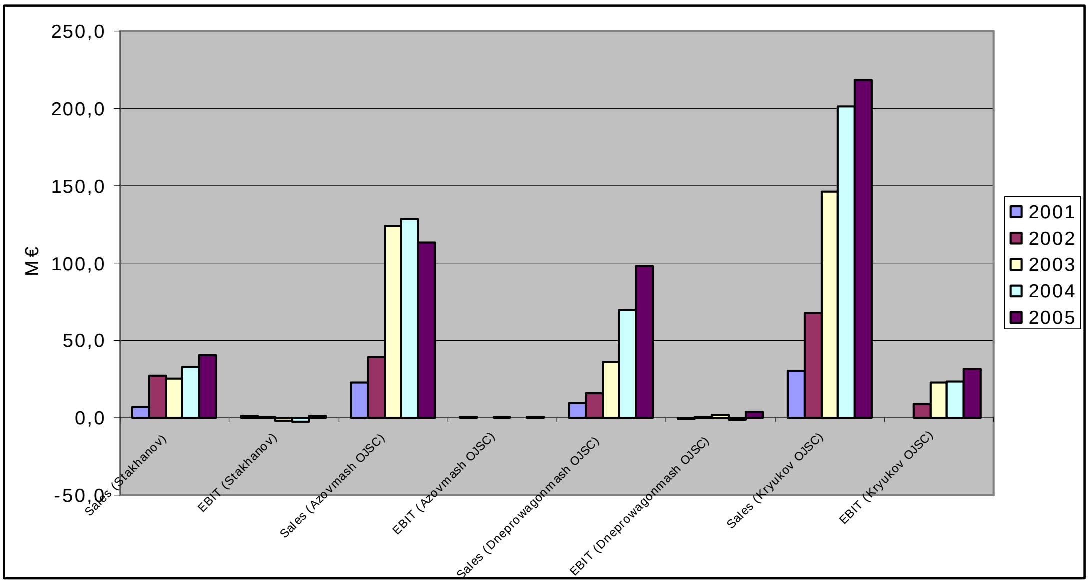

Figure 54. Ukrainian manufacturers' sales and profits during 2001-2005. Source: Smida.gov.ua

As Figure 54 shows, almost all Ukrainian wagon manufacturers (with the exception of Azovmash OJSC) were experiencing the growth in their sales during 2001 – 2005. Earnings before tax and interest have also increased in every company, although their level is still rather low.

Figure 55 shows the Ukrainian wagon manufacturers' depreciation in 2001-2005. As it can be seen from Figure 55, all of the Ukrainian manufacturers that had increasing sales also had more depreciation. It can be concluded that these three companies had the capital to make investments in new equipment and machinery.

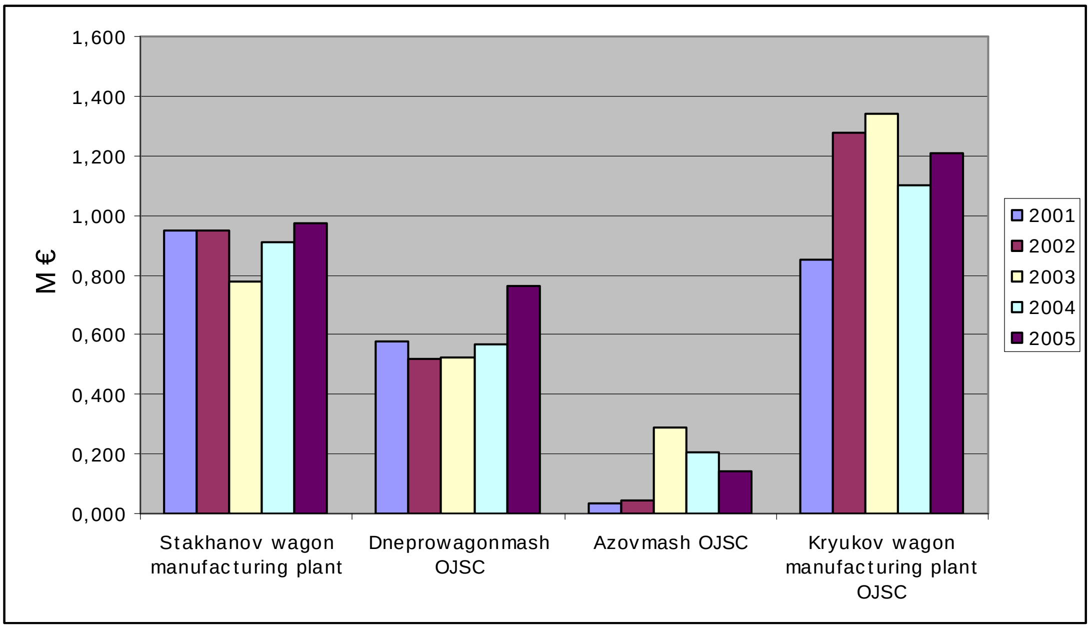

Figure 55. Ukrainian manufacturers' depreciations in 2001-2005. Source: Smida.gov.ua

8.5 Railway wagon manufacturers in Europe

Figure 56 shows the sales and profits made by European wagon manufacturers in 2000-2005. As it can be seen from Figure 56, sales during the observation period of European wagon manufacturers were changing insignificantly and were mostly declining. Only Construcciones y Auxiliar de Ferrocarriles, S.A (CAF) was able to increase its sales and EBIT. The new wave of investments in freight wagons, which started in the US, has not reached Europe yet. In the US the need in replacement of the old wagons caused growth in sales. In Europe this has not been the case, as lately only one manufacturer was able to make profit on a regular base.

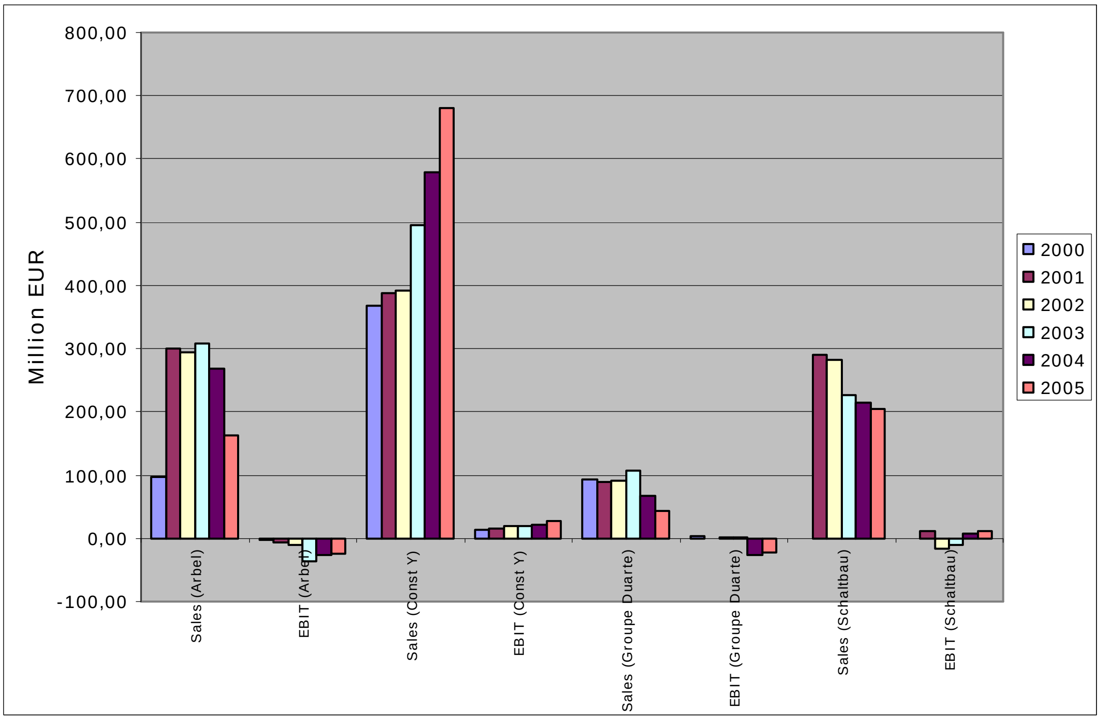

Figure 56. European manufacturers' sales and EBIT. Source: Thomson One 2007

8.6 Railway wagon manufacturing market altogether

The total sales and EBIT of wagon manufacturer from America, EU, Russia and Ukraine are shown on Figure 57 and Figure 58. The sales and EBIT data for each region were calculated using the sales and EBIT values for each studied company in that particular region. Data for the Russian company were only available for 2004 and 2005, while data for other companies were collected for the period 2001-2005 (for American companies also for 2006).

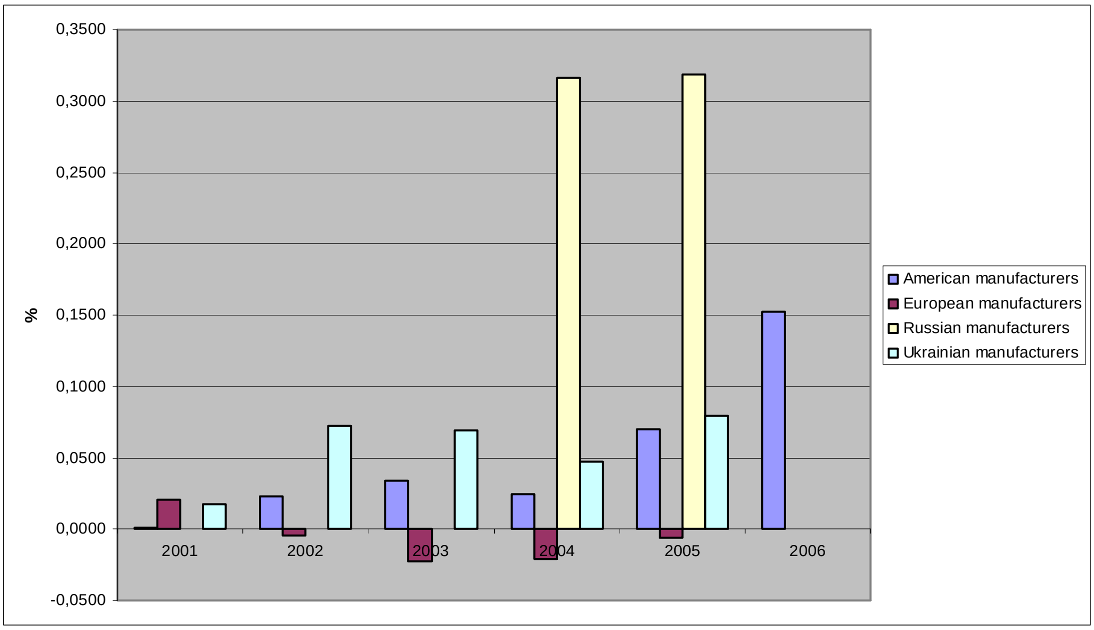

Figure 57. Railway wagon manufacturers' EBIT 2001-2006. Source: Thomson One 2007

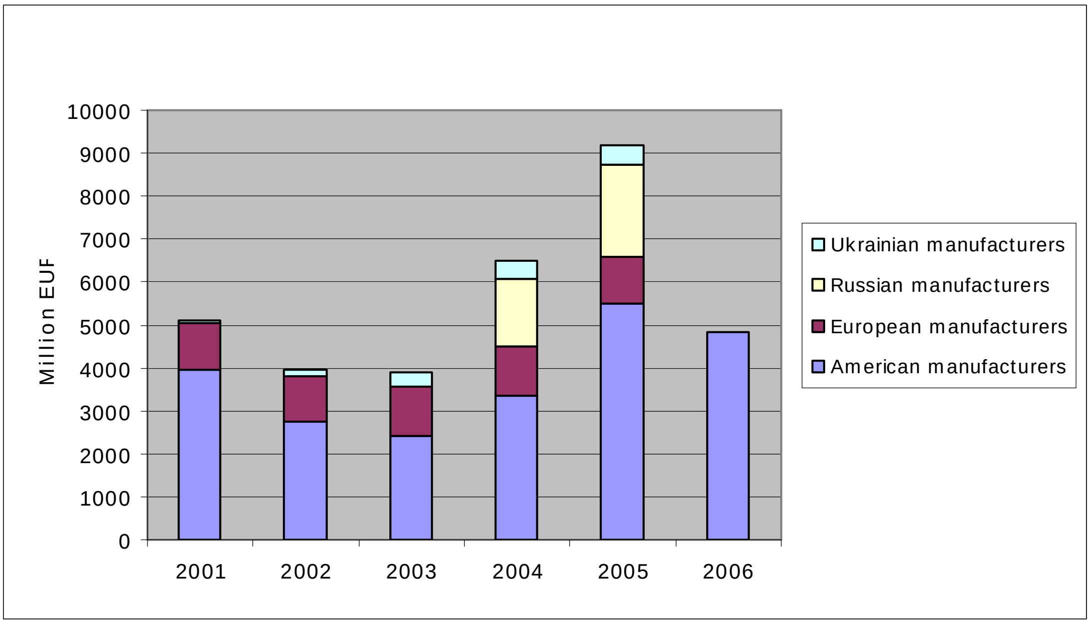

Figure 58. Railway wagon manufacturers' sales 2001-2006. Source: Thomson One 2007

As it can be seen from Figure 57 and Figure 58, the wagon manufacturing production in general is growing. During 2003-2005 the growth in sales of manufacturers from all regions could be observed. However, American wagon manufacturers are more active and perform much better than European manufacturers. Also the significant growth in production of Russian and Ukrainian manufacturers could be observed. In 2005 the total sales of all studied companies reached EUR 8 677 million and the EBIT was EUR 1 079 million.

Market values of each studied manufacturer are shown on Figure 59 and in Table 10. They were calculated by multiplying the amount of shares available multiplied with the price per share (as of 27.04.2007).

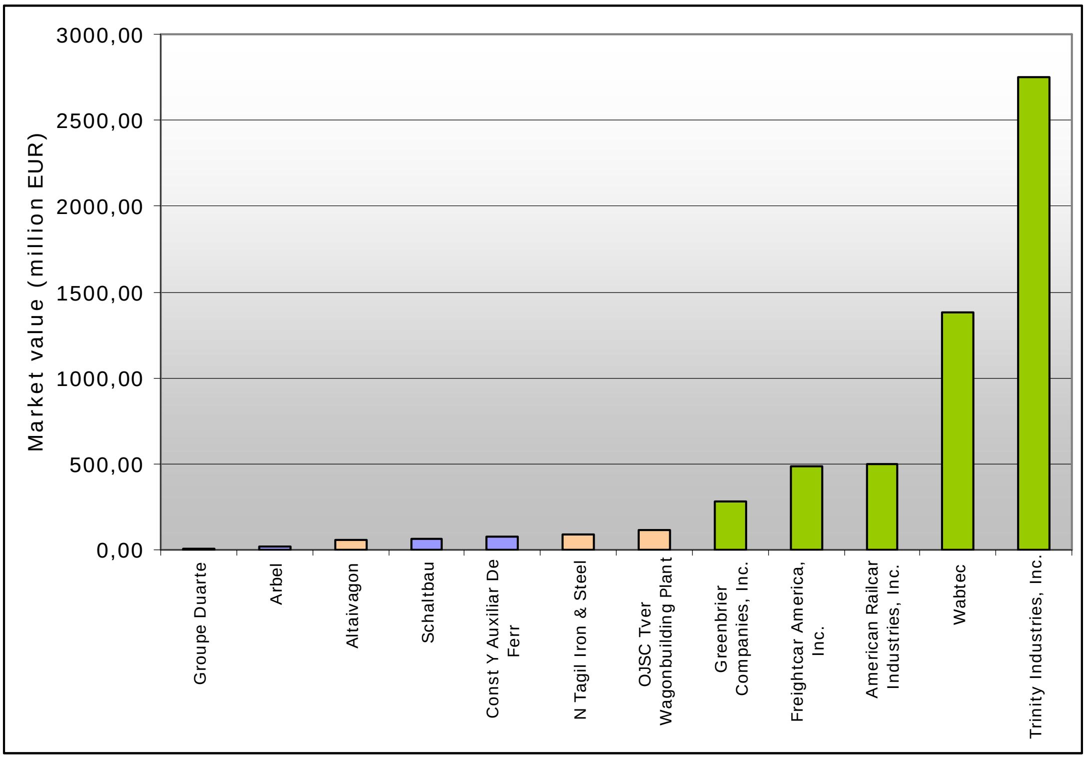

Figure 59. Railway wagon manufacturers' market values in April 2007. Source: Thomson One 2007

The American Trinity Industries, Inc. has the highest market value (EUR 2 752 million) and the French Groupe Duarte has the lowest market value (EUR 4.39 million). As a summary, the American companies have the highest market values and in contrary the European ones seem to have the lowest market values. The Russian manufacturer has a fairly low market value (EUR 88 million), although it seems to be doing better than all of the other companies that were studied. The sales of the Russian company were EUR 2 123 million and EBIT reached EUR 676.21 million in 2005. At the same time the highest market value owner Trinity Industries, Inc. had slightly larger sales (EUR 2 459.51 million), but its EBIT was only EUR 157.5 million. That is just about 23 % of the N. Tagil's EBIT, and yet N. Tagil's market value is only 3 % of Trinity's market value. As it can be seen from Table 10, theoretically, in order to buy all the studied companies, one should have EUR 5 817 million.

Table 10. Market values of studied manufacturers as of April 27, 2007. Source: Thomson One 2007

Company	Market value (M €)
Groupe Duarte	4,39
Arbel	16,47
Altaivagon	58,68
Schaltbau	62,29
Const Y Auxiliar De Ferr	77,83
N Tagil Iron & Steel	87,96
OJSC Tver Wagonbuilding Plant	114,30
Greenbrier Companies, Inc.	280,90
Freightcar America, Inc.	483,18
American Railcar Industries, Inc.	500,77
Wabtec	1378,53
Trinity Industries, Inc.	2751,85
Total	5817,15

9 OVERVIEW OF THE MAIN FLAT CAR MODELS OPERATED IN RUSSIA AND IN FINLAND

9.1 Main characteristics of the Russian flat car models

Since 1995 the container transportation volumes have been constantly growing in Russia. In 1997 only 7.2 million tons of cargo in Russia were transported in containers, in 2005 this figure reached 20.8 million tons. According to the expert estimations, in 2010 it will exceed 30 million tons. Constantly increasing export-import and transit cargo flows caused changes in the structure of large-tonnage containers transported in Russia. In 1990's mostly 20-foot containers were used, nowadays about 60-65 % of cargo is transported in 40-foot containers. About 90% of Russian import and 20-25 % of its export is transported in 40-foot containers. However, mainly 60-foot platforms are operated on Russian railways. As a result in 50 % of cases platform is underloaded (Kyakk, 2007). The situation with the production of Russian wagons suitable for container transportation is described in details in Box I.

Box I. Modern Russian railway wagons for container transportation

The growing demand in containers transportation stimulated the production of platforms in Russia and CIS. Lately in addition to universal platforms more and more specialized models suitable for container transportation are produced.

The leader in platform production is Ukrainian JSC Dneprovagonmash. It manufactures standard model 13-4012, which modifications are suitable for transportation of forest and forest products (13-4012 with posts VO-118) as well as containers (13-4012-15). Another Ukrainian manufacturer JSC Kriukov Car Building Works offers platform model 13-785 capable to carry three 20-foot or one 40-foot and one 20-foot containers. OJSC Azovmash (Ukraine) produces platform model 13-1664 with the carrying capacity of 61 tons.

The biggest Russian wagon manufacturer Uralvagonzavod SUE manufactures models 13-198 (forest goods) and 13-192 (containers). The other Russian company JSC Ruzkhimmash manufactures model 13-1281, which tare weight is 25 tons and carrying capacity - 69 tons. OJSC Bryansk wagon manufacturing plant (Russia) manufactures platform model 13-3110 for the transportation of one 40-foot container (or two 20-foot containers), which also can be used for transportation of wheels and caterpillar mechanics.

The first 80-foot platform model 13-2118 was manufactured by JSC Altaivagon (Russia) in 2004 and it passed the required test in June 2005. Its length is 25 meters and carrying capacity- 69 tons, although the aim is to raise the carrying capacity up to 72 tons in the future. The JSC Transmash manufactures models 13-9743 and 13-9751. Both are capable to carry two 40- foot or four 20-foot containers. Model 13-9743 with tare weight of 32 tons and carrying capacity of 62 tons is suitable also for transportation of 12 and 24 meters pipes and other long loads. Analogous platform (model 13-9016) is manufactured by JSC Abakanvagonzavod (Russia). Model 13-9751 can carry 68.4 tons, weighs 25.6 tons and is 25 meters long. OJSC Bryansk wagon manufacturing plant offers model 13-3115-1 with the tare weight of 27 tons and carrying capacity of 67 tons. In cooperation with JSC RZD and the All-Russian Railway Research Institute it also designed unique double-deck platform (13-3124).

Recently JSC Kryukov Car Building Works started manufacturing of model 13-7024 that fits four 20-foot or two 40-foot containers. Model 13-7024 is a new model and has tare weight of only 22.3 tons and carrying capacity of 71.2 tons. JSC Dneprovagonmash has a new wagon projects as well. Model 13-4123 is 29.6 meters long and uses three bogies. Its tare weight is 29 tons and carrying capacity is 96 tons. Model 13-4117 is suitable for transportation of 20-, 30-, and 40-foot containers. Use of modern materials in construction of this platform let to lower its tare weight to 20 tons, while its carrying capacity is 72 tons that results in maximum load. The other JSC Dneprovagonmash's model 13-4095 provides possibility to load self-propelled trailers on the platform. Technical characteristics of different platform models offered on Russian market are summarized in Table 11.

Table 11. Main platform model offered on Russia market

Model	Length (m)	Carrying Capacity (t)	Tare weight (t)	Manufacturer/designer
13-4012	14.62	72.0	22.0	JSC Dneprovagonmash
13-4012-15	14.62	69.0	25.0	JSC Dneprovagonmash
13-198	13.92	65.0	26.0	SUE Uralvagonzavod
13-192	13.92	60.0	20.4	SUE Uralvagonzavod
13-785	19.88	64.0	26.0	JSC Kryukov Car Building Works
13-7024	25.62	71.2	22.3	JSC Kryukov Car Building Works
13-1281	25.72	69.0	25.0	JSC Ruzkhimmash
13-1664	13.60	61.3	17.0	JSC Azovmash
13-3110	14.62	71.0	22.3	BMZ, Transmashholding
13-2118	26.22	69.0	25.0	JSC Altaivagon
13-9743	26.06	62.0	32.0	JSC Transmash
13-9016		62.0	32.0	JSC Abakanvagonzavod
13-9751	25.00	69.0	25.6	JSC Transmash
13-3115-1	25.87	67.0	27.0	BMZ, Transmashholding
13-3124	16.00	67.0	26.3	JSC BMZ, JSC RZD and All-Russian Railway Research Institute
13-4123	29.60	96.0	29.0	JSC Dneprovagonmash
13-4092	27.00	63.0	30.0	JSC Dneprovagonmash
13-4117	19.72	72.0	20.0	JSC Dneprovagonmash
13-4095	22.52	48.0	28.0	JSC Dneprovagonmash

Author: Eugene Korovyakovsky, St. Petersburg State Transport University

In this analysis only long platforms, which are considered to be the most efficient for container transportation, were taken into account. Chosen platforms vary in length from 25.52 meters to 29.60 meters and they can carry from 62 tons to 127 tons of cargo. Generally, these long platforms are 2.46-3.98 meters wide and 1.06-3.2 meters high. They can be used to transport, for example, pipes, round wood, vehicles and containers. Long platforms and their main characteristics are shown in Table 12.

