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ORIGINAL PAPER

Assessing the impact of the 2011 EU Transport White Paper - a rail freight demand forecast up to 2050 for the EU27

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Abstract
Purpose This paper presents a rail freight forecast for the EU27 for the period up to 2050.
Background Rail freight's market share of the transport sector in Europe has been falling or remained stagnant since 1970. In contrast, the share of road freight has been increasing. As rail freight transport is generally considered an environmentally friendly option, various measures have been implemented for more than two decades, at national and European level, to encourage a modal shift from road to rail. In the latest EU Transport White paper policy paper of 2011, an optimistic target is set for greater use of rail freight transport, in both the near and the longer term future. Specifically: a modal shift, from road to rail, and waterway transport, of 30 % by 2030 and 50 % by 2050 - for distances greater than 300 km.
Methodology With the aforesaid policy objectives, the current research examines the possible effects of these aims in terms of future levels of rail freight demand. This research relies heavily upon the EU TRANS-TOOLS modelling tool and explores three scenarios. A Reference scenario - with no significant change to current rail freight policy, infrastructure and existing trends is considered alongside two White Paper scenarios (High and Low) which take more optimistic views of the white paper policy objectives.
Results The study finds that the Reference and White Paper Low scenarios demonstrate similar results in terms of growth and modal split. In stark contrast, the White paper High scenario results show that demand for rail freight services almost doubles compared to the Reference values.
Conclusions The rail sector is expected to attract new commodities from road transport such as foodstuffs and building and transport materials. To meet this demand, the rail industry - including operators, infrastructure managers and governments - will have to invest in technologies, infrastructure and terminals with a view to significantly increasing productivity against current levels.

Keywords Rail freight · Forecast · Modal shift · Impact · 2050 · Europe

1 Introduction

Freight transport is fundamental to the prosperity of nations both within and outside of Europe. Central Europe consists of a dense network of road, railways and inland waterways (IWT) gradually becoming less dense as the periphery is approached and population densities reduce (TRANSVisions 2009). The transport of goods adds place and time utility to the product, which in turn facilitates a positive contribution to a region's gross domestic product (GDP). The positive contributions of transport services include economic growth and job creation, amongst others. Conversely, transport is generally associated with negative effects, such as congestion, emissions and noise (which are acute in the central regions). Transport modes (road, rail and IWT) increasingly aim to address these negative impacts and be efficient, competitive and sustainable. Today's transport offers a global service inline with global supply chains therefore requiring the participation of national and international actors. In Europe, the desire to make transport more sustainable, efficient and

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competitive is expressed as part of the EU Transport White Paper 2011 (European Commission 2011). This overarching policy document sets targets for greater use of rail freight and inland waterways transport, in both the near and the longer term futures. Specifically, the paper targets a modal shift from road to more sustainable modes (rail freight & IWT) of 30 % by 2030 and 50 % by 2050 for distances greater than 300 km.

This paper aims to determine the impact of achieving the modal shift targets presented in the EC 2011 transport white paper by predicting the demand for goods in the EU27 up to 2050. The ambitious nature and the long term thinking of the white paper policy objectives presents a challenge to those wishing to gauge the potential impact of these policies. This paper therefore presents three scenarios to demonstrate the affects of white paper policy implementation at varying levels of success.

To determine the originality of this paper the authors have examined a number of similar studies - albeit in some cases with a different scope and objective such as forecast rail freight demand up to 2030 (iTREN - 2030, 2012; K+P Transport Consultants and Fraunhofer ISL 2011) and 2050 (TOSCA 2011; TRANSVisions 2009).

The objective of the TransVision (2009) study was to 'provide technical support to a debate on transport scenarios with a 20–40 year horizon' for both passenger and freight transport in Europe. The study considered three types of drivers: a) five categories of external (to the transport sector) drivers such as population, economic development, energy, technology development and social change; b) internal (to the transport sector) drivers such as infrastructure, vehicles, fuel development, impact of transport on the environment and society; and c) policy drivers that affect the evolution of the transport sector, such as governance. (This study precedes the EU Transport White Paper 2011.)