Table 12. Long platforms. Source: Litrail 2002

Model Number	Width (mm)	Height (mm)	Length (mm)	Tare weight (t)	Carrying capacity (tons)
13-9009	3060	1450	25520	33,5	60
13-9751	3100+-8	1060+-20	25616	25	69
13-7024			25620	22,8	71,2
13-1796	2920	1725	25690	23,5	70
13-1796-01			25690	32	62
13-1281	2460	1400	25720	25	69
13-3115-1			25866	26,2	67
13-9745			26070	32	62
13-1163			26220	30,7	63,3
13-2118	3000	1060+-20	26220	25	69
13-4108	3980	3200	26220	32	62
13-4128			26220	33	61
13-3066	3000		26336		127
13-4092			27000	31	63
13-4123			29600	29	96

The majority of the studied platforms were suitable for container transportation, although some of them may need additional container latches. Only five of the platform models, namely 13-4012-10, 13-4012-11, 13-479, 23-4084 and 23-4090, can't be used for container transportation. The half of analyzed models can be used for transporting timber or pipes and a fraction of them is suitable for transporting, for example, automotives, trucks, steel plates, or transformers. New platforms cost about EUR 45 – 55 thousand and used platforms can be bought at the approximate price of EUR 10 – 15 thousand. (Voronin 2005; Sobolevskiy 2008).

Figure 60 shows the starting year of production of flat cars and Figure 61 reflects start of production of other wagons in Russia.

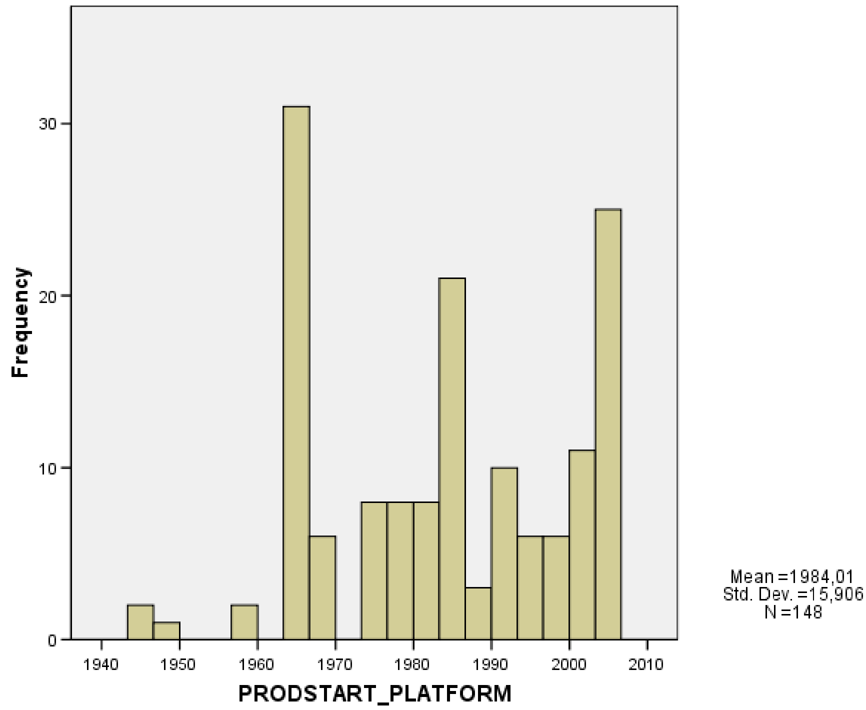

Figure 60. Production start for platforms in Russia. Source: Litrail (2002)

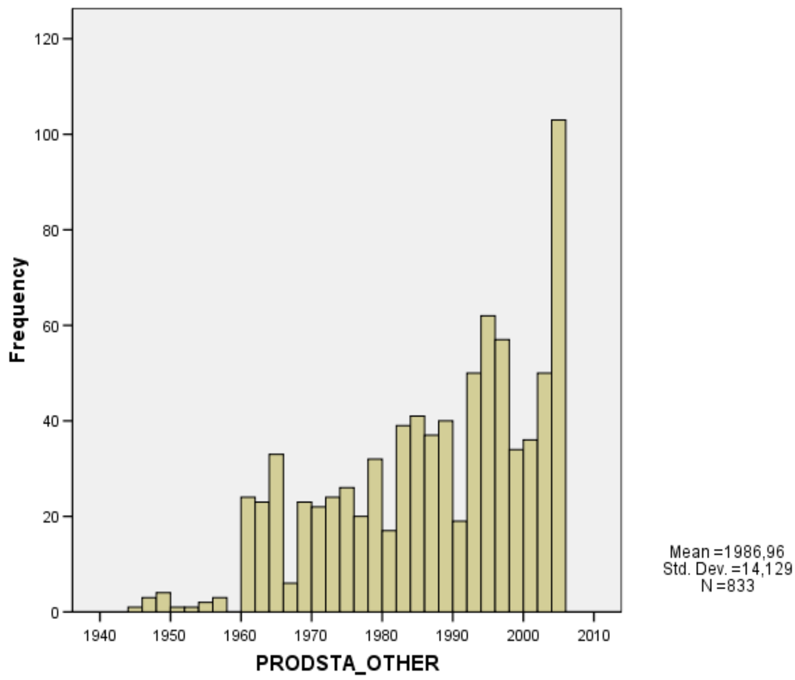

Figure 61. Production start for wagons (all except platforms) in Russia. Source: Litrail (2002)

As it can be seen from Figure 60, the production of the majority of platforms started during 1965-1985. A rapid increase in production of flat cars could be observed after the turn of the century. That increase was determined by the overall growth in the industry in the demand of container transportation services and the necessity to replace the increasingly old wagons. The average starting year of production for platforms is 1984 and for other kinds of wagons 1986.

Figure 62 shows the carrying capacity of platforms and Figure 63 the carrying capacity of the other wagons in Russia.

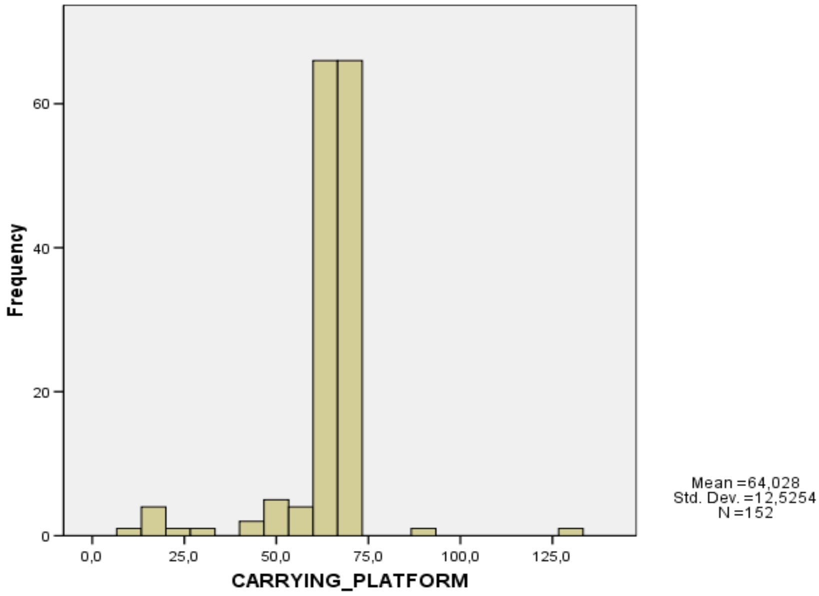

Figure 62. The carrying capacity of platforms in Russia. Source: Litrail (2002)

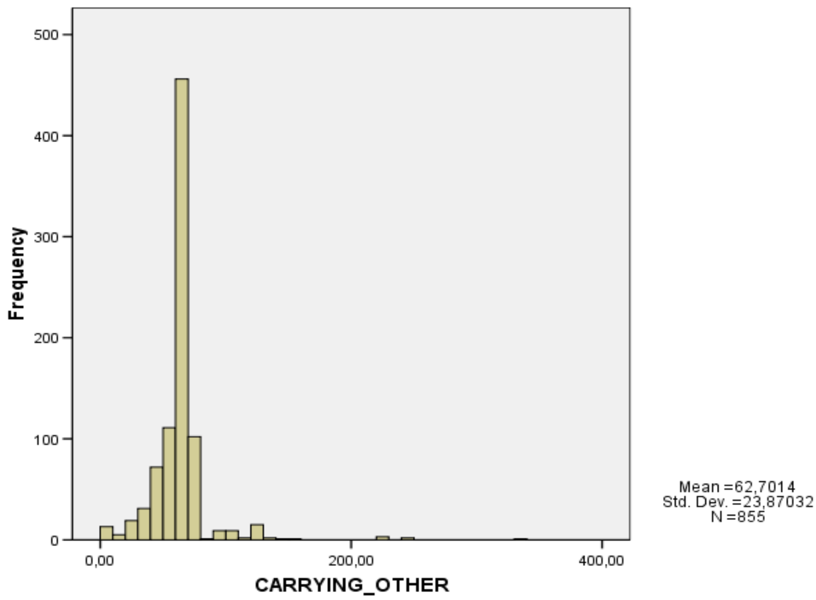

Figure 63. The carrying capacity for other kind of wagons in Russia. Source: Litrail (2002)

Figure 62 shows that the majority of the platforms manufactured are able to carry loads between 60 and 74 tons. There are also platforms that can carry up to 127 tons and the carrying capacity altogether varies from 10 to 127 tons. As Figure 63 shows, the standard carrying capacity for other wagons is around 60 tons, but the scale ranges from 7.4 to 340 tons.

The lengths of flat cars and other wagons are shown on Figure 64 and Figure 65.

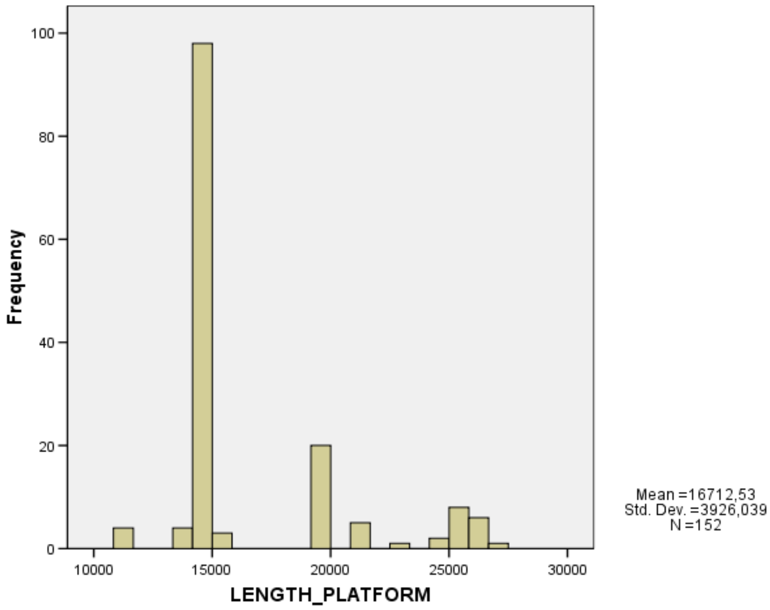

Figure 64. Length of platforms in Russia. Source: Litrail (2002)

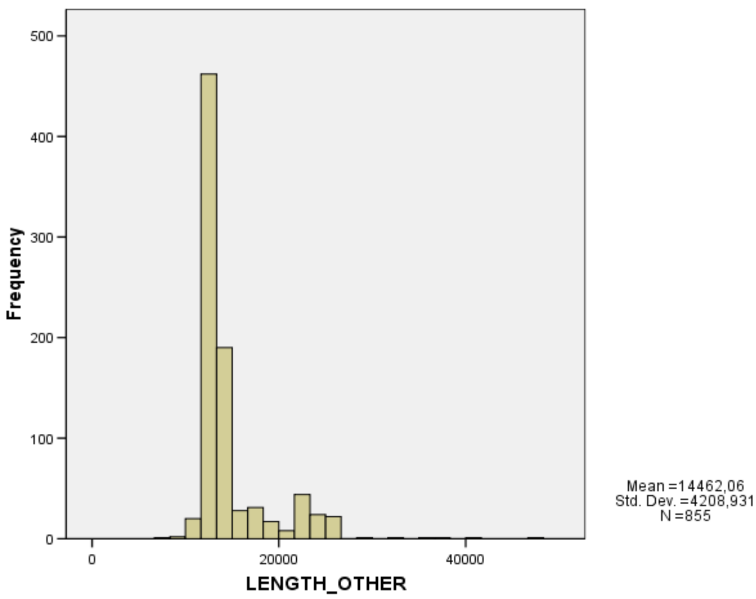

Figure 65. Length of other wagons in Russia. Source Litrail (2002)

As it can be seen from Figure 64, the most common length of flat cars in Russia is 14.62 m, but in general their length varies from 11.22 m to 27.00 m. Figure 65 shows that the most common length of other wagons is 12.02 m, but the scale varies from 8.03 m to 46.84 m. It should be noted that the longer platforms does not necessarily guarantee a higher carrying capacity. Platforms of the same length can carry different size loads.

9.2 Analysis of the potential of Russian flat cars for container transportation

To analyze the potential of different flat car models for container transportation, the lengths and carrying capacities of trains consisting of different platforms carrying 100 units of 20 foot and 50 units of 40 foot containers were calculated. The calculations did not take into account the length of the locomotive or any limitations for the length of the whole train. Altogether 44 different flat car models were considered. The results of those calculations are shown on Figure 66 and Figure 67.

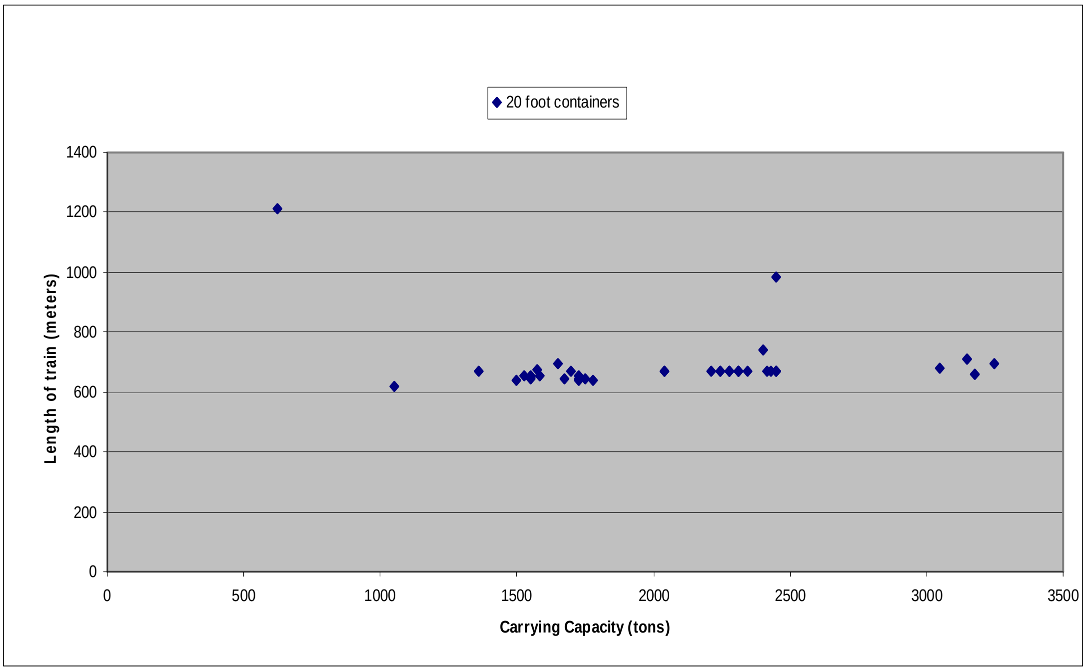

Figure 66. Length and carrying capacity for trains, which transport 100 units of 20 foot containers on platforms.

With 20 foot containers and different platforms, most trains are about 700 meters long and the total carrying capacity varies between 1 500 and 2 500 tons. There also exist a few very clear exceptions. One 1.2 kilometres long train can only carry about 600 tons of load and four 700 meters long trains can carry a bit over 3 000 tons of load.

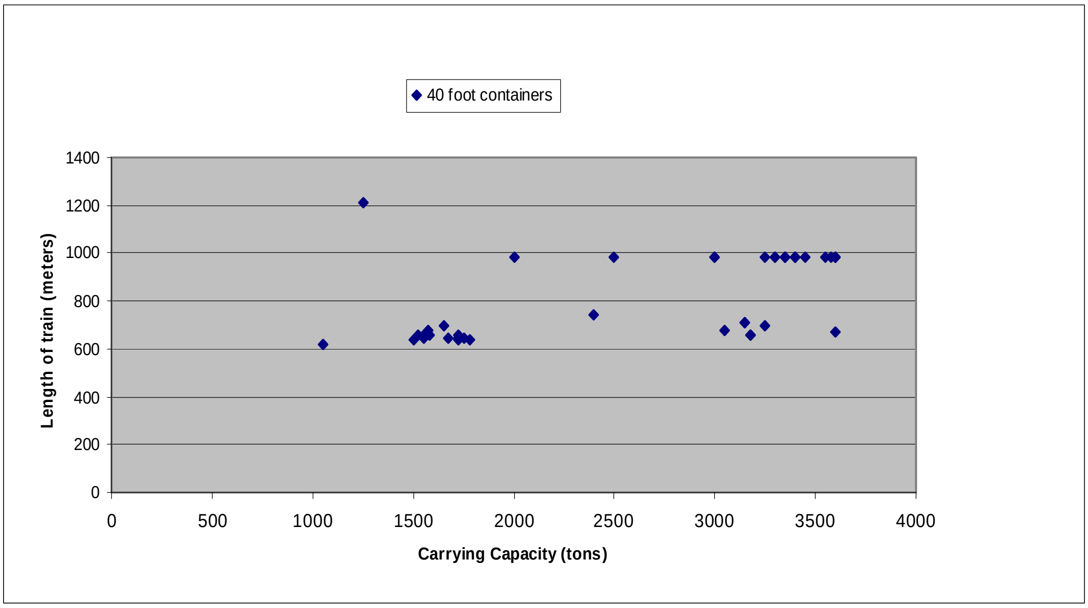

Figure 67. Length and carrying capacity for trains, which transport 50 units of 40 foot containers on platforms.

With 40 foot containers and different platforms, the deviation is broader. As in case of 20 foot containers, about half of the trains are 700 meters long and can carry loads between 1 500 and 2 500 tons. There are also four 700 meters long trains that can carry a bit over 3 000 tons and one that can carry load over 3 500 tons. Then there are a few trains that can carry amounts smaller than 1 500 tons and a few trains that are nearly a kilometre long and can carry cargo up to 3 700 tons.

A standard 20 foot container is 2.350 meters high, 2.330 meters wide and 5.867 meters long. An empty container weights 2 400 kg and the maximum gross weight for it is 24 000 kg. This means that one 20 foot container can have 21 600 kg of payload. Similarly, 40 foot container is approximately 12 meters long and its maximum gross weight is 30 480 kg. Considering the weight and maximum payload of the containers and the carrying capacity for each freight wagon, a clear conclusion can be made that the wagons can carry more load than the containers can contain. Therefore, there will be unused carrying capacity in each train, whether it transports 20 foot containers or 40 foot containers.

Figure 68 and Figure 69 show the amount of unused carrying capacity for trains of different length transporting 20 foot and 40 foot containers.

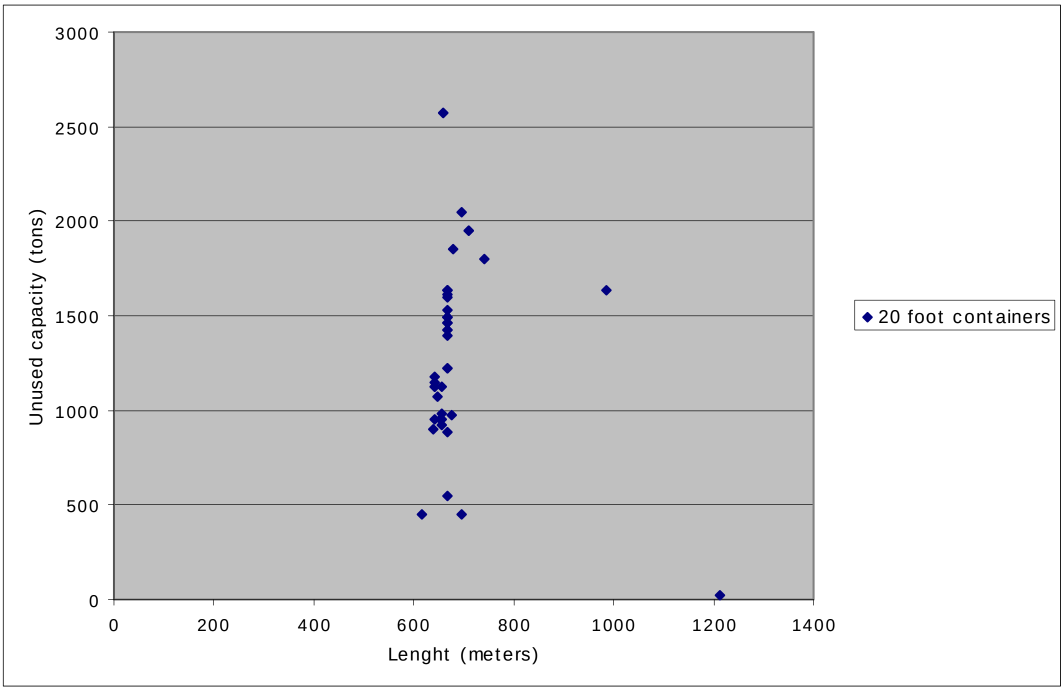

Figure 68. Length and unused carrying capacity for trains, which transport 100 units of 20 foot containers on platforms.

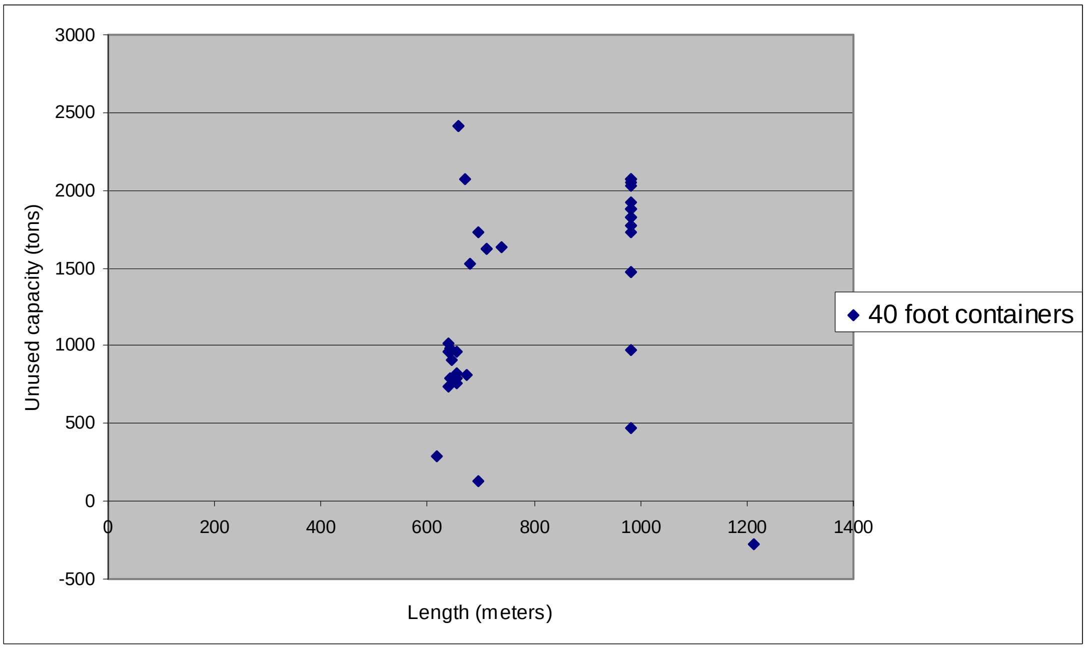

Figure 69. Length and unused carrying capacity for trains, which transport 50 units of 40 foot containers on platforms.

With 20 foot containers, most of the trains are around 700 meters long and the unused carrying capacity varies from a little less than 500 tons up to 2 000 tons. Three distinct exceptions can be noticed: one train has over 2 500 tons of unused carrying capacity and another has only 25 tons of unused carrying capacity, the third train is about a kilometre long and has 1 600 tons of unused capacity.

With 40 foot containers, most trains are around 700 meters or one kilometre long and the unused carrying capacity varies, according to the used wagon model, from 500 tons to a little over 2 000 tons. A few exceptions can be seen here as well. There is a train that has almost 2500 tons of unused carrying capacity and three trains that have less than 500 tons of unused carrying capacity. There is also one train that seems to have negative unused carrying capacity. This means that the train with that specific wagon model cannot carry the maximum weight of containers. This can be good when transporting lightweight goods that will fill the containers, but will not weigh as much as the containers can carry. Then there is no unused carrying capacity and all the potential can be used.

The unused carrying capacity for the trains was calculated with the assumption that all containers would be packed full and would carry their maximum payload. This, however, is rarely the case, since lighter products tend to fill the container before the maximum weight is gained and the heavier products tend to gain the maximum weight before the container is full. Four most common types of products in the Finland – China import-export trade were taken into account and the unused carrying capacity was calculated again. Copying paper and mobile phones were chosen to represent the Finnish export to China and DVD-players and shoes were chosen to represent the import from China to Finland. Amounts and weights of those products transported in a 20-foot container are shown in Table 13

Table 13. Amounts and weights of products transported in a 20-foot container

Product	product weight (kg)	products in a 20-foot container	total weight of products (kg)
Copy paper	12.805	1686	21589.23
Mobile phone	0.679	12193	8279.047
DVD-player	2.386	1654	3946.444
pair of shoes	0.771	6029	4648.359

One 20 foot container can accommodate 1 817 packages of paper in terms of space. But because of the high weight of paper (21 960 kg for 1 817 packages), one container can carry only 1 686 packages of paper. So, a container filled with copying paper will weigh 21 589 kg. Altogether 1654 DVD-players can be fitted into a 20 foot container and they will weigh 3 916 kg. A fully-loaded container can carry 12 193 mobile phone boxes (e.g. Nokia 6630) and they will weigh 8 279 kg. An average pair of shoes weigh 771 g, so, on average, one container can carry 6 029 pairs of shoes and they will weigh 4 648 kg.

The unused carrying capacity of different wagon models transporting those four example foreign trade products in 20 foot containers are shown in Figure 70.

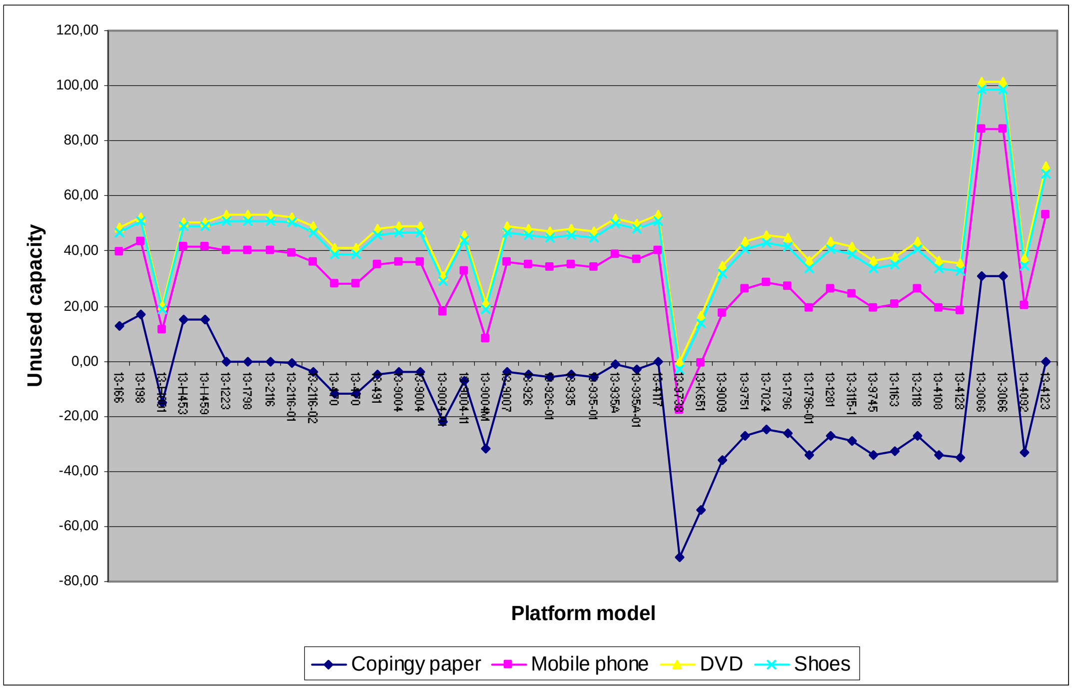

Figure 70. Unused carrying capacity of different platform models with 20-foot containers.

The wagons with negative unused carrying capacity can't carry the full amount of products and containers, because their weight exceeds the carrying capacity of the wagon. This only happens with copying paper, because of its weight and with mobile phones in two freight car platforms (13-9738 and 13-K651), because they have a low carrying capacity (25 and 42 tons). There are also wagons that have a high unused carrying capacity, and it is not very economical to use them. However, for every example product the most suitable wagons can be found. For instance, for copying paper, there are wagons that would have only 30 kg of unused carrying capacity and for DVD-players there are wagons that would have only around 15 tons of unused carrying capacity.

The total weight of trains consisting of different platforms carrying four products are shown on Figure 71.

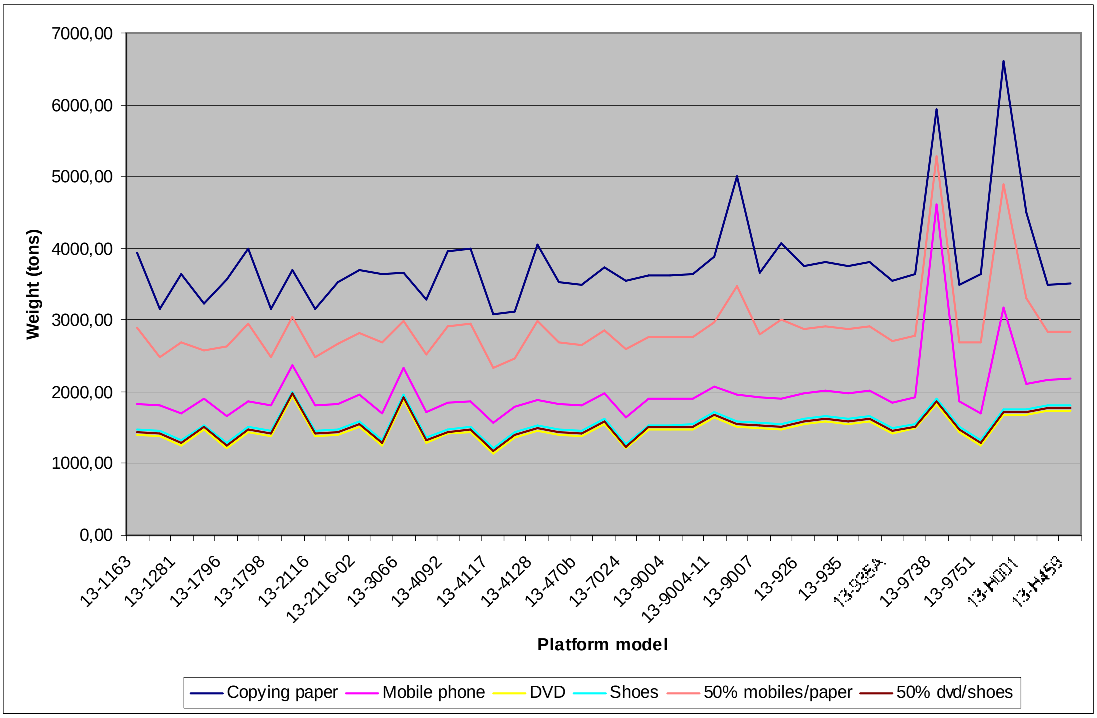

Figure 71. Total weight of a train transporting 20 foot containers with platforms, four different products considered.

The weight varies according to the weight of the product and trains with copying paper are the heaviest and trains with DVD-players and shoes are the lightest. The product-mixes with half mobile phones and half copying paper are also quite heavy. These weights were calculated assuming that all the containers would have the maximum amount of products inside. The length of these trains is shown on Figure 72.

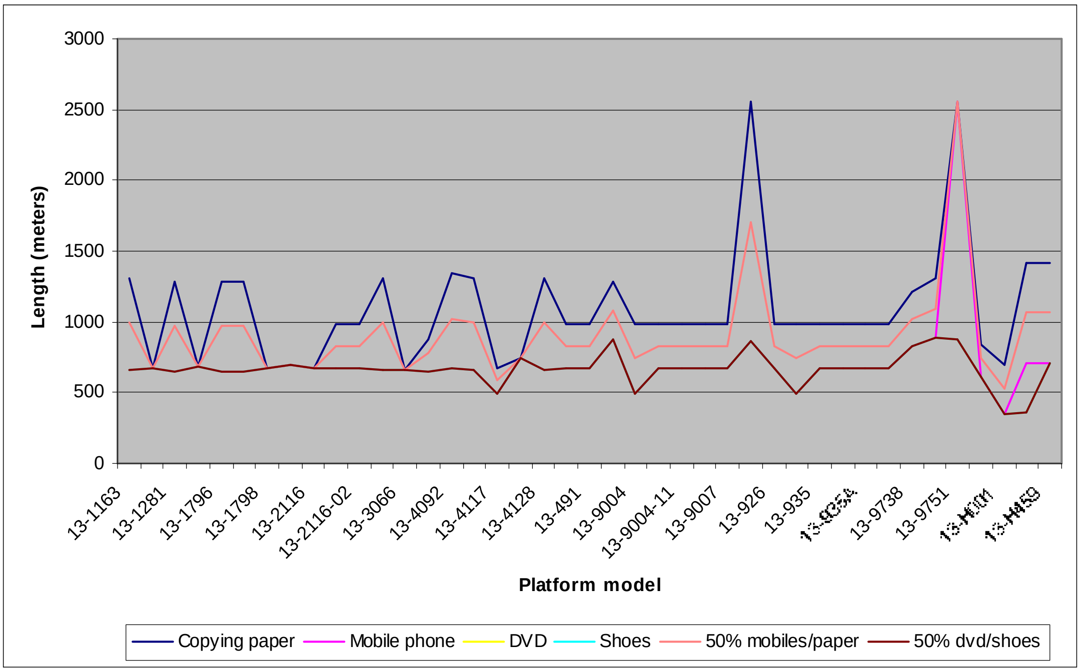

Figure 72. Total length of a train transporting 20 foot containers with platforms, four different products considered.

Figure 72 shows that to transport heavier products, like copying paper, more platforms are needed and the length of the train grows. With lighter products, like mobile phones, DVD-players, shoes and their mixes, the length of the train is nearly always the same, since the same amount of platforms is needed to transport the products. This is also why on Figure 72 only the dark red line (50 % dvd/shoes) can be seen clearly.

DEA models for Russian flat cars carrying different types of products are described in Box II; with this method we have an opportunity to objectively evaluate most suitable platforms for container transports.

Box II. DEA Models for Russian flat cars carrying different types of products

Data envelopment analysis (DEA) is a method to measure relative efficiency of different decision making units (DMUs) or producers based on their observed inputs and outputs. The most efficient producers have relative efficiency of 1 and others have something in between 0 and 1. There is a fundamental difference between traditional statistical approaches using regression analysis and DEA. The former reflects the average behaviour of the observations, while the latter deals with best performance, evaluating all performances from the efficient frontier line (Cooper et al. 2000). The original linear programming model was developed by Charnes, Cooper and Rhodes (1978). Their research is traditionally considered as seminal one concerning DEA.

In this study DEA is used to analyse the suitability of flat car platforms for container transportation. Calculations were made with a program called DEAP (written by Tim J. Coelli, software is available at: http://www.uq.edu.au/economics/cepa/deap.htm.). First model (Figure 73) consists of 12 inputs and 1 output. The other models (see as an example Figure 74) also have only the same one output of 100 containers, but for only train length and weight for one at a time.

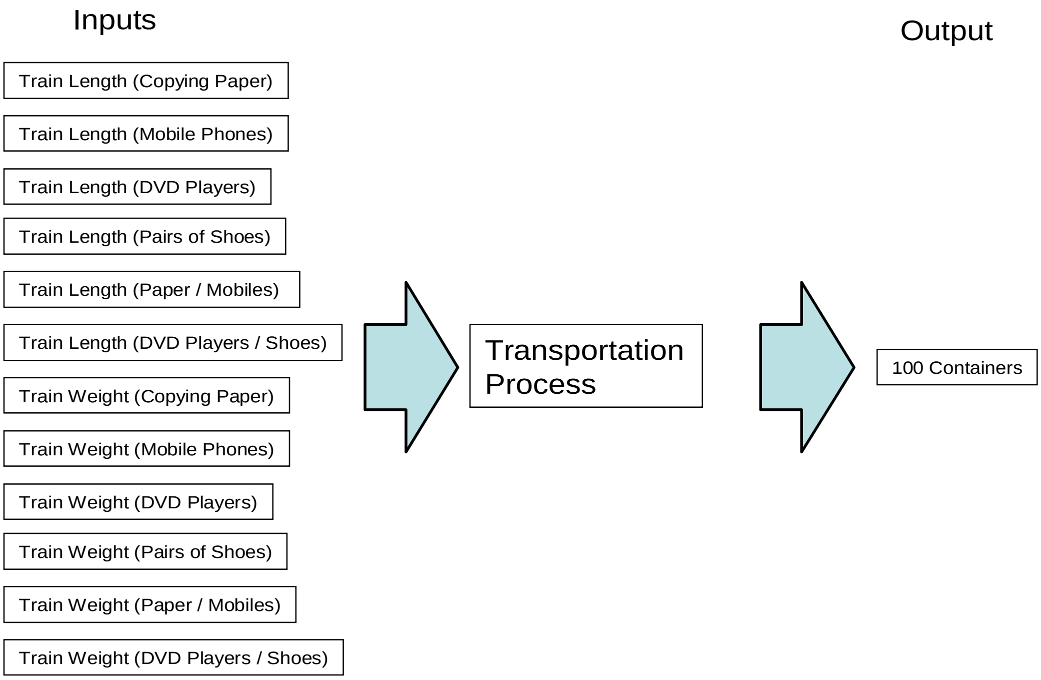

Figure 73. DEA of Platforms – 1 output and 12 inputs models

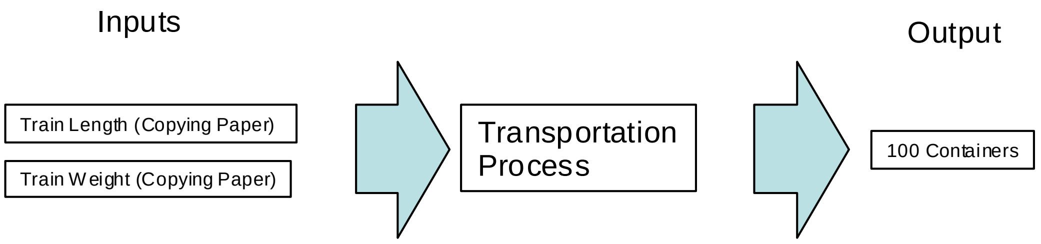

Figure 74. DEA of Platforms – 1 output and 12 inputs models

The main goal of the analysis was to determine, which flat cars are the most efficient in terms of train length and weight, when considering products with different characteristics. In the analysis four products, namely copying paper, mobile phones, DVD players and shoes were considered. In addition, also two transport mixes (50/50 mixes of mobiles and paper, and DVD players and shoes) were taken into account.

All in all, 7 models were built. The first model is measuring overall efficiency of platforms for container transportation, and the rest of the models measure the same efficiency for individual product groups. The results can be seen from Tables 10-15 (see Appendix 2).

According to the DEA models, best suited for copying paper transportation would be flat car models number 13-1223, 13-1798, 13-2116, 13-3066 and 13-4117, since they have the relative efficiency value of 1. These flat cars all have a very high carrying capacity in relation to their length, which explains their suitability for transporting heavier containers. There is enough carrying capacity to transport the copying paper and yet there is not much empty space on the platform. The carrying capacity is clearly a constraining factor when transporting copying paper.

For the mobile phones, best suited platforms are 13-7024, 13-9009 and 13-9751. These platforms are all approximately 25.5 meters long and their carrying capacity is 60-71.2 tons. They can all fit four containers per platform with only a little extra space.

With DVD-players and shoes, the best suited platforms for both seem to be models 13-7024 and 13-K651. The first one is 25.62 meters long and can carry 71.2 tons and the latter is 24.68 meters long and can carry 42 tons. Both can fit four containers with only a little extra space. With these lighter products, the length of the platform is essential, since the carrying capacity sets no limits to the transport.

A closer look at the efficiencies shows that for copying paper, the best platforms are models 13-1223, 13-1798, 13-1226, 13-4117 and 13-4123 although for some of them the relative efficiency value is only very close to 1. For DVD-players, mobile phones and shoes, the best platforms would be models 13-1281, 13-1796, 13-2118, 13-3115-1 and 13-7024.

Correlations for all products, individual products and products and product mixes (copying paper / mobile phones and DVD-players / shoes) were calculated using the length and weight of a train transporting these products. The correlations are presented in Figure 75.

According to calculations, there is correlation between mobile phones, DVD-players and shoes. Copying paper, however, does not seem to have any correlation with the others. This is due to the weight of the products, since all the other products are fairly light weighted and copying paper is very heavy. Therefore, the same flat cars do not work for both. The carrying capacity is the restricting factor.

Correlations

		ALL_12	COPY	MOBILE	DVD_PS	SHOES	COP_MOB	DVD_SHO
ALL_12	Pearson Correlation	1	,459**	,700**	,844**	,849**	,580**	,873**
	Sig. (2-tailed)		,002	,000	,000	,000	,000	,000
	N	42	42	42	42	42	42	42
COPY	Pearson Correlation	,459**	1	,590**	,064	,067	,976**	,090
	Sig. (2-tailed)	,002		,000	,689	,672	,000	,571
	N	42	42	42	42	42	42	42
MOBILE	Pearson Correlation	,700**	,590**	1	,571**	,572**	,732**	,579**
	Sig. (2-tailed)	,000	,000		,000	,000	,000	,000
	N	42	42	42	42	42	42	42
DVD_PS	Pearson Correlation	,844**	,064	,571**	1	1,000**	,237	,993**
	Sig. (2-tailed)	,000	,689	,000		,000	,131	,000
	N	42	42	42	42	42	42	42
SHOES	Pearson Correlation	,849**	,067	,572**	1,000**	1	,240	,995**
	Sig. (2-tailed)	,000	,672	,000	,000		,125	,000
	N	42	42	42	42	42	42	42
COP_MOB	Pearson Correlation	,580**	,976**	,732**	,237	,240	1	,262
	Sig. (2-tailed)	,000	,000	,000	,131	,125		,094
	N	42	42	42	42	42	42	42
DVD_SHO	Pearson Correlation	,873**	,090	,579**	,993**	,995**	,262	1
	Sig. (2-tailed)	,000	,571	,000	,000	,000	,094	
	N	42	42	42	42	42	42	42

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 75. Calculated correlations for different products and product mixes

With the lighter products, weight is not a limitation, so the same platforms may be used for transporting all three products or their mixes. Here the length seems to be more of a question. Since the carrying capacity is not a problem, the 25 meter platforms seem to be optimal; the platforms can fit four containers and there is no excess space.

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9.3 Main characteristics of the Finnish container wagons

The length of Finnish freight wagons used in container transport is shown in Figure 76. Most of the wagons are 14, 14.5 or 21 meters long. There seems to be more of the shorter wagons than the longer ones, and the average length for a Finnish container freight wagon is 15.89 meters. There exist only a few wagons longer than 21 meters. In the material gathered from Finnish Rail Agency’s data, there are also wagons with no specifics. These wagons are excluded from the figures and charts shown below.

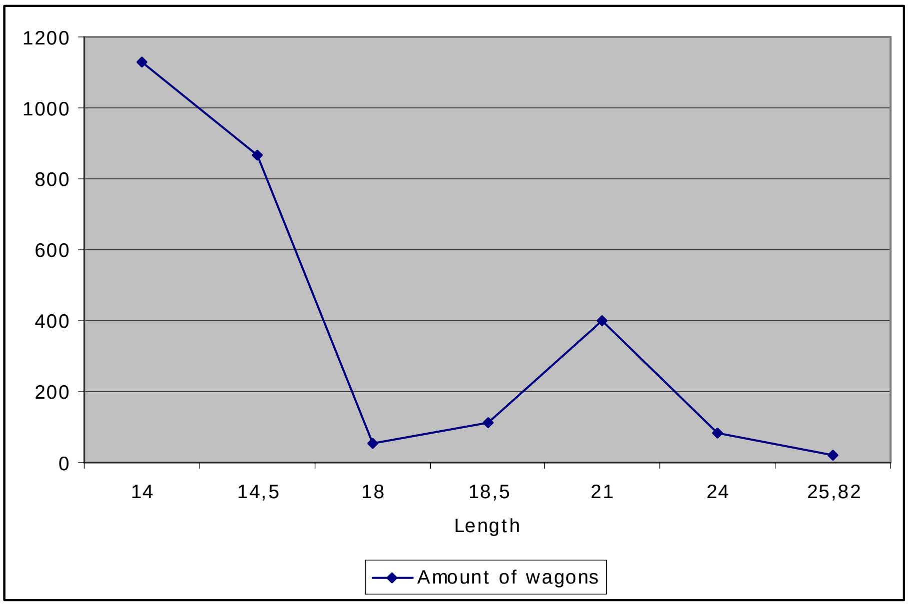

Figure 76. Length of freight wagons used in container transport in Finland (y-axis is the amount of observations). Source: The Finnish Rail Agency (2006)

The weight of the freight wagons varies a lot more than their length. Over a half of the wagons are 13 tons. The weight of other wagons varies in between 12 and 34 tons and the average weight is 15.5 tons. The weight of the wagons is shown on Figure 77.