With the explicit aim of investigating alternative vehicle technologies to reduce the environmental impact of transport, the (TOSCA 2011) study conducted transport demand projections for passenger and freight up to 2050, for the EU27. Like TransVision (2009), the TOSCA (2011) study also used the TRANS-TOOLS modelling tool and assumed three scenarios: a) a reference/baseline scenario (with continuation of the existing socio-economic trends); b) a challenging scenario (with economic prosperity resulting in higher emission reduction targets); and c) a favourable scenario (with a period of economic vulnerability resulting in a reduction in emission targets).

Until now, growth estimates for freight volume and cargo types within the EU27 countries up to 2050 have not considered the effects of the 2008 economic crisis. With the objective of contributing to the development of future rail systems, this research, which is based on more current transport statistical evidence, aims to address this gap and to forecast rail freight volume to 2050, in the EU27.

2 Research methodology

The current research uses transport modelling package TRANSTOOLS to estimate the increase in demand for rail freight services as a result of the implementation of the white paper policy objectives. The Transport Research & Innovation Portal (2013) notes that, prior to the development of TRANS-TOOLS, there were many shortcomings in applying the then European freight transport models. Hansen (2011) notes that there were many partial models (e.g. ASTRA, VACLAV, NEAC, SLAM and CG Europe) that were developed under the EU framework programmes for different scope and purposes, such as geography, mode, freight or passenger transport, economic models, demand models or network models. These models were not used, maintained or continuously updated, after the research and development phase was completed. This resulted in poor representation of the mix of traffic and an absence of intermodality and freight logistics. Building on the positive achievements of these prior projects however, TRANS-TOOLS was developed as an IPR free transport model, covering both passenger and freight services and – importantly - includes intermodal transport (Hansen 2011). The model combines advanced modelling techniques in transport generation and assignment, economic activity, trade, logistics, regional development and environmental impacts. Since the finalisation of the model in 2004, TRANS-TOOLS has been used extensively and is recognised as a reliable tool for freight forecasting in European transport research (Burgess and Nielsen 2008; Hansen 2011). The framework for TRANS-TOOLS is demonstrated in Fig. 1.

The current research applies an integrated approach, generally used in the assessment of a scenario, combining qualitative and quantitative research methods, to exploit the advantages of each method. Scenarios are defined as a coherent illustration of possible future situations, together with pathways that might lead to these situations (Justen et al. 2010).

Qualitative research is conducted to identify current trends and the drivers behind modal shift. Trends are categorised as: a) general trends (GDP, population, fuel prices etc.); b) transport and logistics trends; and c) rail sector specific trends, with emphasis on rail freight developments. TOSCA (2011) suggests that there is a strong link between socio-economic trends such as GDP growth, population growth and an increase in transport demand.

Qualitatively the simulation of such a significant shift in demand from road to rail required the introduction of further conditions. In reality, road freight demand is greater and as a mode is used in many more regions than rail. In recognition of this, two control variables were added to the freight model in order to better depict the affects of implementing ambitious aims of the White Paper. The first variable indicates the existence of rail infrastructure in each region. The second points to the presence of existing rail freight demand in the region.

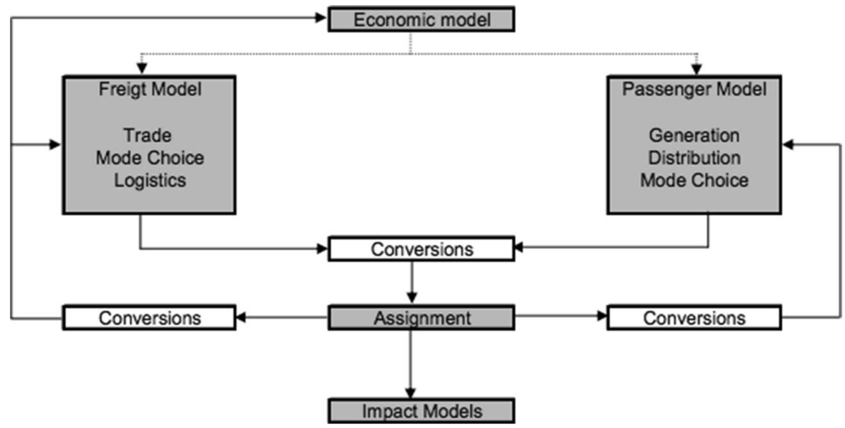

Fig. 1 Overview of the TRAN STOOLS model configuration (Burgess et al. 2008)

In this way it is firstly ensured that the network exists to permit modal shift from road to rail and secondly highlights the parts of the network that are already used for freight transport by rail.