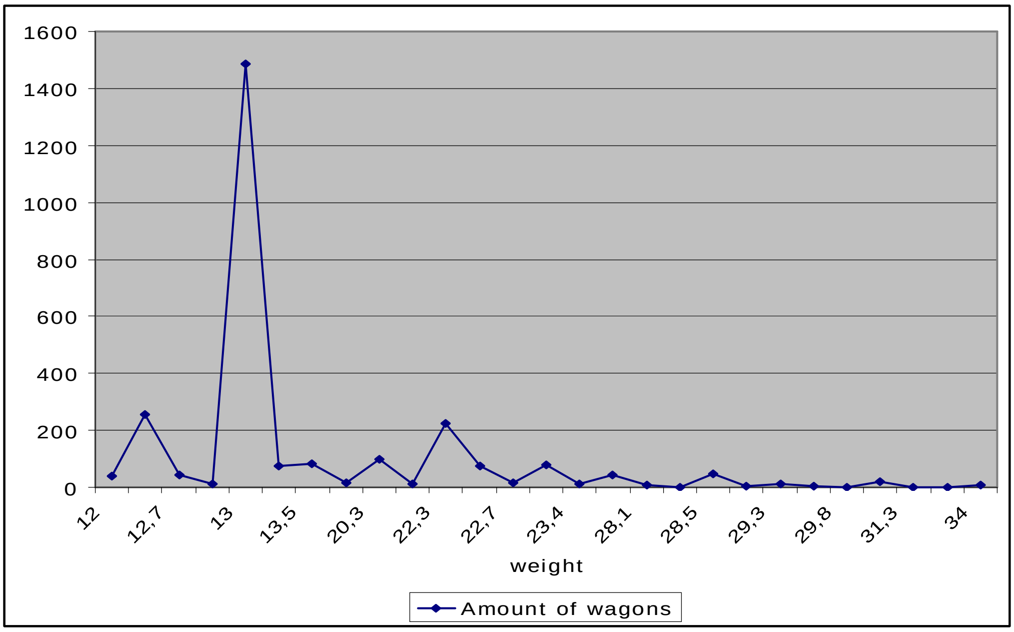

Figure 77. Weight of freight wagons used in container transport in Finland. Source: Finnish Rail Agency (2006)

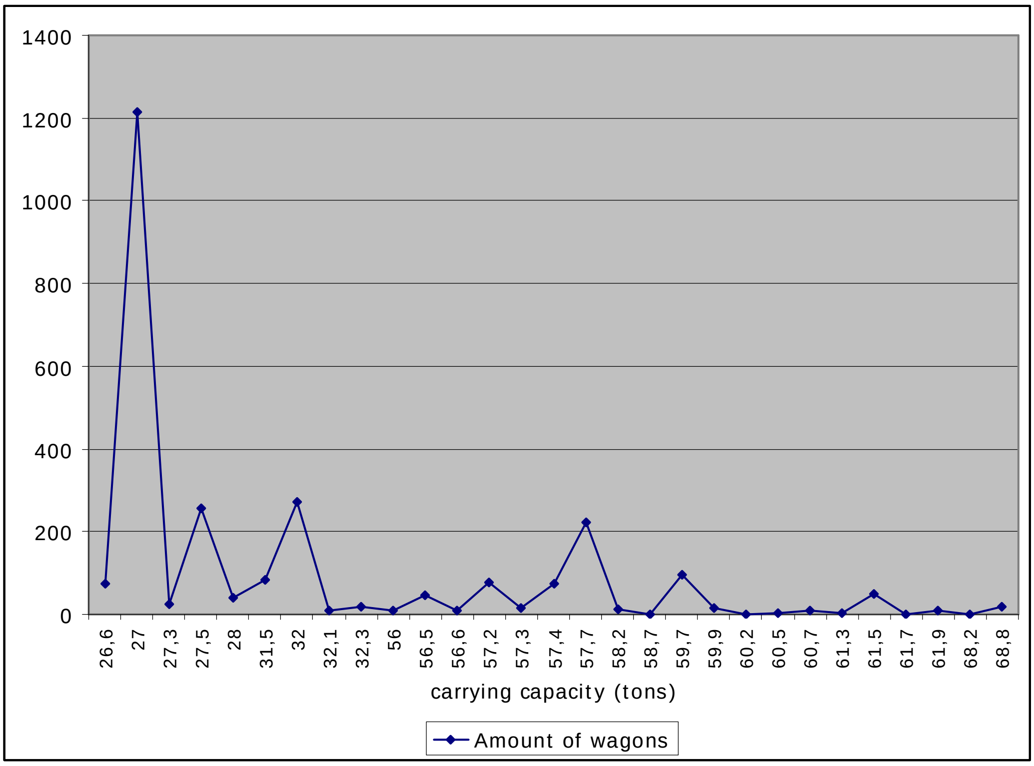

Figure 78. Carrying capacity of freight wagons in Finland. Source: Finnish Rail Agency (2006)

The carrying capacities of Finnish wagons are shown on Figure 78. The carrying capacity for the Finish freight wagons also varies considerably. Most of them can carry cargo 27 tons and the average carrying capacity is 35.7 tons. The carrying capacity of the Finnish wagons seems to be a lot lower than for the Russian wagons. The carrying capacity of the Russian wagons on average is 64 tons, while the highest carrying capacity of Finnish freight wagons is around 70 tons.

9.4 Analysis of the potential of Finnish flat cars for container transportation

As mentioned before, the carrying capacity of Finnish freight wagons is much smaller than the carrying capacity of Russian freight wagons. Figures 79 and 80 show the length and unused carrying capacity of Finnish wagons being able to transport 20 and 40 foot containers. These were calculated in similar manner as what was the case with Russian wagons, so the first results show the unused carrying capacity in a train transporting 100 containers, when the containers are packed full. For the 20 foot containers, almost all wagons have a negative unused carrying capacity. This means that there is no unused capacity with these wagons, and that the wagons cannot carry as much cargo as the containers could. Here the limitation is not the container, it is the wagon.

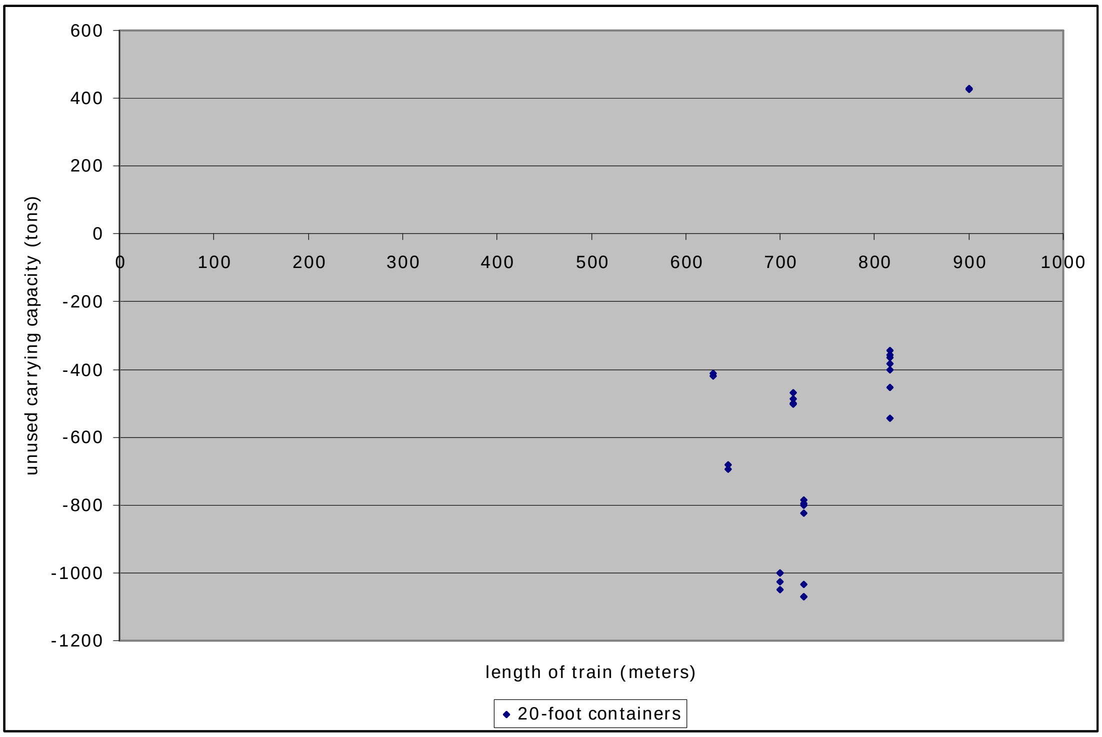

Figure 79. Length and unused carrying capacity for trains with 20 foot containers.

However, as can be seen from Figure 79, there are a few exceptions from that rule. There are two wagons that can carry all the weight in the containers and even more. These wagons are models 52510 and 52745. The first is 18 meters long and can carry 56.6 tons of cargo and the second is the same length and can carry 0.1 tons less.

For the 40-foot containers, the problem of unused carrying capacity seems to be the same as for the Russian wagons. The 40-foot container can carry only about 6 tons more than the 20-foot containers and at the same time only half of the amount of containers (compared to 20-foot) can be fitted to the wagons. In case of Finnish wagons this is enough to cause more unused capacity for trains transporting 40-foot containers. Figure 80 shows this unused capacity that seems to increase with the trains' length. The shorter trains, that have a smaller carrying capacity, have only a little or no unused capacity, but the longer trains have high unused carrying capacities.

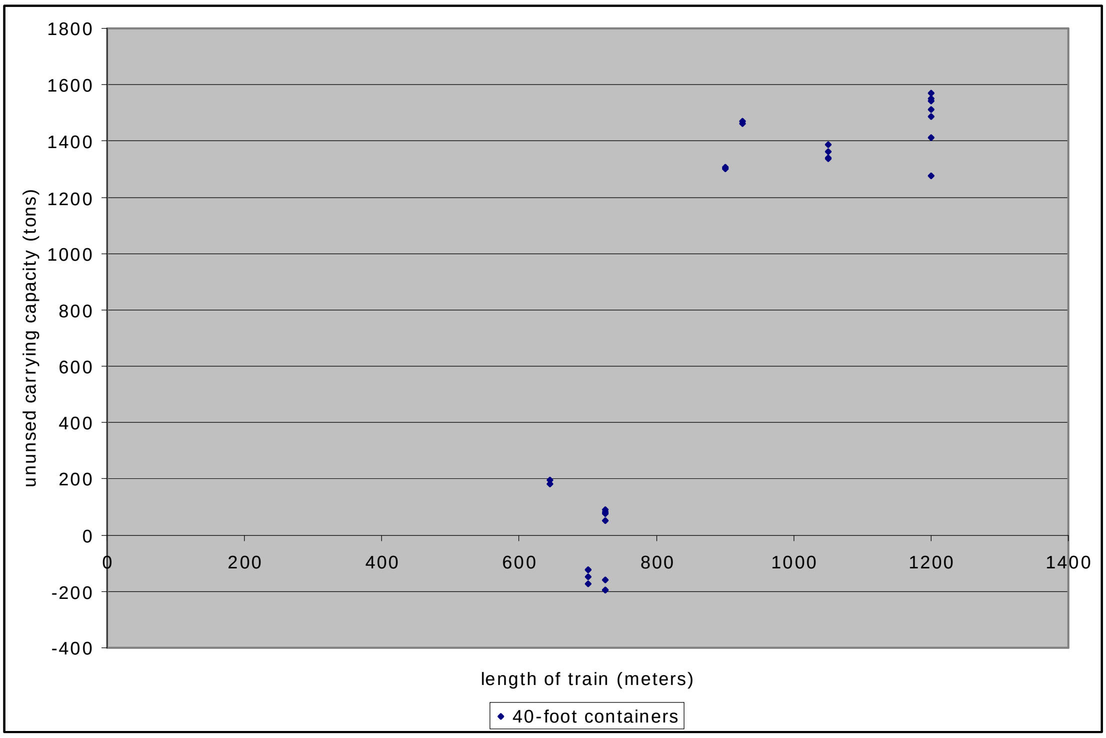

Figure 80. Length and unused carrying capacity for trains with 40 foot containers.

When the 20-foot containers are packed with the same goods used in the example with the Russian platforms, the situation is slightly different. Only copying paper is small and heavy enough to almost fill the container and use all its carrying capacity. The mobile phones, DVD-players and shoes are so light, that even when the container is full, the weight is rather light. Therefore, transporting these lighter goods in Finnish freight wagons seems to be more effective than when transporting them in the Russian wagons. There is only a little unused carrying capacity on the wagon side and all the containers are full. With the copying paper, in general, there does not exist unused capacity for the wagon, but they also can’t carry the full weight of the containers, so they have to be packed only partly full. However, there are two wagons that can carry the full weight of the containers and still have a little to spare. These are the previously mentioned models 52510 and 52745. The unused carrying capacity in one wagon with these four products is shown in Figure 81.

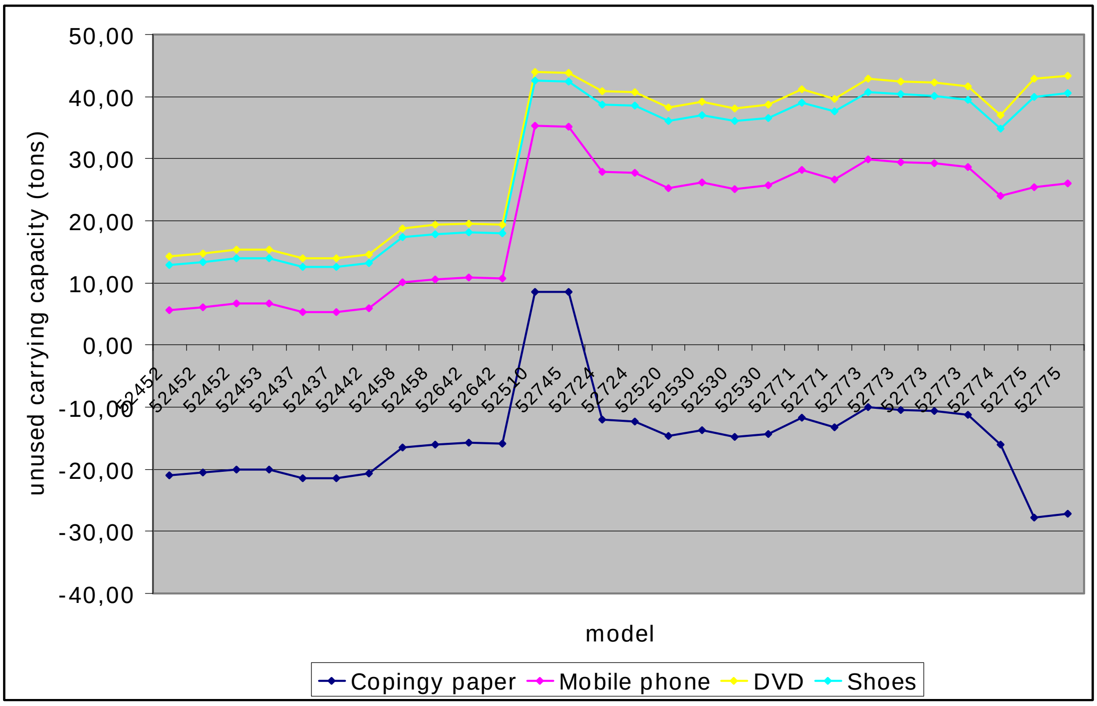

Figure 81. Unused carrying capacity for different products in one wagon with Finnish freight wagons

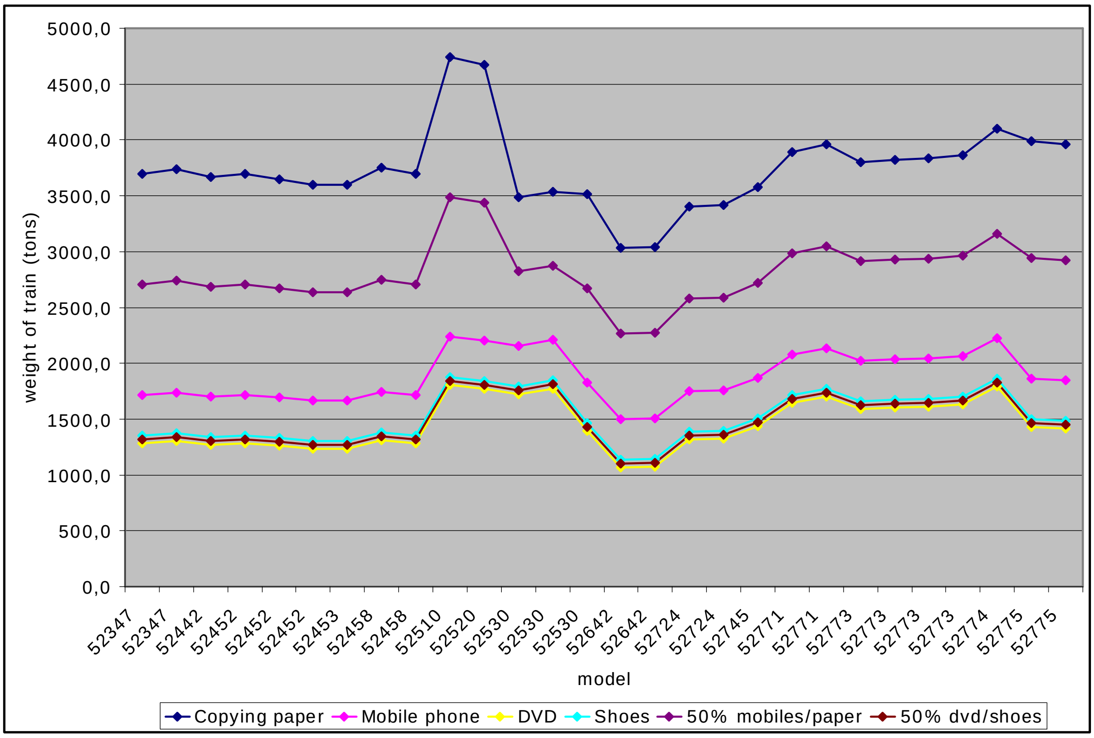

Figure 82. Weight of trains transporting goods in Finnish wagons

Figure 82 shows the weight of trains transporting the four products in Finnish wagons. As can be seen from Figure 82, the trains with copying paper as cargo (even if paper comprises only 50 %) are the heaviest. DVD-players, shoes and their mixes are the lightest.

All the calculations shown here were made with no actual regard to the length of the train, since that problem can be solved simply by halving additional trains, and using two or more locomotives. This is also why the lengths of trains shown on Figure 83 are so long.

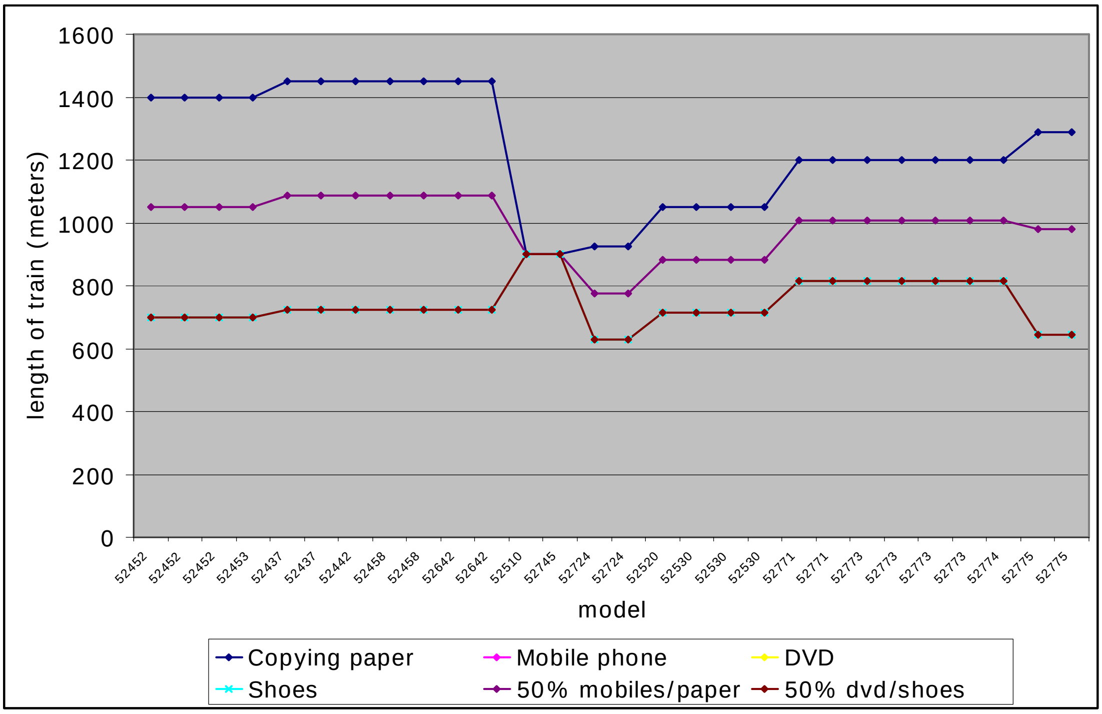

Figure 83. Length of train transporting goods in Finnish wagons

The lengths of trains reflected on Figure 83 are calculated simply by adding all the lengths of wagons together. Since the copying paper is the heaviest, it also demands the most wagons and makes for the longest trains. For the lightest products (DVD-players, shoes, their mixes, and mobile phones), the trains are equally long, because they require same amount of wagons.

10 EVALUATING DIFFERENT RAILWAY WAGON ALTERNATIVES FOR COMBINED TIMBER-CONTAINER TRANSPORTS BY DISCRETE EVENT SIMULATION

10.1 Research environment: Finnish wood demand and freight transport on the Finnish Russian border

Finland and Sweden are the two most important pulp producing countries in Europe (CEPI 2001, 2003 & 2006), accounting nearly 60 % from total production. During year 2005 Finnish wood gathering recorded 52.1 million m^3. During the same year total amount of wood imported to Finland was 21.5 million m^3, with an increase of as much as 23 % compared to the previous year. As can be seen from Figure 84, the amount of wood imported from Russia has risen steadily, and it holds as a source for 79 % of imported wood to Finland (Finnish Forest Research Institute, later Metla). Rails favor wood transports, and 59 % of Russian wood is transported via rails.

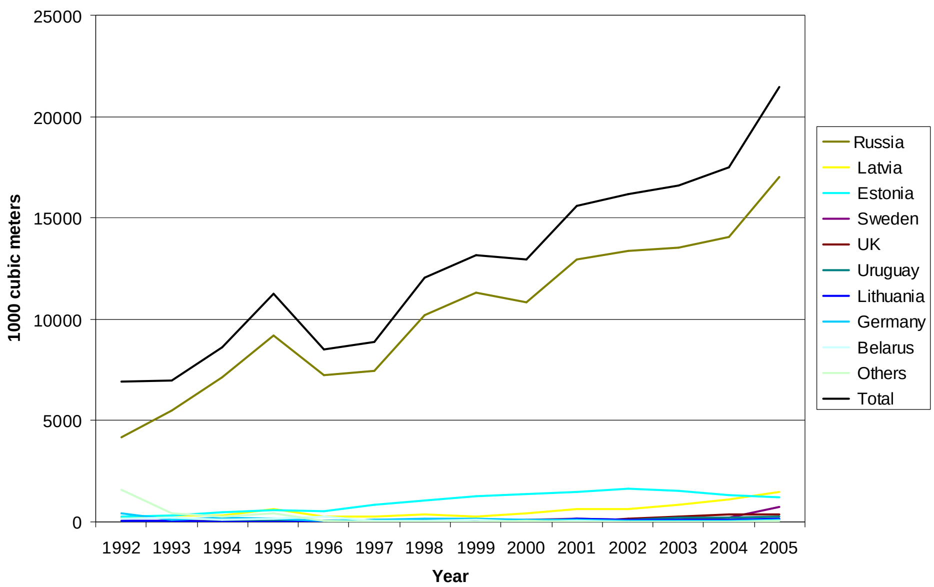

Figure 84. Finnish imports of round wood and wood residues by country, 1992–2005. Source: Metla (2006)

Until now Russian timber has had a cost advantage in comparison to Finnish raw material. The availability of a cheaper alternative has also kept the price of domestic raw material at a relatively low level. However, Russia has announced a schedule to increase tariffs for timber exports – these are already effective, and based on the tariff increase programme only going to get higher in the future. This has already harmed Finnish pulp and paper manufacturing industry with plant shutdowns, however, notable is the fact that northern China is facing similar situation with Finland (China and Finland together, with rather similar volumes, account more than 80 % of Russian timber exports!). More details from Chinese situation in Box III.

Table 14 shows that a disparity between the modes of transportation between Russia and Finland. Especially rail transports have idle capacity in the eastbound direction. The transit flow is due to the insufficient capacity of the Russian ports to handle the ever increasing demand for imports. Finnish ports are used for unloading the cargo and the goods are transported to Russia mostly by road.

Table 14. Finnish Russian trade and transit flows (1000 t). Source: Finnish Board of Customs 2005, 2006 & 2007

2004	Water	Rail	Road	Air	Other	Total
Import	15866	10054	3941	0	3365	33226
Export	160	408	1363	0	0	1932
Transit			2336			2336

2005	Water	Rail	Road	Air	Other	Total
Import	14372	10685	4274	0	3068	32399
Export	115	372	1554	1	2	2045
Transit			2640			

2006	Water	Rail	Road	Air	Other	Total
Import	14223	10725	4096	0	3313	32358
Export	146	521	1649	1	6	2324
Transit			2964			2964

On Russian railways customers are allowed to own railway wagons, but nationally owned RZD owns the locomotives and charges for a traction. In Finland freight operations have been under free competition from the beginning of year 2007, but only small number of other companies, than governmentally owned VR, have shown interest in this isolated market. Explanation could be given with geographical position in European map; Finland is more like a shore in Europe, and is one of the eastern border countries of EU. This fact makes railway markets increasingly protected, since European railway packages of opening up of international freight and passenger traffic are mostly ineffective, since Finland has land connection to Sweden only in up north, and possible international freight and passenger services inside of EU's countries are therefore impossible in both time and cost aspects. Among long-distance freight and passenger transports, there exist several barriers for competition within short-distance passenger transports. Also Russian traffic has been contracted to be privilege between Finnish state railways and Russian RZD (more from deregulation of Finnish railways, see Hilmola & Leino 2006).

Box III. Chinese Timber Imports from Russia by Rail

During the year 1998, "Natural Forests Protection Project", was enacted by the Chinese government; therefore very limited forests are allowed to be used for production purposes. Currently, the national demand of timber is 0.4 billion cubic meters, but the maximum supply by the local market is about 0.22 billion cubic meters, so the shortage of timber supply is approximately 0.18 billion cubic meters. Experts have estimated that this shortage will remain in this level for the next decade perspective (Harbin Customs District 2007a; Manzhouli Economic Bureau 2007; Sun 2007).

China imports logs from various countries, with following volumes during year 2006 (calculated by million cubic meters, percentage in parenthesis): (1) Russia: 21.8 (67.9 %), (2) Papua New Guinea: 2.1 (6.4%), (3) Malaysia: 1.4 (4.4 %), (4) Burma: 1.0 (3.2 %), (5) Gabon: 0.96 (3 %), (6) New Zealand: 0.9 (2.8%), (7) Solomon Islands: 0.8, (2.4 %), and (8) Germany: 0.5 (1.4%). The accumulated import volume of these countries have an accumulated import volume of about 29.4 million cubic meters, which accounted for 91.5 % of the total log imports. Russian imports has increased by more than 150 % within 7 years perspective, and it has been forecasted that growth will continue with 10 p.a. (Harbin Customs District 2007a; Manzhouli Economic Bureau 2007; Sun 2007) About 80% of the logs and 70% of the sawn timber of China's timber imports from Russia are imported through border trade, with the usage of railway (see Figure 85). Approximately 20% of the Russian logs and 30% of the Russian sawn timber are imported by ocean freight in the southern part of China.

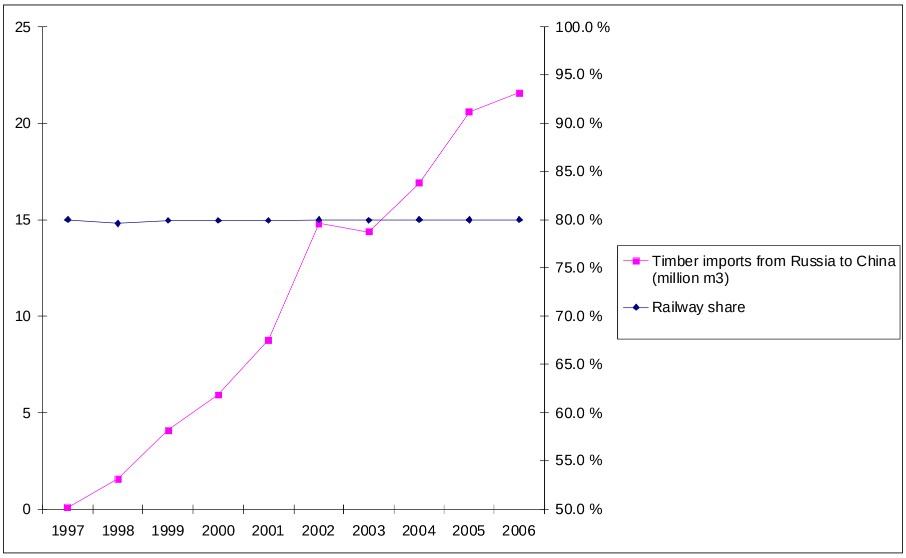

Figure 85. Wooden log imports from Russia to China in a period of 1997 to 2006.

Besides the technical issues, the regulation also emphasizes on the customs procedures. The purpose is to minimize the illegal imports and exports between China and Russia. The Chinese Ministry of Commerce states that Chinese major railway gateway Manzhouli Pass will be affected by this regulation. (Chinese Ministry of Commerce 2007)

Between January and August of the year 2007, there were 14 direct customs districts in China importing logs from Russia. The biggest passes are Manzhouli (43.6% from volume), Helongjiang (province, 31.9%), Mongolia (12.2%) and Jiangsu (province, 6.5%). (Harbin Customs District 2007a)

According to the latest legislation enacted by the Russian Government- "The Forests Legislation", from the year 2007 July, the export tariff of timber has been increased up to 10 euros per cubic meter. The increase of timber export tariffs will be preceded by 4 phases respectively: During the year 2009, timber export tariffs will be raised up to a minimum of 50 euros per cubic meter (RZD 2007; Harbin Customs District 2007b; Manzhouli Economic Bureau 2007). Owing to the increase in timber export tariffs, in July 2007, China experienced the highest import rate of logs – the average rate per cubic meter rose to 110.6 USD, meanwhile, Manzhouli pass experienced the imports rates up to 116.4 USD per cubic meter. This issue has been influencing on the Chinese forest sector and the Chinese domestic timber market significantly. As a result, faced with these critical issues, the Chinese government has to look at other alternatives, such as increasing the imports from South America and Africa to make up of the shortage of timber supply from Russia.

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10.2 Simulation case of wagons used in wood transports, and possibilities for combined container transports

The simulation study aims at examining the transportation cost of forest industry raw material using two different types of railway wagons.

Simulation tool

The simulation results presented in this section have been completed using Quest, simulation software offered by Delmia Corp. It is a manufacturing-oriented simulation package. Quest combines an object-based, 3-D simulation environment with a graphical user interface. A Quest model consists elements from a number of element classes; modules for modeling labor, conveyors, automated guided vehicles, kinematics devices, cranes, fluids, power and free conveyors and automated storage and retrieval systems are available. Commonly needed behavior logic is selected from menus, and being mainly parameter-driven. For unique problems, Delmia's Quest Simulation Control Language can be used.

Structure of the network

The simulation model of the rail network includes stations and connecting rails with length and intermediate speed. Each connection between two locations in the network is modeled separately, i.e. the model does resemble the actual rail network structure in physical terms. Stations are modeled as buffers; conveyors are used for connecting rails. Input data concerning network lead times as well as simulation output data is stored in text files.

In the case model, rail transport of timber to two mills located in Eastern Finland is being analyzed. The supply of timber comes from 4 terminals located in Russia. The average distance of the terminal to the mills is 458 kilometers.

In the beginning of the simulation run all wagons are located at the terminals. There is a train leaving from each terminal to both mills each day. The amount to be transported has an annual pattern, where the quantity of each month is different. The daily amount carried by each train is drawn from a uniform distribution with a variability of 10 % (i.i.d). The amount is rounded to the closest volume allowing full wagon loads. The quantity of wagons needed for a train is reserved for loading and customs clearance. After customs clearance the trains travel to the destination mill, where they are unloaded. Empty wagons are returned to the terminal where it was originally located. When the route is complete, the wagons are added to terminals inventory and performance data of the route is written to a text file for further economic analysis. Also the wagon inventory at each terminal is written to a text file on a daily basis.

The alternative scenario combines container traffic with wood transportation. In this scenario wagons are after unloading at the mill directed to a container terminal located in Kouvola, Finland. At Kouvola wagons are loaded with containers, which are transported to Saint Petersburg. From here, empty wagons are returned to the terminal where they were originally located, as in the first scenario. This container traffic would substitute road transports. A screenshot of the model is presented in Figure 2. The points in left side of Figure 86 represent container docking point of Kouvola, then two upper points in the middle pulp/paper mills located in Imatra and Eno. Wood collection terminals on Russian side are located all in the right side, while St. Petersburg container dropping point is located in the middle. The length of each simulation run was 14 months with a warm-up period of 2 months.

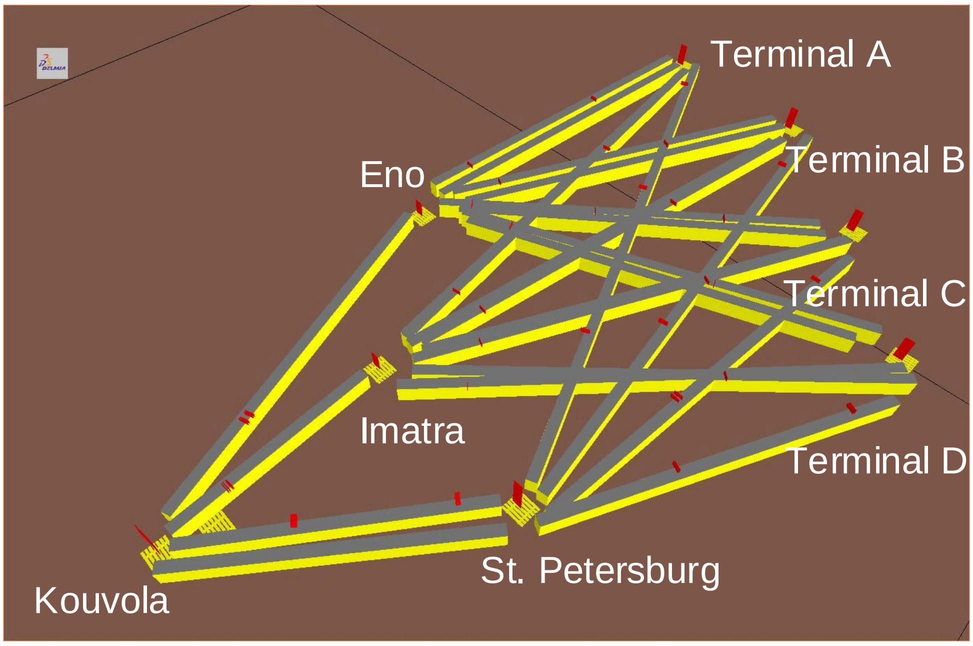

Figure 86. Screenshot of the discrete event simulation model in running mode.

Cost model

The transportation cost in the model consists of two components, cost of the wagons and traction cost. The cost of the wagons includes interest cost and maintenance, while the traction cost charged by the operator is assumed to depend on the gross ton kilometers to be transported.

Parameter values used

The volume to be transported in the peak month from each of the terminals is shown in Table 15. The volume from each terminal is divided between the two mills equally.

Table 15. Terminal volumes for the peak month

Terminal	Terminal A	Terminal B	Terminal C	Terminal D
Volume m^3	22 700	17 300	24 000	17 300

Although, mills basically run and produce at a fairly constant rate, wood harvesting and transportation experience a heavy annual pattern. For the seasonal pattern of the transports Finnish commercial round wood removals by month are used. The pattern is shown in Figure 87.

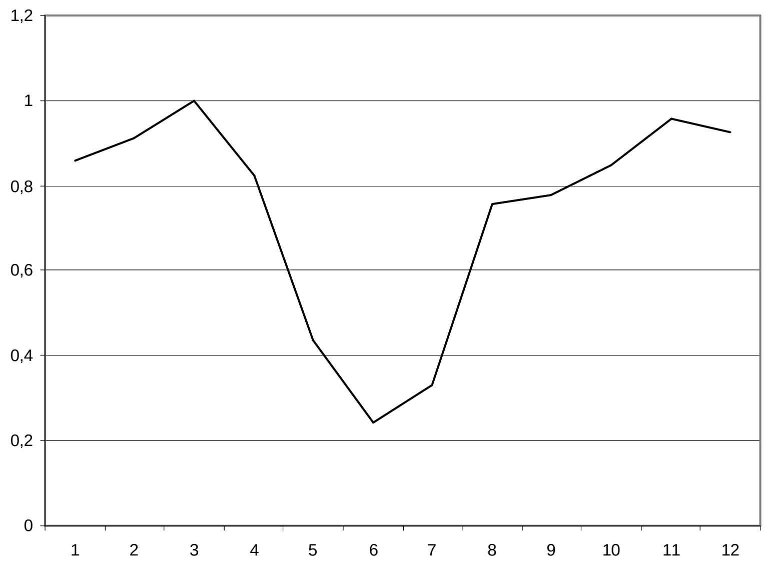

Figure 87. Commercial round wood removals by month (source: Metla 2006)

Technical and economic parameters of the two wagon types evaluated are presented in Table 16. Technically a 13-926-01 type wagon could carry 66 tons of cargo. However, the maximum axel weight allowed on the rail network is 22.5 ton, which restricts the cargo to 62.2 tons.

Table 16. Wagon parameters for two different alternatives.

Wagon type	13-401-20	13-926-01
Length	14620 mm	19620 mm
Body Weight	23.8 ton	27.8 ton
Load Weight	66 ton	66 ton
Load Volume	130 cubic meter	158 cubic meter
Price	45 000 €	50 000 €
Lifetime	32 years	32 years
Resale price	2 000 €	2 000 €

Lead times used in the base and combined scenario are presented in Tables 17 and 18 respectively. As can be seen from the tables, typical turns are 12 and 19 days respectively – this leads to very low average transportation speed (couple of kms per hour!). However, these given values are taken from real-life and they correspond with raw material transport speed between Finland and Russia.

Table 17. Lead times in base scenario

Source	Term. A	Term. B	Term. C	Term. D	Term. A	Term. B	Term. C	Term. D
Destination	Mill 1	Mill 1	Mill 1	Mill 1	Mill 2	Mill 2	Mill 2	Mill 2
Loading	3	3	3	3	3	3	3	3
Loaded travel	4	4	4	4	3	4	5	4
Unloading	1	1	1	1	1	1	1	1
Empty travel	4	4	4	4	3	4	5	4
Turn	12	12	12	12	10	12	14	12

Table 18. Lead times in the combined scenario.

Source	Term. A	Term. B	Term. C	Term. D	Term. A	Term. B	Term. C	Term. D
Destination	Mill 1	Mill 1	Mill 1	Mill 1	Mill 2	Mill 2	Mill 2	Mill 2
Loading and Customs	3	3	3	3	3	3	3	3
Loaded travel (wood)	4	4	4	4	3	4	5	4
Unloading Mill	1	1	1	1	1	1	1	1
Unloaded travel (FIN)	1	1	1	1	1	1	1	1
Loading Containers	1	1	1	1	1	1	1	1
Loaded travel (containers)	4	4	4	4	4	4	4	4
Unloading Containers	1	1	1	1	1	1	1	1
Unloaded travel (RUS)	4	4	4	4	5	4	4	4
Turn	19	19	19	19	19	19	20	19

In reality the pricing policy of the operator is probably case dependent. In the model cost of traction is assumed to depend on the gross ton kilometers transported. Total sales of the Finnish freight operator VR was 358.9 M€ in year 2006 with a 11 060 million ton kilometers being transported (net). This gives an average of 3.25 eurocent per ton kilometer. The wagons used for the transport are typically owned by VR. The calculations based on the simulations were performed using the value of 3.0 eurocent per ton kilometer. When calculating the annual capital cost an interest rate of 5 % is used.

Model validation and verification

The lead times and volumes used in the model were supplied by the people responsible for timber transports. The performance measure calculation of the simulation model was verified manually. The lead time verification process was based on visual observation of the model running.

10.3 Results

Table 6 shows the summary of the four scenarios. As the cargo carried by the 14 meter wagon is bigger than by the 19 meter wagon, 66 and 62.2 tons respectively, fewer the smaller 14m wagons are needed for transporting the same amount of wood. With equal lifetime the 14 meter wagon induces less capital cost per ton kilometer. Furthermore, as it has a better cargo-dead weight ratio, also the traction cost is lower. So, in the base scenario the 14 meter wagon is the more efficient and economic choice of the two wagons.

When container traffic is combined with wood transportation, extra wagons are needed, which increases the capital cost. Additional freight is carried and distance is traveled, which increases the traction cost. Table 19 lists the additional cost incurred by the combination. This extra cost is divided by the systems annual capacity to transfer TEUs. A 14 meter wagon can carry 2 TEUs, while the capacity of the 19 meter wagon is 3 TEU. The break even figure is calculated against the base scenario using the similar wagon.

A break even price of the 19 meter combined scenario against the 14 meter base scenario can be calculated. With the parameter values used the break even price is 274 € for TEU. However, at this price the 14 meter combined scenario would make a 612 000 € profit. Because of the larger TEU capacity of the system based on the 19 meter wagons, the 19 meter combined scenario becomes more attractive as the price of transporting a TEU increases. The break even point for the parameter set used is 338 €.

Table 19. Cost comparison with a traction cost of 3.0 eurocent.

	14 meter base	14 meter combined	19 meter base	19 meter combined
Wagons needed	521	819	558	883
Ton kilometers (gross)	579 220 962	729 995 811	643 261 020	853 417 949
Ton kilometers (net)	336 541 788	337 012 038	339 674 511	339 007 665
Interest rate	5 %	5 %	5 %	5 %
Wagon price	45000	45000	50000	50000
Life Time	32	32	32	32
Resale price	2000	2000	2000	2000
Annual cost per wagon	2 833 €	2 833 €	3 134 €	3 134 €
Annual cost total fleet	1 475 760 €	2 319 860 €	1 748 709 €	2 767 223 €
Capital cost per ton kilometer	0,0044 €	0,0069 €	0,0051 €	0,0082 €
share	7,8 %	9,6 %	8,3 %	9,8 %
Traction per tkm (gross)	0,030 €	0,030 €	0,030 €	0,030 €
Traction cost per ton kilometer	0,052 €	0,065 €	0,057 €	0,076 €
share	92,2 %	90,4 %	91,7 %	90,2 %
Total cost per ton kilometer	0,0560 €	0,0719 €	0,0620 €	0,0837 €
Total cost	18 852 389 €	24 219 734 €	21 046 540 €	28 369 761 €
Cost due to Combination	x	5 367 346 €		7 323 221 €
Number of wagon turns	10924	10924	11592	11592
TEU capacity		21848		34776
Break even for TEU		246 €		211 €

The time usage break-down is not dependent of wagon type. The break-down for the base and combined scenario are shown in Figures 88 and 89 respectively. Wagons are unused 26 % of the time, because of the seasonal pattern of the volume – it is surprising to find out that unused time is having rather similar amount with loaded travel time. So, it could be argued that only in wood transports 75 % of time is "wasted" in non-value adding activities, and in a case of combined transports this is a bit better, 69 %.

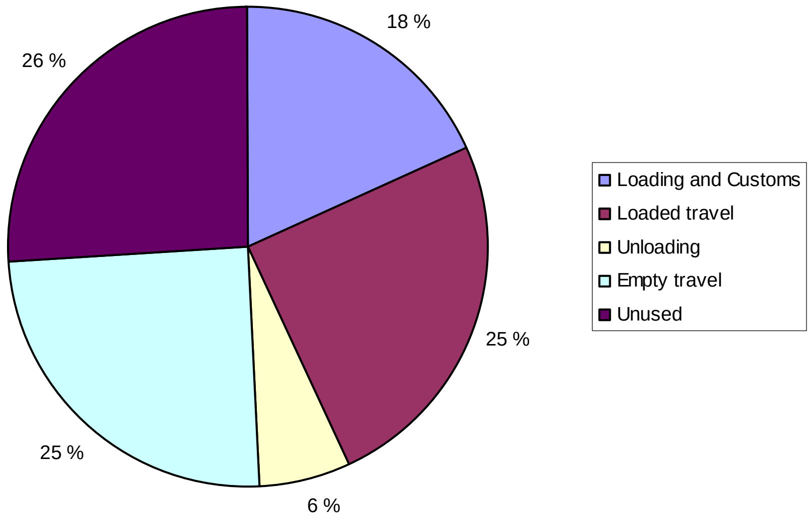

Figure 88. Time usage break-down of wagons in the base scenario (only wood transports with wagons).

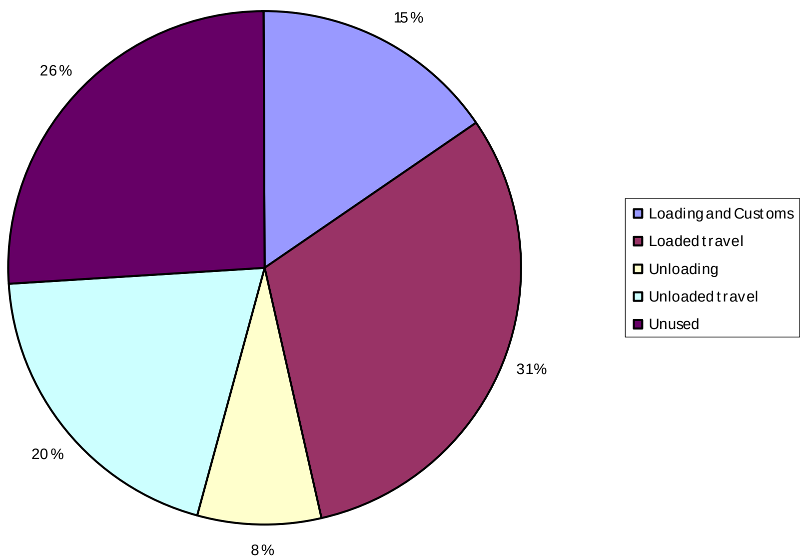

Figure 89. Time usage break-down of wagons in the combined scenario (wood and containers transported with same wagon).

Sensitivity analyses

The sensitivity of the results against three factors was explored. The traction charge of the operator obtained the values from 2.0 to 5.0 eurocent per ton kilometer with a increment of 0.5 eurocent.