The trends identified as part of the qualitative research are clustered based on their relevance and uncertainty levels. A summary of these is provided in Table 1.

In relation to the model assumptions, the Reference scenario takes input from both high and low uncertainty variables. For the White Paper scenarios, only the variables of high relevance and high impact are considered.

For forecasting up to 2030, the TransVision (2009) study used TRANS-TOOLS and assumed three scenarios: a) Baseline; b) High Growth (Sustainable Economic Development) with higher levels of GDP growth compared to the Baseline scenario); and c) Low Growth (with lower levels of GDP growth compared to the Baseline scenario).

In a similar method, three scenarios have been considered as part of the current forecast; a) Reference Scenario – extrapolation of current demographic and transport trends, where no major policy change is envisaged; b) White Paper Low Scenario - based on a pessimistic realisation of the 2011 White Paper modal shift targets; and c) White Paper High Scenario - based on a full realisation of the 2011 White Paper modal shift aspirations.

The WPL scenario allocates the road demand to rail only if both control variable conditions are true, i.e. rail network exists that is currently used for rail freight transport. The WPH scenario calculates the rail freight demand taking into account only the first condition, namely, that the rail network is present.

In the third stage, the quantitative research focuses on a two-step forecasting process. Up to 2030, the TRANS-TOOLS freight model, drawing heavily from the ETISplus database, is used to estimate the demand for goods by type and volume. ETIS plus is a European Transport policy Information System, combining data, analytical modelling with maps (GIS), a single online interface for accessing the data. It aims therefore to provide a bridge between official statistics and applications within the transport policy theme. It serves a major contributor to the TRANSTOOL model for passenger and freight modules.

The TRANS-TOOLS freight model, consists of a sequential trade module, modal split module and a logistics module and is capable of forecasting transport demand for all EU27 Member States, up to 2030. Beyond 2030 trends are extrapolated with the support of meta-models up to 2050.

In the fourth and final stage, the outputs of TRANS-TOOLS are treated and aggregated at regional level (i.e. UK counties) for freight transport and encompass the following areas:

- Transport data: (tonnes, vehicle-km, tonnes-km etc. as Origin–destination matrices, per mode type and commodity type)
- Modal split (the distribution of transport demand per modality)
- Commodity split (the distribution of transport demand per commodity type in NSTR1[1] classification)

In addition, and essential to the research, aggregated country level origin destination (O/D) matrices are produced. These contain predicted transport demand from an Origin country towards a Destination country, for a certain NUTS level, and for a certain commodity.

[1] NSTR1 nomenclature is used, which stands for Standard Goods Classification for Transport Statistics / Revised from 1967. It consists of 10 groups: 0 := agricultural products and live animals, 1:= foodstuffs and animal fodder, 2:= solid mineral fuels, 3:= petroleum products, 4 := ores and metal waste, 5 := metal products, 6 := crude and manufactures minerals, building materials, 7 := fertilizers, 8 := chemicals, 9 := machinery, transport equipment, manufactures and miscellaneous articles

Table 1 Summary of factors considered / ignored in forecasting procedure

Uncertainty/Relevance	Low uncertainty	High uncertainty
Low relevance	Ignored A. General trends B. Transport trends Liberalisation of transport market C. Rail trends	Ignored e.g. Carbon intensity, non EU GDP growth, oil dependency, …
High relevance	Embedded in REF A. General trends Population (ageing, household structure) Urbanization Motorization B. Transport trends Liberalisation of transport market C. Rail trends	Embedded in both REF and White Paper Sc A. General trends Oil prices Economic growth (GDP, GPD per capita) B. Transport trends Technological breakthroughs C. Rail trends

3 Findings

The scenario results for the rail freight demand ***in tonnes (lifted)*** are provided in Table 2. Here, it should be stated that these findings consider domestic and European international freight transport demand. Hence, as the modal shift percentages from road to rail result from distances greater than 300 km, they do not, in most cases, include domestic demand, which is a significant part of the road demand. This explains why the modal split results (see Table 3) are relatively low.