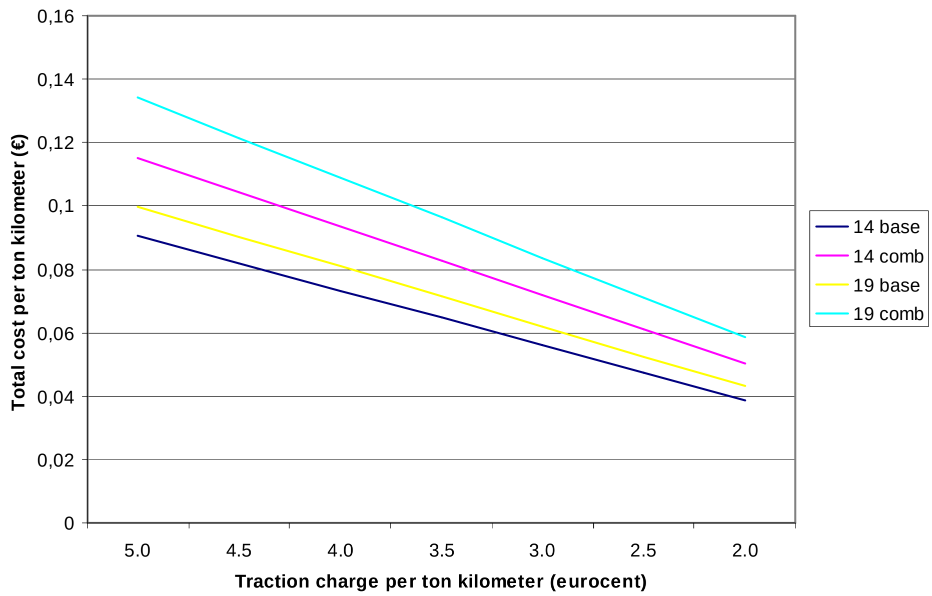

Figure 90. Total cost as a function of traction charge.

As can be seen from Figure 90, the traction charge has a major impact on the total cost per ton kilometer. The relative rank of the scenarios does not change.

Even more interestingly the traction charge affects the TEU break even prices of the combined systems. If the market price for transporting a TEU is below the lower break-even level in Figure 91, the cost efficient alternative is to use 14 meter wagons solely for timber transportation. If the market price lays between the two lines found in Figure 91, the combined system using 14 meter wagons is optimal. If the market price of TEU transport is above both lines, the combined system based on 19 meter wagons should implemented.

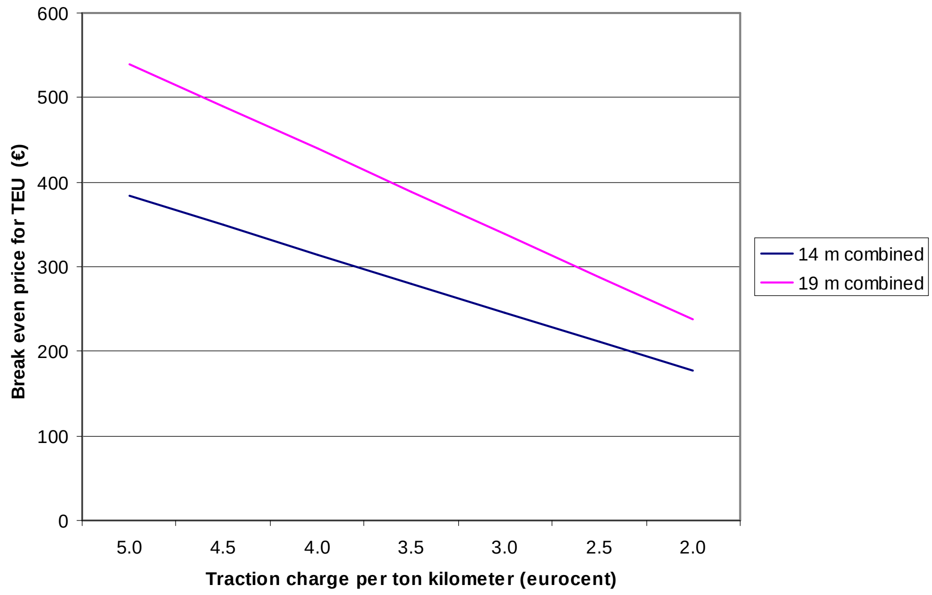

Figure 91. TEU Break-even prices of the combined systems a function of traction charge.

In the second experiment the effect of combining only Mill 1 wood transports with container traffic was evaluated. The motivation of this experiment is that Mill 1 is located closer to the container route, avoiding unnecessary unloaded travel. The volume of the operations was reduced to a half, but the average cost per ton kilometer was not affected. This is because lead times for both mills were similar. Furthermore, additional kilometers traveled empty are compensated by longer transport legs in case of more distant terminals. However, the break-even for combining container transports in the Mill 1 loop is around 10 percent lower than for the whole system. Although the Mill 1 is located closer to Kouvola than Mill 2, the difference reduced by the longer transport leg required by the most distant terminal after the combination.

Table 20. The effect of increased travel speed on the capital cost per ton kilometer.

	14 base	14 combined	19 base	19 combined
Original	0,0044 €	0,0069 €	0,0051 €	0,0082 €
Two times higher speed	0,0030 €	0,0048 €	0,0036 €	0,0056 €

In the third experiment the travel speed of the trains was doubled, i.e. the lead time of each leg is reduced to one half. As the model is on daily level, new lead times are rounded upwards to the nearest integer. In effect only legs involving travel on Russian soil are affected. This scenario is motivated by the relatively low travel speed of the wood transport, which is around 5 kilometers an hour. The results of this experiment are presented in Table 20. Increased speed reduces the number of wagons needed and thus capital cost per ton kilometer. However, traction cost, which constitutes around 90 % of the total costs, is unaffected. Thus traveling at a double speed reduces total cost only by 3-4 %.

In the fourth experiment the border crossing point near Mill 1 was not used (factory located in Imatra). This scenario is motivated by announcement of the Russian authority to possibly decrease the number of border crossing points in the near future. In the network in question wood transports to Mill 1 are affected. The wood would need to be transported using the border crossing point located on the Kouvola – St.Petersburg route. This change will increase the distance traveled, but also reduce the cost of combining wood transports with container traffic as the additional distance caused by the combination is decreased.

The additional travel in one direction required by change in the network was approximately 60 kilometers. It is assumed that the additional distance can be completed within the times used in the original scenarios. This is realistic as the additional kilometers are traveled on the Finnish side of the border, while the use of Russian network is somewhat reduced. Because equipment turns are not affected, the wagon need remains on the original level. The new break-even prices for the whole system are shown in Figure 92 using dotted lines.

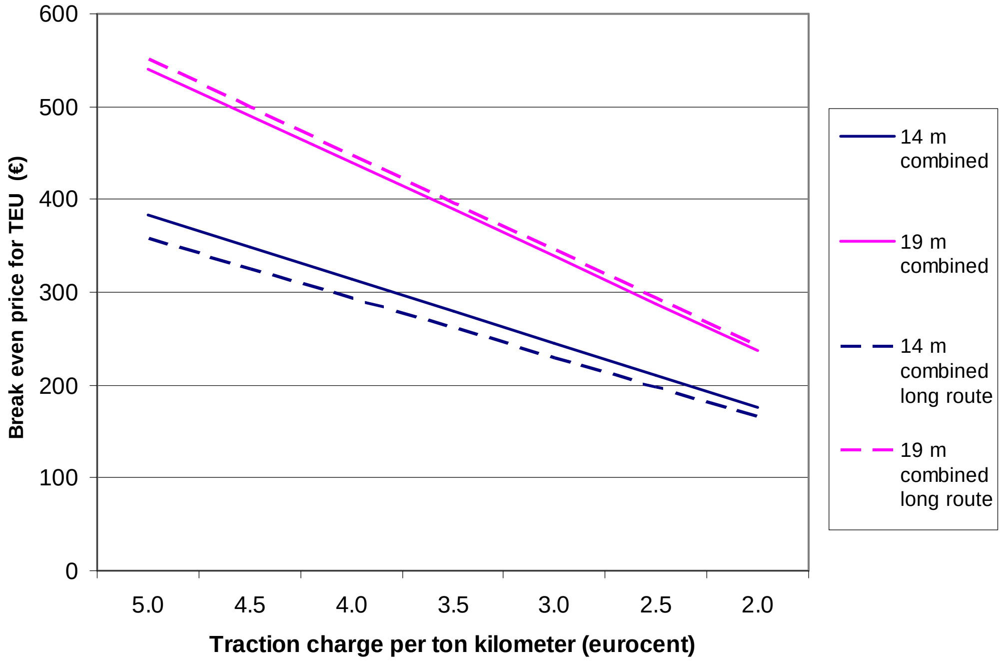

Figure 92. TEU Break-even Prices for the whole System, Mill 1 border crossing closed.

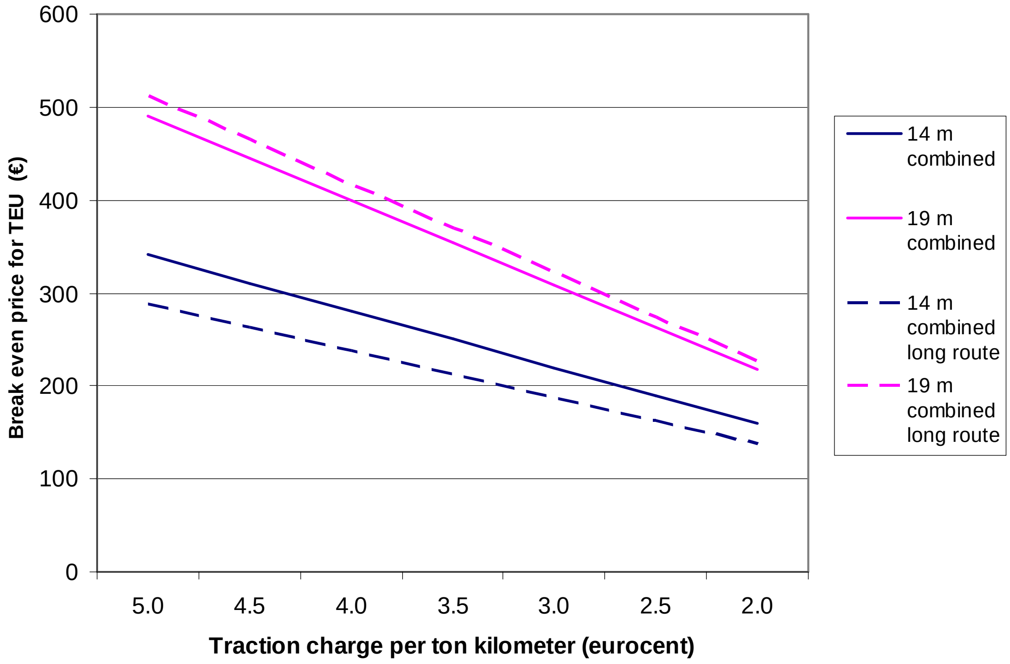

Figure 93. TEU Break-even Prices for Mill 1 Transports, Mill 1 border crossing closed.

As stated earlier the cost of combining transports is decreased by the network change, i.e. the 14 meter combined line is lower than originally. On the other hand the break even line for the 19 meter system has moved upwards. Although, combining transports does become more economic, the 19 meter wagon system suffers from the extra kilometers relative to using the 14 meter wagons.

As the network change affects only wood transports to Mill 1, Figure 93 concentrates on the break even prices of this subsystem. In the figure the shift in the break even prices is more evident than for the whole system.

The transportation *cost per ton kilometer* is not affected by larger extent from the closing of the border crossing point – this is mostly due to the reason that two dimensional measure causes bias, since empty travel increases with the same proportion with loaded travel. So, transportation system could have higher cost, but due to this mentioned reason, cost per ton kilometer would not change.

In the network in question the average distance from a terminal to a mill is 458 kilometers. The transportation *cost per ton* is a mostly function of traction charge, and can be derived from Figure 90 for the whole system. Transportation cost per ton to Mill 1 (Imatra) is 9 to 11 percent lower than for the whole system, because of the shorter transportation distances. Traveling at a double speed reduces transportation cost per ton by 3-4 percent, due to reasons discussed earlier in the context of transportation cost per ton (or cost per ton kilometer as speed affects within same manner on both measures). Closing the border crossing point near Mill 1 increases transportation *cost per ton* by 8 percent as longer transportation is needed to reach the mill – in our simulation model it was assumed that raw materials flow in equal parts to two mills, which results in a situation that system transportation *costs per ton* increase by .4 percent.

10.4 Discussion from simulation study results

The evaluation of the combined concept is complicated by the fact that no public information for the price of the Kouvola – St. Petersburg container leg exist. According to RZD the lead time for the leg is 4 days. In the model 1 day was reserved for unloading and loading respectively. If the return leg would take 4 days, the turn of the wagons in container traffic would be 10 days (1+4+1+4). The typical turn in the base scenario concentrating on timber transport was 12 days, while the turn in the combined scenario was 19 days. Thus, in comparison to the two separate transportation systems the combined scenario gives a three 3 day or 16 % advantage in wagon turn and reduces wagon need accordingly.

Furthermore, the positive effects of the combined transport can be reasoned on the basis of network geometry, which is schematically presented in Figure 94. As long as A+B>C+D, the fully loaded travel ratio, which affects the traction cost per ton kilometer is improved, if the transports are combined. In the case network this criterion is fulfilled for 7 of the 8 transportation loops.

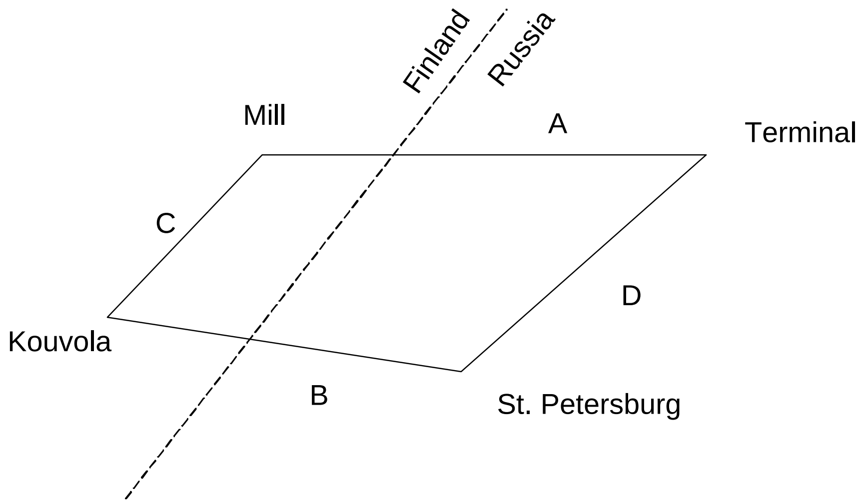

Figure 94. Schematic transportation loop used in the simulation research.

The transportation cost is dominated by traction charge, which is defined by the operator. Leaving capital cost the only cost component, which can directly be affected, as the traction charge has to be taken as given. However, also the traction charge can be affected by the selection of the wagon type, as traction charges are assumed to depend on gross ton kilometers, while the actual transportation need is in net ton kilometers.

Based on our results when only wood is transported, the 14 meter wagons have a cost advantage in comparison to the 19 meter wagons independently of interest rate and other parameters. In this case 19 meter wagons would have to be cheaper than the smaller 14 meter wagons to compensate for the poor cargo dead weight ratio.

As can be seen from Figure 91, the optimal transportation system configuration depends on two factors (1) the market price for TEU transport on the given route and (2) the ton kilometer charge of RZD. The formed is defined by the competition from road transportation while RZD has monopoly on determining the latter. To be prepared for sudden changes in the cost structure, it would be safer to implement a system using 14 meter wagons, which are always the preferred option if the combined transportation concept needs to be abandoned.

Furthermore, the capacity advantage of the 19 meter wagon relies on two assumptions: (1) the share of 40 feet containers must not exceed 50 % of the containers to be carried in each train, and (2) the weight of the cargo on each wagon must not exceed 62.8 ton.

Our calculations concerning the break-even price of TEU do not include resources used for loading and unloading containers. Inclusion of these costs would shift the two break-even price lines in Figure 91. Nor does the price include administration cost. To ensure efficiency marketing and administration of container traffic should be outsourced, as container traffic is not the core business of Finnish forest industry. However, we would like to highlight that freight costs of 3.25 eurocents per ton kilometer, as calculated from the revenues and transported amount of Finnish VR, include loading/unloading as well as administrative, other expenses and profits (with high probability freight segment of VR is profitable, and passenger side in deficits), so the correct paid amount from pure traction services should be around 2 eurocents per ton kilometer.

In the combined scenario it was assumed that all containers would be always available for the return trip. One could argue that the annual pattern of container traffic does not follow Figure 87. Here it is assumed that container traffic is mainly transported by road also in the future.

The seasonality affects also the utilization of the wagons. As can be seen from Figures 88 and 89, wagons are unused 26 % of the time. Although not even possible, the cost reduction potential of smoothing out seasonality and fluctuation is not large – around 2 to 3 % of total cost.

Some remarks about the assumptions used in the model and their effect on the resulting cost need to be made. In the model one train is send from each terminal to both mills on daily basis. The volume of each train is drawn from a uniform distribution using 10 % variability. Furthermore wagons return to the same terminal. In reality the number of daily trains to the mills is not 4. However, the number of daily trains does not affect ton kilometers traveled and thus not costs. In reality wagons could be directed from the mill to the terminal where they are needed. Given a turn of at least 12 (or even 19) days and two destinations the daily variability is cancelled out and the fluctuation in wagon inventory is determined by seasonal factors. The potential effect of modeling fleet control in a more detailed level would affect only capital cost in the model. The cost reduction potential of smoothing out avoiding idle totally is not large – again around 2 to 3 % of total cost.

11 TOWARDS NEW NETWORKED WAGON MANUFACTURING WITH OPTIMAL COMBINED TRANSPORTS RAILWAY FREIGHT WAGON

11.1 Wagon manufacturing trade relations between leading countries

The statistical data gathered from the United Nations Statistics Division concerns observation period of 2002-2006 (except France and Japan in which case the year is 2005), and it covers all the transactions of international trade related to the railway wagon manufacturing in selected countries of interest (these are Canada, China, France, Finland, Germany, Japan, Russia, Sweden Ukraine, and USA). Firstly our interest is given on the overall development in trade during the five year period (see Figure 95) – most important partner clusters are shown in Figures 96 (built from import) and 97 (built from export). Based on the analysis it can be argued that three groups of countries can be identified with intensive import and export activities with each other: (1) China, Japan and USA is included in the first set, (2) Germany, France and Sweden are the members of the second one, and (3) Russia with Ukraine are included in the third. Finland could be considered to be actor between second and third group.

General observation based on the set of data being analyzed seems to support the widely accepted view of the existence of trade imbalances between continents. On the other hand, in many cases neighbouring countries are involved in ever tightening interactions with each other and this might increase demand imbalances between continents. Overall, international trade among railway wagons is increasing within fast phase, as Figure 1 shows, imports have increased by approx. 70 %, while exports with over 120 % in four year respect in the analyzed countries of interest. We could also identify that certain countries have developed more like export led, while other relay more on imports – indicating that specialization in wagon manufacturing is taking increasingly space in the business environment. In addition it has to be mentioned that the data concerning analyzed countries may have differed significantly in some places (as exports of Germany to China is compared with Chinese imports from Germany concerning that very same year), but this is most likely due to the different accuracy procedures of updating databases of the countries involved.

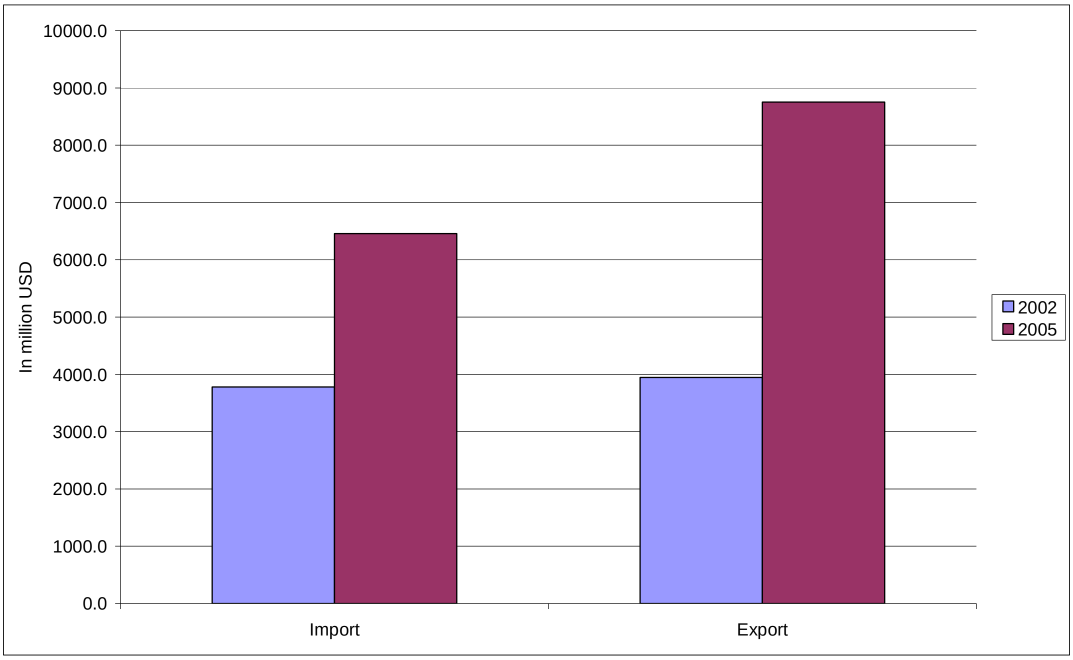

Figure 95. Import and export volumes of railway wagon manufacturing during year 2002 and 2005.

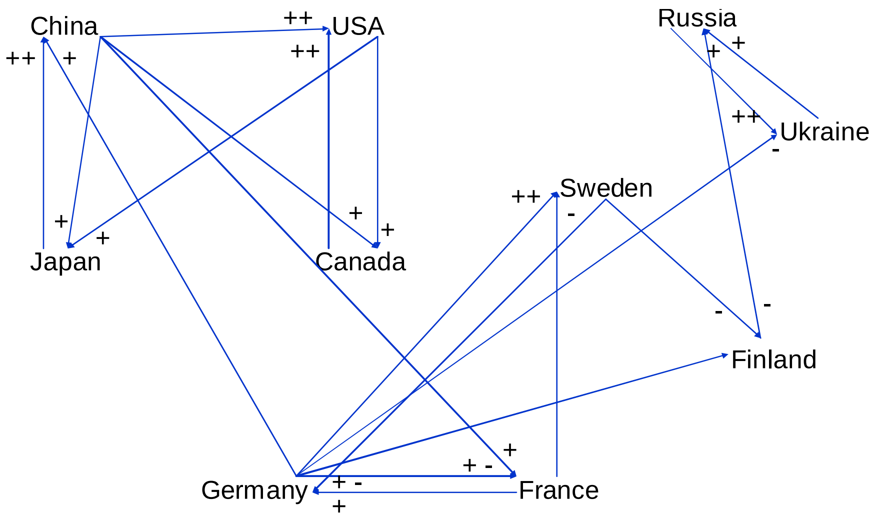

Figure 96. Most important trade flow relations built from import statistics, and their direction of growth in five year period (all the selected countries have latest data from year 2006 with the exception of Japan & France from year 2005). Source: United Nations (2006), Denotations: “++” indicates smooth growth of trade (export) between countries, “+” equals of some growth, while “+/-“ indicates that the relations are constant, and “-“ is a mark of reduction of activities between countries.

Analyzing Figures 96 and 97 brings more details. From Figure 96, built through import statistics, it can be deducted that import oriented interactions between countries are on the pathway of stable growth in the five year perspective. Despite the positive trends, there also exist decreasing relationships between some countries: For instance Finland has been reducing its trade transactions with Sweden. The amount of import from France to Sweden came down too during one year observation period. In overall United States seems to be the country reaping the most active role in its import operations, whereas for Finland the importance of import took a downturn.

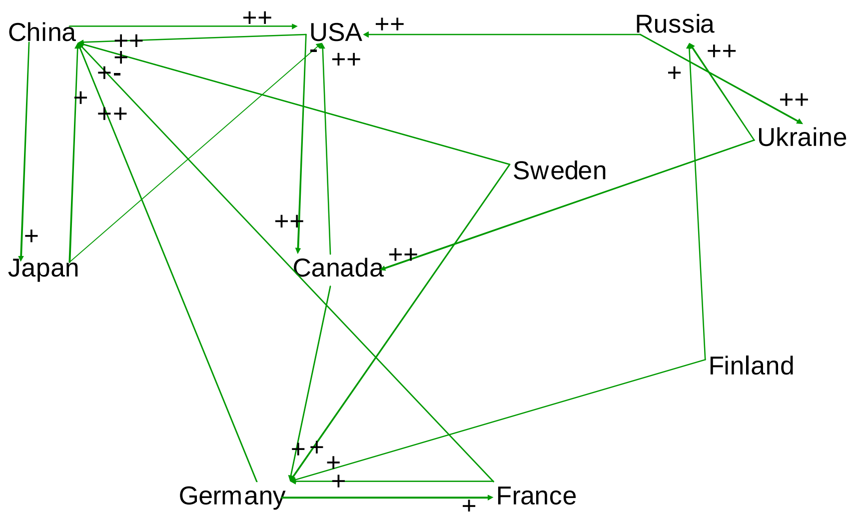

Figure 97. Most important trade flow relations built from export statistics, and their direction of growth in five year period (all the selected countries have latest data from year 2006 with the exception of Japan & France from year 2005). Source: United Nations (2006), Denotations: “++” indicates smooth growth of trade (export) between countries, “+” equals of some growth, while “+/-“ indicates that the relations are constant, and “-“ is a mark of reduction of activities between countries.

Figure 97 sheds a light on the same issue with Figure 96, but using export statistics (as trade statistics contains biases and errors, it is worth of analyzing both sides of a token). One of the key observations is that we did not find any downward development in this segment of international trade – confirming our argumentation from Figure 96. Overall, no country alone plays critical role in export operations, but same three trade clusters seems to exist in export data as well. In the following we will analyze most important partners for Finland: Russia, Ukraine and Germany in more details. The aim is to discover the path of developments of trade influencing the positioning of Finland in the networked chain of wagon manufacturing.

11.2 Detailed analysis of trade flows from Finnish manufacturing perspective

11.2.1 Finland's trade flows in wagon manufacturing

Altogether, trade flows of Finnish wagon manufacturing are rather minimalist, or even non-existent in international scale. As Figure 98 shows, largest export partner is Russia, which has showed impressively increasing proportional development within exports (more than quadrupled), but in absolute terms trade is still at low levels, roughly 30 million USD. Rather similarly sized, but complimentary and showing decreasing development, could be found with Germany – during year 2006 German wagons were imported to Finland worth of 20 million USD. Sweden contributes to the development of the Finnish wagon market mainly on the import side - still the amount of trade is marginal (roughly 6 million USD), and in small scale, decreasing.

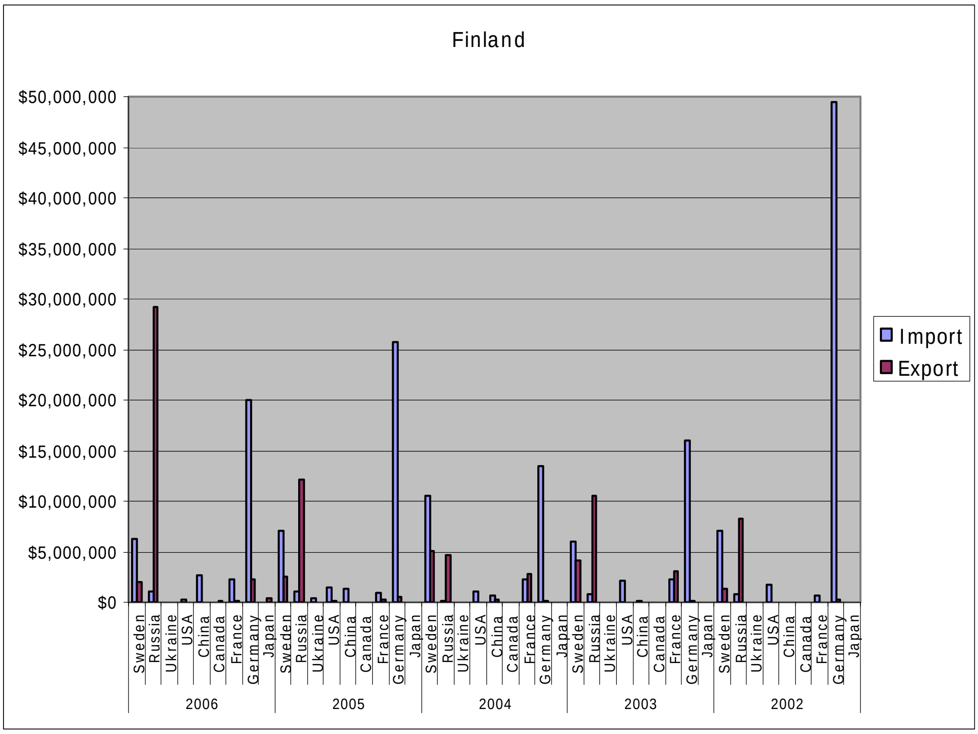

Figure 98. The development of trade of Finland in a country by country manner between 2002 and 2006 (y-axis, USD). Source: United Nations

However, as we look the Finnish trade flows within five year perspective, we could identify that shift has occurred from import to exports, but still it has to be reminded that volumes are small. In 2002 the value of export from the total value of trade of Finland was only 14 % whereas the same percentage in the end of 2006 was over 51 %. At the same time it has to be stated that among the examined countries Finland is the only one where the total value of trade decreased between 2002 and 2006: The reduction was 4.5 %, from 69.8 million USD in 2002 to 66.7 million USD in 2006.

11.2.2 Russia’s and Ukraine’s trade flows in wagon manufacturing

In wagon manufacturing, Russia and Ukraine showed rather strong trade relations with each other, and therefore in the following we have analyzed them together. From Figure 99 it can be concluded for Russia Ukraine is the single most important partner both in terms of import and export. The rate of growth in this respect is impressive, whether measured in terms of proportional or absolute numbers: From 2002 till 2006 the import from Ukraine and export to it from Russia more than tripled – exports from roughly 238.4 million USD ending up to 883.4 mill. USD, while the latter starting from 68 million USD and reaching 244 mill. USD. Dramatic increase of 1400 % occurred in export to United States from Russia too; during these five years taking off from low level of 6.4 million USD sweeping up to 90.3 million. In contrary it can be stated that the import from Germany decreased significantly at this period: the reduction equaling to 85 % from 79.9 to 11.8 million USD. As it can be seen, during the five years time Russian wagon sector has remained dependent on imports from its most important trade partners, but surprisingly, value of total trade in wagon manufacturing climbed up by 51 % from 450.7 to 940.5 million USD. Interesting nuance is that during this five years time trade flows with Sweden collapsed completely, both in terms of import and export.

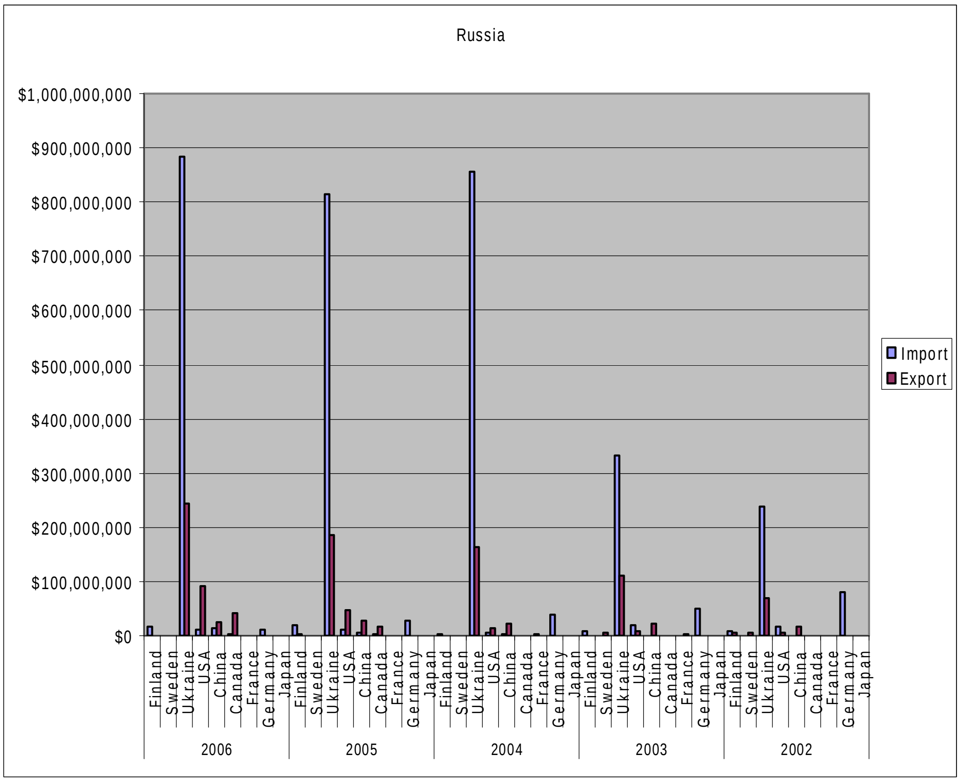

Figure 99. The development of trade of Russia in a country by country manner between 2002 and 2006. Source: United Nations

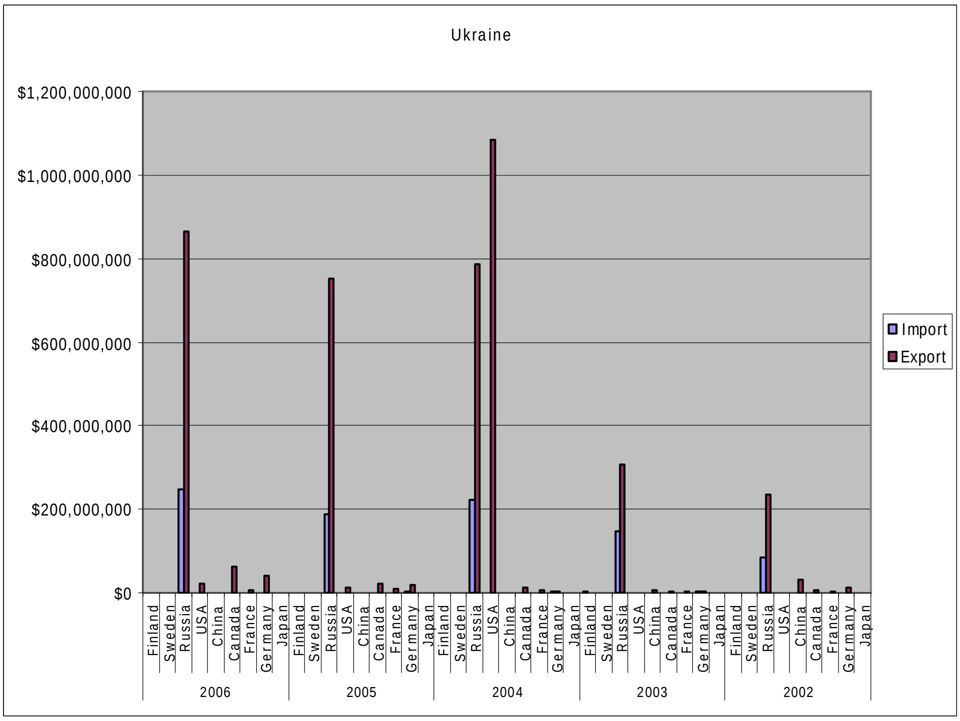

Figure 100. The development of trade of Ukraine in a country by country manner between 2002 and 2006. Source: United Nations

Figure 100 repeats same message from tight relations between Russia and Ukraine in wagon manufacturing, but it should be noted that rather significant growth has occurred with Canada and Germany as well. Both of these latter mentioned countries have purchased from Ukraine roughly 40-60 million USD worth of railway wagons. Ukraine is much more dependent on export rather than on import, showing opposite situation to Russia's trade flows in this sector. However, it should be reminded that the value of total trade between this five year interval rose by 335 % from 372 to 1246 million USD.

11.2.3 Germany's trade flows in wagon manufacturing

As could be noted from Figure 101, during the observation period most remarkable change in wagon trade flows occurred between Germany and China, and this concerned mostly exports from Germany! The export of wagons to China exploded by 730 %, from 40.3 to 294.3 million USD. However, France maintained its position even more firmly as a central business partner to Germany: In terms of export the value took off by 188 % being at the level of 160.7, and ending up to 303 million USD – thus, import from France increased by 63 % up as well, ending into 165.6 million USD. Significant trade activity was recorded also with Sweden; imports from Sweden seem to be increasing within long-term perspective, but export operations from Germany to Sweden recorded impressive level during year 2005 (more than 350 million USD worth of exports!). Overall, Germany is an export led economy in wagon manufacturing, and nearly 70 % from total trade volume is exports. Germany's total value of wagon trade increased by 93 % during this five years time from 655.9 to 1268 million USD.

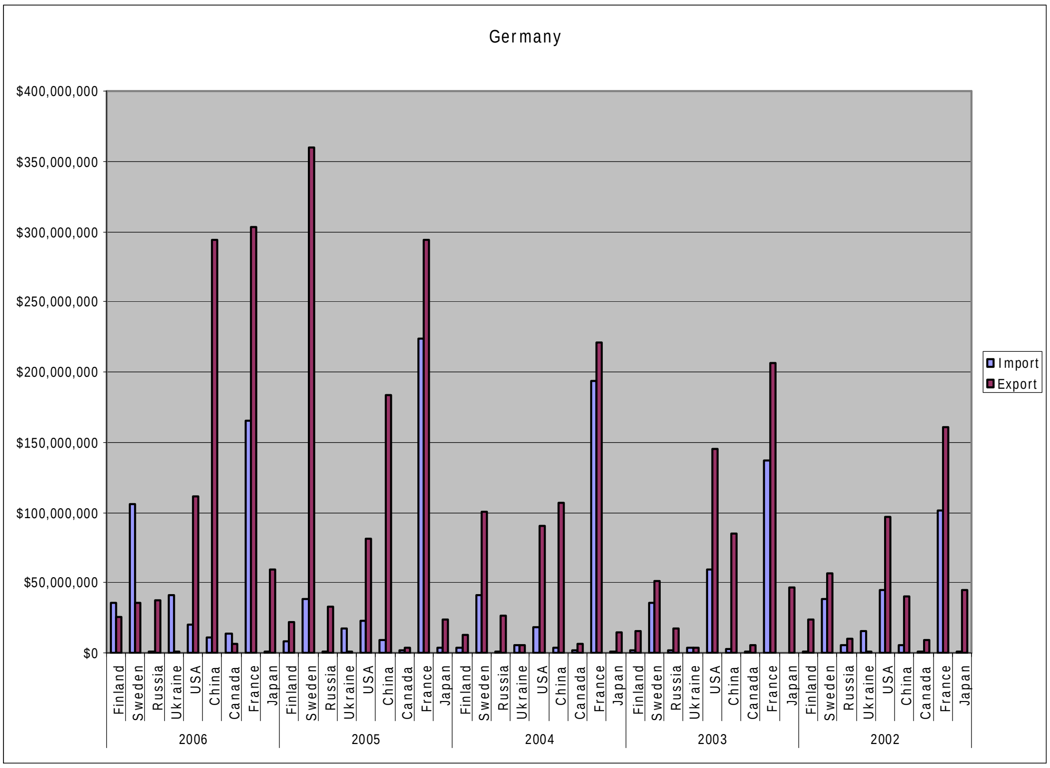

Figure 101. The development of trade of Germany in a country by country manner between 2002 and 2006

11.3 Finnish railway machine building in international cooperation

Finland is quite isolated from the most of the European railway and road network, and could be characterised as an island in logistical terms. Altogether Finland shares borderline with three countries, and railway connection exists with Sweden and Russia. With the former one Finland has only two major connections: (1) one land border-crossing point and (2) one rail-sea-rail connection through city of Turku. However, connection to European network through Sweden is not that widely used, since Sweden uses in rail tracks most commonly applied European gauge width, while Finland is having ex-Soviet/Russian empire standard of 1520/1524 mm. This is mostly due to the historical reasons, since during period of 1809-1917 autonomous Finland was part of Russian empire, and railway revolution in the whole world context was under great growth during the 19th century. So, still today freight wagons, e.g. operated in Finland could be used in Russia without major problems – this works in other way around as well (basically in Russia gauge width is 1524 mm and in Finland 1520 mm, but this does not affect in the wagon fleet). Currently these two countries share four railroad crossing-points, and three of them are used only for freight transport.

Apart from land connection, railway wagons have been shipped from Finland to e.g. Germany (gauge 1435 mm) and Sweden by sea and vice versa. Because of the different gauge, the bogies have to be changed each time. Usually this is done either in the port of the exporting country or importing country. Among Finland, only Baltic States are using same railway gauge width, as shown in Table 21 with bolded text. It should be noted that Baltic States have proposed as one railway track renovation alternative replacement of old 1524 mm standard to 1435 mm in north-south corridor (Rail Baltica 2007). If this will realize in the future, it will isolate Finnish railways even more.

Table 21. Railway gauges used in European countries. Source: European Union (2005)

Country	Track Gauge (mm)
Greece	600
Greece	1000
Spain	1000
France	1000
Portugal	1000
Belgium	1435
Czech Republic	1435
Denmark	1435
Germany	1435
Greece	1435
Spain	1435
France	1435
Italy	1435
Luxembourg	1435
Hungary	1435
The Netherlands	1435
Austria	1435
Poland	1435
Slovenia	1435
Slovak Republic	1435
Sweden	1435
United Kingdom	1435
Estonia	**1524**
Latvia	**1524**
Lithuania	**1524**
Finland	**1524**
Ireland	1600
United Kingdom	1600
Spain	1668
Portugal	1668

As in other production environments, like in automotive, motor-cycle, PC as well as mobile phone manufacturing, production of railway wagons is increasingly starting to show specialization among companies, by dividing responsibility to smaller pieces. So, some companies are mainly concentrated to produce some detailed parts of the railway wagons, or they are responsible for the production of a frame of railway wagon, and/or are completing final assembly of a wagon (among customization). As our company analysis from US, Europe, Ukraine and Russia showed, companies manufacturing detailed parts, are numerous, they are located around the world, and they can be specialized for e.g. heating, ventilation and cooling systems, bogies and dampers, wheels and wheel sets, brakes and brake systems, couplers etc. Usually all the details fitted in a wagon can and must be changed, replaced or taken into service or repair. All the railroad wagons must be regularly taken into service based on the time or quantity of kilometres' the wagon has run. Very often the wagons have to be taken into between these planned services because e.g. a broken wheel. This causes the fact that also e.g. wheels and axles are interchangeable in Russian wagons with them which wheels are used in Finland. So, competitive advantage in wagon manufacturing does not necessarily lie in component manufacturing – significant investments, dedicated assets and volumes are needed that new entrant is able to challenge existing ones.

Figure 102. A railway wagon intended for raw wood transportation in unloading process. Source: RP-Hitsaus Ltd.

One opportunity to compete in wagon manufacturing with new wagon concepts is by networked approach, where detailed parts are manufactured by other specialized actors, and possible main parts of it are coming from other companies as well. For example in Figure 102 one market accepted such kind of wagon is showed in action. This shown wagon is based on Ukrainian made flat wagon (serial number of 13-935A – in DEA analyses it was more efficient in lighter weighted container transports), intended for container transportation, but equipped with Finnish-made stanchions, and assembled eventually in Russia. Usually these sold wagons are registered to Russia, and they can be used in the internal transportation of Russia, but as well in international transportation of Russia and Finland. However, current Finnish and EU legislation prohibits the usage of these wagons in internal Finnish transports. Based on our study, this produced wagon is a good example about a networked production principles tying three countries together – for Finnish freight wagon manufacturing Russia and Ukraine are great asset, which should be utilized more carefully. Based on the trade flow analysis, wagon export from Finland is lacking volume, and only growth area has been Russia. Based on this study we fill that trade growth in wagon manufacturing could only be strengthened through more intensive collaboration with Russia and Ukraine – these wagons could also be sold to other 1520/1524 mm countries, and with modification into other standard regions.

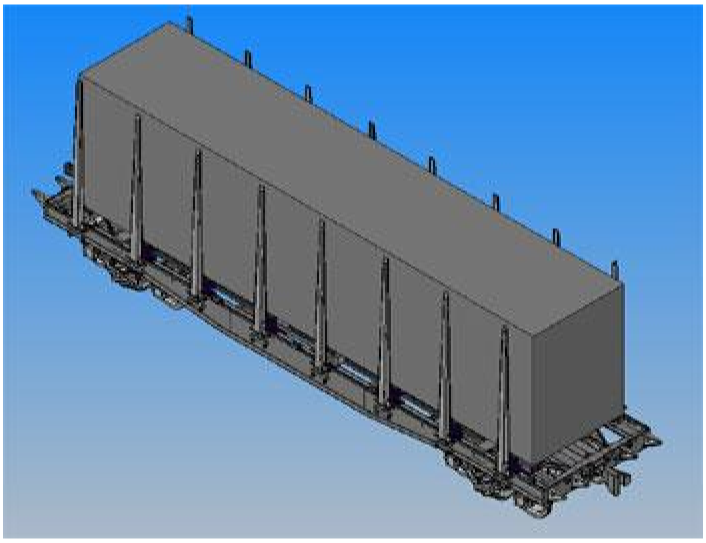

Figure 103. A Railway wagon suitable for both raw wood and container transport. Source: RP-Hitsaus Ltd.

The above mentioned wagon, which has been modified to be used in raw material transports, could also be still be used for container transports, if container locks are added. Figure 103 illustrates this situation. Our simulation from combined transports was made with assumption of the functionality of this wagon, and it has showed its cost efficiency as well. Among wood transports, this wagon could be used for other similar type of raw material transports (e.g. steel bars) – increasing its feasibility within other freight transportation groups and other countries (e.g. Baltic States, and raw material producing countries from east). If European and Finnish legislative barrier in the usage of this type of wagon in internal transports could be resolved, then markets for these types of in networks produced wagons would not only be eastern related, but would include similarly sized European markets – this would then mean significant market and financial potential for new cross-border and networked wagon manufacturing business model.

12 DISCUSSION AND CONCLUSIONS

In this research work we have analyzed widely the status of railway wagon fleet for freight transports in Russia, Finland, Sweden, Estonia, and generally in Europe. It could be concluded that considerable renewal investments are needed, if the fleet is desired to be kept to meet its quality as well as quantity demands of future freight transports. In this research work, as well as in our previous one (Ivanova et al. 2006), we have concluded that container revolution is yet in the high growth pace in Russia and other Central and East European (CEE) economies, and therefore new transportation solutions should be connected into this. Also constant wealth increase among CEE economies is supporting high volume growth of imports, and further fostering the effect of container transports. However, customers of these new type of wagons are different than state owned (or greatly influenced) railway companies – this was the case in the renewal of Russian oil transportation wagons, as e.g. Estonian investors leased significant amounts of wagons to this market, and new market entrants in European as well as in Russian railways need new operational business innovations, and eventually new wagons. However, based on our research work, we conclude that for long distance railway transports (like landbridge of North-America or Trans-Siberia/China) should be equipped with container wagons, which are most optimal with respect of this type of transports. These types of wagons we searched and found from already existing Russian wagon database and the usage of these in Finnish-Russian and possible Chinese long-distance transports is most optimal. Based on the two country agreements, wagons registered to Russia, could operate also in Finland in traffic connecting these two countries, and therefore it would be beneficial to use wagons, which are approved to be used in Russia. Also impressive amount of Russian and Ukrainian railway wagon producers are unused source of manufacturing advantage, which could be connected on Finnish wagon manufacturing in new global economy, through networked principles. However, it should be reminded that Chinese railway gauge width is different, and currently containers are reloaded in the Russian-Chinese border to Chinese container wagons, but nothing prevents using multi-gauge wagons in this connection. Thus, this is mostly operating principle of future, since as long as there exist low cost labour in the border-crossing points, these are more attractive to use rather than investing extra funds on wagons and gauge width changing equipment.

Most suitable wagon type for shorter distance transports is most probably different than entirely optimal container transport wagon (difference is mostly on length, simplistically speaking longer wagons are good for longer transportation distances) – in transportation activity e.g. Russia and Finland, or even China-Russia railways are most often used in the transports of raw materials. However, e.g. in case of Finland consumer and other items are being transported to Russia with trucks and containers. This is clearly an advantage for new wagon development. As we showed in this research work, multi-purpose wagon is even economically viable, as being examined through real-life transportation network of wood imports from Russia to Finland as well as container transports by rail from Kouvola, Finland to St. Petersburg, Russia. Thus, wagon length is not similar with the most optimal wagon used in the very long-distance landbridge transports – our simulation results indicate that shorter wagon holds some cost and flexibility advantage. Tested transportation network, and realization of multi-purpose wagon, needs new organizational arrangements – it requires logistics operator, which is able to connect container transports, wood transports and two state owned railway companies together. This is not impossible task, but requires long-term commitment from all of the parties involved as well as unchanging legislative and policy environment. However, used wagon in any case should take into account container market growth and used container types. Currently forty foot containers are favoured over twenty foot ones – this should be driving factor in freight wagons. In one side it favours really long wagons, but on the other hand wagons having length of one 40 foot container. Wagons being stuck in between seem to hold considerable disadvantage.

As a further research in this area, we would be interested to continue with the economic evaluation of different wagon concepts in different transportation networks. In this research we only tested one real-life network, but similar simulation with changing gauge widths being tested in Chinese-Russian environment would be interesting to accomplish. Distances in this context could be a bit longer, and also raw material terminals could be located quite near of container drop-off points – most probably giving a bit different results than simulation model used in this research work. Another simulation related topic would be to test transportation network functionality in setting, where e.g. one border-crossing point becomes unavailable, or how multi-purpose wagons could be used in low seasons of raw material transports (e.g. finding contra-seasonal raw materials, and enlarging these into transportation network, and/or using these wagons in container transports). For policy level issues, we would be interested to continue with registration issues of wagons to European Union area – currently Russian and Ukrainian wagons can’t be used in the internal transports of e.g. Finland or with gauge modifications in other EU countries (like Sweden, Germany etc.). However, this legislative barrier is one key for future prosperity of North-European wagon manufacturing – large-scale factories connected with high quality engineering abilities of Finland could hold considerable advantage. This is naturally interesting topic to continue with, and holds certainly business related avenue for networked wagon manufacturing proposed in this research work.

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APPENDIX 1

Wagon manufacturers and their business in Baltic countries, CIS and Russia

Baltic Countries	**Web-page**
Freight wagon manufacturers	
Riga wagon manufacturing plant OJSC	http://www.rvr.lv
Other manufacturers	
ALPA Vagons LTD	http://www.alpa.lv
Latvijas dzelzcels (Latvian railways). Wagon repair centre.	http://www.ldz.lv
Transservice AS AVR	http://www.avrts.com
CIS	**Web-page**
Freight wagon manufacturers	
Azovmash OJSC	http://azovmash.com.ua
Dneprovagonmash JSC	http://www.dvmash.com
Serep JSC	http://www.serep.azov.net
Stakhanov Wagon works OJSC	http://svz.php.net.ua
Other manufacturers	
Akmolinskiy wagon repair plant OJSC	http://www.vrz.kz
Central machinery and repair shop UE Trest Beltransstroi	
Mariupol heavy machine-building plant OJSC	
Tbilisi electric wagon repair plant SC	
Russia	**Web-page**
Freight wagon manufacturers	
Abakan wagon manufacturing plant	http://www.vagonmash.com
Altaivagon JSC	http://www.altaivagon.ru
Bryansk wagon manufacturing plant-Wagon OJSC	http://www.bmz.032.ru
Kaliningrad wagon manufacturing plant OJSC	http://vsk.kaliningrad.ru
Ruzkhimmash JSC	http://www.ruzhim.ru
CJSC Transmashholding	http://eng.tmholding.ru/work/about
Uralvagonzavod SUE	http://www.uvz.ru
Passenger wagon manufacturers	
Vagonmash CJSC	http://www.vagonmash.ru
Voronezh wagon repair plant named after Telman	http://www.vagon.vrn.ru
Other manufacturers	
Barnaul wagon repair plant	
Bezhitskiy steelworks OJSC	http://www.vagonmash.com
Bogotol wagon reapir plant	http://www.bvrz.ru
Bugulma mechanical plant	http://tatneft.ru/bmz
Dzerzhinskkhimmash SC	
Izhora plants OJSC	http://www.omz.ru/eng/segments/cranes/
Kanash wagon repair plant	http://kvrz.chuvashia.com
Krasnoyarsk electric wagon repair plant OJSC	
Oktyabrskiy electric wagon repair plant. St.	http://www.tmholding.ru/main/factories/3783
Pskov electric wagon manufacturing plant OJSC.	
Rolling stock repair plant.	
Roslavl wagon repair plant.	http://www.rail-way.ru/company/production/157/

Wagon manufacturers and their business in Baltic countries, CIS and Russia (continued)

Russia, other manufacturers	**Web-page**
Sterlitamak wagon repair plant.	http://www.svrz.ru
Tambov wagon repair plant.	
TAP Titran-Express CJSC	http://www.tihvin-titran.ru
Technopark Kamskiy wagon repair plant Ltd	
Wagon and container repair SUE.	
Velikie Luki locomotive repair plant Ltd.	
Vladikavkaz wagon repair plant..	
Voronezh wagon repair plant named after Telman	
Vyksa metalurgical plant.	http://www.vsw.ru
Yaroslavl machine assembly plant CJSC	http://yamsz.narod.ru/
Zheldormash	

APPENDIX 2

DEA-results for copying paper

Model	Output	Weight Copy paper	Length Copy paper	Output / weight	Output / Length	DEA eff.
13-1163	200	3934	1311	0,051	0,153	0,783
13-1223	200	3147	667	0,064	0,300	1
13-1281	200	3649	1286	0,055	0,156	0,844
13-166	200	3234	680	0,062	0,294	0,98
13-1796	200	3574	1285	0,056	0,156	0,861
13-1796-01	200	3999	1285	0,050	0,156	0,77
13-1798	200	3147	667	0,064	0,300	1
13-198	200	3699	696	0,054	0,287	0,949
13-2116	200	3147	667	0,064	0,300	1
13-2116-01	200	3524	981	0,057	0,204	0,874
13-2116-02	200	3699	981	0,054	0,204	0,832
13-2118	200	3649	1311	0,055	0,153	0,844
13-3066	200	3659	658	0,055	0,304	1
13-3115-1	200	3709	1293	0,054	0,155	0,83
13-4092	200	3949	1350	0,051	0,148	0,78
13-4108	200	3999	1311	0,050	0,153	0,77
13-4117	200	3079	670	0,065	0,299	1
13-4123	200	3124	740	0,064	0,270	0,986
13-4128	200	4049	1311	0,049	0,153	0,76
13-470a	200	3529	981	0,057	0,204	0,872
13-470b	200	3499	981	0,057	0,204	0,88
13-491	200	3739	981	0,053	0,204	0,823
13-7024	200	3539	1281	0,057	0,156	0,87
13-9004	200	3624	981	0,055	0,204	0,85
13-9004-01	200	3634	981	0,055	0,204	0,847
13-9004-11	200	3879	981	0,052	0,204	0,794
13-9004M	200	4999	1962	0,040	0,102	0,616
13-9007	200	3659	981	0,055	0,204	0,841
13-9009	200	4074	1276	0,049	0,157	0,756
13-926	200	3749	981	0,053	0,204	0,821
13-926-01	200	3799	981	0,053	0,204	0,81
13-935	200	3749	981	0,053	0,204	0,821
13-935-01	200	3799	981	0,053	0,204	0,81
13-935A	200	3549	981	0,056	0,204	0,868
13-935A-01	200	3649	981	0,055	0,204	0,844
13-9738	200	5939	2426	0,034	0,082	0,518
13-9745	200	3999	1304	0,050	0,153	0,77
13-9751	200	3649	1281	0,055	0,156	0,844
13-K651	200	6599	2468	0,030	0,081	0,467
13-H001	200	4499	1392	0,044	0,144	0,684
13-H453	200	3499	710	0,057	0,282	0,936
13-H459	200	3509	710	0,057	0,282	0,936
Average		3812,667	1112,214	0,054	0,200	0,837
St_dev		663,190	410,214	0,007	0,061	0,117
Min		3079	658	0,030	0,081	0,467
Max		6599	2468	0,065	0,304	1

DEA-results for mobile phones

model	Output	Weight Mobile phone	Length Mobile phone	Output / weight	Output / Length	DEA eff.
13-1163	200	1835	656	0,109	0,305	0,974
13-1223	200	1816	667	0,110	0,300	0,959
13-1281	200	1693	643	0,118	0,311	0,996
13-166	200	1903	680	0,105	0,294	0,94
13-1796	200	1655	642	0,121	0,312	0,998
13-1796-01	200	1868	642	0,107	0,312	0,994
13-1798	200	1816	667	0,110	0,300	0,959
13-198	200	2368	696	0,084	0,287	0,917
13-2116	200	1816	667	0,110	0,300	0,959
13-2116-01	200	1833	667	0,109	0,300	0,959
13-2116-02	200	1952	667	0,102	0,300	0,957
13-2118	200	1693	656	0,118	0,305	0,977
13-3066	200	2328	658	0,086	0,304	0,97
13-3115-1	200	1723	647	0,116	0,309	0,989
13-4092	200	1843	675	0,109	0,296	0,947
13-4108	200	1868	656	0,107	0,305	0,974
13-4117	200	1748	670	0,114	0,299	0,956
13-4123	200	1793	740	0,112	0,270	0,914
13-4128	200	1893	656	0,106	0,305	0,973
13-470a	200	1836	667	0,109	0,300	0,959
13-470b	200	1816	667	0,110	0,300	0,959
13-491	200	1979	667	0,101	0,300	0,957
13-7024	200	1638	641	0,122	0,312	1
13-9004	200	1901	667	0,105	0,300	0,958
13-9004-01	200	1908	667	0,105	0,300	0,958
13-9004-11	200	2074	667	0,096	0,300	0,957
13-9004M	200	1952	667	0,102	0,300	0,957
13-9007	200	1925	667	0,104	0,300	0,957
13-9009	200	1905	638	0,105	0,313	1
13-926	200	1986	667	0,101	0,300	0,957
13-926-01	200	2020	667	0,099	0,300	0,957
13-935	200	1986	667	0,101	0,300	0,957
13-935-01	200	2020	667	0,099	0,300	0,957
13-935A	200	1850	667	0,108	0,300	0,958
13-935A-01	200	1918	667	0,104	0,300	0,957
13-9738	200	4608	2426	0,043	0,082	0,355
13-9745	200	1868	652	0,107	0,307	0,98
13-9751	200	1693	640	0,118	0,313	1
13-K651	200	3168	1234	0,063	0,162	0,519
13-H001	200	2118	696	0,094	0,287	0,917
13-H453	200	2168	710	0,092	0,282	0,899
13-H459	200	2178	710	0,092	0,282	0,899
Average		1999,024	722,310	0,103	0,292	0,935
St_dev		483,575	283,845	0,014	0,040	0,117
Min		1638	638	0,043	0,082	0,355
Max		4608	2426	0,122	0,313	1

DEA-results for DVD-players

model	Output	Weight DVD	Length DVD	Output / weight	Output / Length	DEA eff.
13-1163	200	1402	656	0,143	0,305	0,966
13-1223	200	1383	667	0,145	0,300	0,953
13-1281	200	1260	643	0,159	0,311	0,993
13-166	200	1470	680	0,136	0,294	0,931
13-1796	200	1222	642	0,164	0,312	0,997
13-1796-01	200	1435	642	0,139	0,312	0,982
13-1798	200	1383	667	0,145	0,300	0,953
13-198	200	1935	696	0,103	0,287	0,886
13-2116	200	1383	667	0,145	0,300	0,953
13-2116-01	200	1400	667	0,143	0,300	0,951
13-2116-02	200	1519	667	0,132	0,300	0,944
13-2118	200	1260	656	0,159	0,305	0,975
13-3066	200	1895	658	0,106	0,304	0,938
13-3115-1	200	1290	647	0,155	0,309	0,986
13-4092	200	1410	675	0,142	0,296	0,941
13-4108	200	1435	656	0,139	0,305	0,964
13-4117	200	1315	670	0,152	0,299	0,953
13-4123	200	1360	740	0,147	0,270	0,886
13-4128	200	1460	656	0,137	0,305	0,962
13-470a	200	1403	667	0,143	0,300	0,951
13-470b	200	1383	667	0,145	0,300	0,953
13-491	200	1546	667	0,129	0,300	0,942
13-7024	200	1205	641	0,166	0,312	1
13-9004	200	1468	667	0,136	0,300	0,947
13-9004-01	200	1474	667	0,136	0,300	0,947
13-9004-11	200	1641	667	0,122	0,300	0,936
13-9004M	200	1519	667	0,132	0,300	0,944
13-9007	200	1491	667	0,134	0,300	0,946
13-9009	200	1472	638	0,136	0,313	0,985
13-926	200	1553	667	0,129	0,300	0,942
13-926-01	200	1587	667	0,126	0,300	0,94
13-935	200	1553	667	0,129	0,300	0,942
13-935-01	200	1587	667	0,126	0,300	0,94
13-935A	200	1417	667	0,141	0,300	0,95
13-935A-01	200	1485	667	0,135	0,300	0,946
13-9738	200	1838	825	0,109	0,242	0,765
13-9745	200	1435	652	0,139	0,307	0,969
13-9751	200	1260	640	0,159	0,313	0,998
13-K651	200	1685	617	0,119	0,324	1
13-H001	200	1685	696	0,119	0,287	0,899
13-H453	200	1735	710	0,115	0,282	0,88
13-H459	200	1745	710	0,115	0,282	0,88
Average		1485,333	669,500	0,136	0,299	0,946
St_dev		173,162	32,541	0,015	0,013	0,042
Min		1205	617	0,103	0,242	0,765
Max		1935	825	0,166	0,324	1

DEA-results for pairs of shoes

model	Output	Weight Shoes	Length Shoes	Output / weight	Output / Length	DEA eff.
13-1163	200	1472	656	0,136	0,305	0,966
13-1223	200	1453	667	0,138	0,300	0,953
13-1281	200	1330	643	0,150	0,311	0,993
13-166	200	1540	680	0,130	0,294	0,931
13-1796	200	1292	642	0,155	0,312	0,997
13-1796-01	200	1505	642	0,133	0,312	0,983
13-1798	200	1453	667	0,138	0,300	0,953
13-198	200	2005	696	0,100	0,287	0,886
13-2116	200	1453	667	0,138	0,300	0,953
13-2116-01	200	1470	667	0,136	0,300	0,952
13-2116-02	200	1589	667	0,126	0,300	0,944
13-2118	200	1330	656	0,150	0,305	0,975
13-3066	200	1965	658	0,102	0,304	0,938
13-3115-1	200	1360	647	0,147	0,309	0,986
13-4092	200	1480	675	0,135	0,296	0,941
13-4108	200	1505	656	0,133	0,305	0,964
13-4117	200	1385	670	0,144	0,299	0,953
13-4123	200	1430	740	0,140	0,270	0,892
13-4128	200	1530	656	0,131	0,305	0,962
13-470a	200	1473	667	0,136	0,300	0,952
13-470b	200	1453	667	0,138	0,300	0,953
13-491	200	1616	667	0,124	0,300	0,942
13-7024	200	1275	641	0,157	0,312	1
13-9004	200	1538	667	0,130	0,300	0,947
13-9004-01	200	1545	667	0,129	0,300	0,947
13-9004-11	200	1711	667	0,117	0,300	0,936
13-9004M	200	1589	667	0,126	0,300	0,944
13-9007	200	1562	667	0,128	0,300	0,946
13-9009	200	1542	638	0,130	0,313	0,986
13-926	200	1623	667	0,123	0,300	0,942
13-926-01	200	1657	667	0,121	0,300	0,94
13-935	200	1623	667	0,123	0,300	0,942
13-935-01	200	1657	667	0,121	0,300	0,94
13-935A	200	1487	667	0,134	0,300	0,951
13-935A-01	200	1555	667	0,129	0,300	0,946
13-9738	200	1908	825	0,105	0,242	0,766
13-9745	200	1505	652	0,133	0,307	0,969
13-9751	200	1330	640	0,150	0,313	0,998
13-K651	200	1755	617	0,114	0,324	1
13-H001	200	1755	696	0,114	0,287	0,899
13-H453	200	1805	710	0,111	0,282	0,881
13-H459	200	1815	710	0,110	0,282	0,88
Average		1555,381	669,500	0,130	0,299	0,946
St_dev		173,162	32,541	0,014	0,013	0,042
Min		1275	617	0,100	0,242	0,766
Max		2005	825	0,157	0,324	1

DEA-results for a product mix with 50% mobile phones and 50% copying paper

model	Output	Weight 50% mobiles/paper	Length50% mobiles/paper	Output / weight	Output / Length	DEA eff.
13-1163	200	2900	996	0,069	0,201	0,832
13-1223	200	2481	667	0,081	0,300	1
13-1281	200	2683	977	0,075	0,205	0,899
13-166	200	2568	680	0,078	0,294	0,98
13-1796	200	2626	976	0,076	0,205	0,919
13-1796-01	200	2949	976	0,068	0,205	0,818
13-1798	200	2481	667	0,081	0,300	1
13-198	200	3033	696	0,066	0,287	0,948
13-2116	200	2481	667	0,081	0,300	1
13-2116-01	200	2678	824	0,075	0,243	0,901
13-2116-02	200	2825	824	0,071	0,243	0,854
13-2118	200	2683	996	0,075	0,201	0,899
13-3066	200	2993	658	0,067	0,304	1
13-3115-1	200	2729	983	0,073	0,203	0,884
13-4092	200	2911	1026	0,069	0,195	0,829
13-4108	200	2949	996	0,068	0,201	0,818
13-4117	200	2413	670	0,083	0,299	1
13-4123	200	2458	740	0,081	0,270	0,982
13-4128	200	2987	996	0,067	0,201	0,808
13-470a	200	2683	824	0,075	0,243	0,899
13-470b	200	2657	824	0,075	0,243	0,908
13-491	200	2859	824	0,070	0,243	0,844
13-7024	200	2600	974	0,077	0,205	0,928
13-9004	200	2762	824	0,072	0,243	0,874
13-9004-01	200	2771	824	0,072	0,243	0,871
13-9004-11	200	2977	824	0,067	0,243	0,813
13-9004M	200	3475	1315	0,058	0,152	0,694
13-9007	200	2792	824	0,072	0,243	0,864
13-9009	200	3006	970	0,067	0,206	0,803
13-926	200	2867	824	0,070	0,243	0,842
13-926-01	200	2909	824	0,069	0,243	0,829
13-935	200	2867	824	0,070	0,243	0,842
13-935-01	200	2909	824	0,069	0,243	0,829
13-935A	200	2699	824	0,074	0,243	0,894
13-935A-01	200	2783	824	0,072	0,243	0,867
13-9738	200	5273	2426	0,038	0,082	0,458
13-9745	200	2949	991	0,068	0,202	0,818
13-9751	200	2683	973	0,075	0,206	0,899
13-K651	200	4883	1851	0,041	0,108	0,494
13-H001	200	3308	1044	0,060	0,192	0,729
13-H453	200	2833	710	0,071	0,282	0,935
13-H459	200	2843	710	0,070	0,282	0,935
Average		2909,905	921,214	0,070	0,232	0,863
St_dev		536,339	314,566	0,009	0,048	0,113
Min		2413	658	0,038	0,082	0,458
Max		5273	2426	0,083	0,304	1

DEA-results for a product mix with 50% DVD-players and 50% shoes

model	Output	Weight 50% dvd/shoes	Length50% dvd/shoes	Output / weight	Output / Length	DEA eff.
13-1163	200	1437	656	0,139	0,305	0,966
13-1223	200	1418	667	0,141	0,300	0,953
13-1281	200	1295	643	0,154	0,311	0,993
13-166	200	1505	680	0,133	0,294	0,931
13-1796	200	1257	642	0,159	0,312	0,997
13-1796-01	200	1470	642	0,136	0,312	0,983
13-1798	200	1418	667	0,141	0,300	0,953
13-198	200	1970	696	0,102	0,287	0,886
13-2116	200	1418	667	0,141	0,300	0,953
13-2116-01	200	1435	667	0,139	0,300	0,952
13-2116-02	200	1554	667	0,129	0,300	0,944
13-2118	200	1295	656	0,154	0,305	0,975
13-3066	200	1930	658	0,104	0,304	0,938
13-3115-1	200	1325	647	0,151	0,309	0,986
13-4092	200	1445	675	0,138	0,296	0,941
13-4108	200	1470	656	0,136	0,305	0,964
13-4117	200	1350	670	0,148	0,299	0,953
13-4123	200	1350	740	0,148	0,270	0,919
13-4128	200	1495	656	0,134	0,305	0,962
13-470a	200	1438	667	0,139	0,300	0,951
13-470b	200	1418	667	0,141	0,300	0,953
13-491	200	1581	667	0,127	0,300	0,942
13-7024	200	1240	641	0,161	0,312	1
13-9004	200	1503	667	0,133	0,300	0,947
13-9004-01	200	1510	667	0,132	0,300	0,947
13-9004-11	200	1676	667	0,119	0,300	0,936
13-9004M	200	1554	667	0,129	0,300	0,944
13-9007	200	1527	667	0,131	0,300	0,946
13-9009	200	1507	638	0,133	0,313	0,985
13-926	200	1588	667	0,126	0,300	0,942
13-926-01	200	1622	667	0,123	0,300	0,94
13-935	200	1588	667	0,126	0,300	0,942
13-935-01	200	1622	667	0,123	0,300	0,94
13-935A	200	1452	667	0,138	0,300	0,951
13-935A-01	200	1520	667	0,132	0,300	0,946
13-9738	200	1873	825	0,107	0,242	0,765
13-9745	200	1470	652	0,136	0,307	0,969
13-9751	200	1295	640	0,154	0,313	0,998
13-K651	200	1720	617	0,116	0,324	1
13-H001	200	1720	696	0,116	0,287	0,899
13-H453	200	1770	710	0,113	0,282	0,88
13-H459	200	1780	710	0,112	0,282	0,88
Average		1519,310	669,500	0,133	0,299	0,946
St_dev		174,093	32,541	0,014	0,013	0,041
Min		1240	617	0,102	0,242	0,765
Max		1970	825	0,161	0,324	1

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