With regard to the Reference scenario, the study anticipated, for the period 2010–2050, a moderate average growth of 1.52 % annually. The average annual growth rate for the total of EU15[2] countries remains at a relatively low level of around 1 %, while for the EU12 this number is more than 2 %. This assumption is based on the knowledge that the EU12 countries have a greater GDP value than the EU15. The majority of transport for all the EU27 remains on national territory; on average only 34 % of the total freight transport demand in Europe is considered international. Exceptions to this are countries such as Austria, Belgium and the Netherlands and Slovenia and Slovakia which can be characterised as "transit" countries.

The effect of the white paper implementation is most noticeable in the White Paper High scenario where demand for transport nearly doubles from an annual average of 1.52 to 2.87 %. As expected, the shift to rail freight in the Low scenario is lower than the High scenario, due to the strict conditions imposed within the scenario – i.e. having to meet two control variables (infrastructure and demand). More specifically, a 90 million tonnes modal shift to rail is foreseen in 2030 and a 165 million tonnes shift in 2050, coming mainly from the EU15 (for example Germany and Italy are responsible for 40 % of the shifted load).

For the White Paper Low scenario, the shift from road is expected to be quite low, with the total rail freight demand similar to the Reference scenario. In contrast, the High scenario anticipates a shift of more than 600 million tonnes in 2030 and more than 1 billion tonnes in 2050, raising the shifted road percentage up to 5.37 %. Again, this is mainly attributed to demand stemming from the EU15 countries.

Table 2 also illustrates (at the bottom) the *projections in billion tonnes-kilometres (btonne-km) (moved over distance).* The results, in tonne-km, depict the importance of the distance factor in the description of the results. For the Reference and Low scenarios, the average growth rates are not significant. However, the growth rate of the High scenario is more than double, compared to the Reference scenario. In short, while only slightly more than 1 % is expected to shift from road to rail in the Low scenario, a move of around 5 and 8 % respectively, for 2030 and 2050, is anticipated for the High Scenario.

At a national level, compared to the Reference scenario, the countries which depict the highest relative growth belong to the EU15, with Germany and Italy still maintaining the highest positions. For the EU12, the higher flows originate from Poland, Czech Republic and Romania, representing 60 % of the total EU12 demand.

[2] For comparison purposes, the EU27 countries are split into two blocs: EU15 (pre-1995) and EU12 (joined in 1995). The EU15 includes the old European countries of Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Sweden (SE), and United Kingdom (UK). On the other hand, the EU12 includes the new entrant countries of Bulgaria (BG), Czech Republic (CZ), Estonia (EE), Hungary (HU), Lithuania (LT), Latvia (LV), Poland (PL), Romania (RO), Slovenia (SI), Slovakia (SK), Cyprus (CY), and Malta (ML).

Table 2 Rail freight demand in tonnes for the EU27)

Rail Freight Demand (in Million Tonnes)	2010	2020	2030	2050	pa growth
Reference Scenario	1,040	1,260	1,590	1,902	1.52 %
White Paper Low Scenario	1,040	1,260	1,679	2,067	1.73 %
White Paper High Scenario	1,040	1,260	2,307	3,224	2.87 %
Modal Shift shift from Road to Rail (in %)	2010	2020	2030	2050	pa growth
Shift from road to Low Scenario			0.46 %	0.77 %	
Shift from road to High Scenario			3.22 %	5.37 %	
Rail Demand per scenario (in btonne-km)	2010	2020	2030	2050	pa growth
Reference	316	365	439	521	1.26 %
White Paper Low	316	365	488	611	1.66 %
White Paper High	316	365	699	1000	2.92 %
Shift from road to rail percentage	2010	2020	2030	2050	
Shift from road to Low Scenario			1.13 %	1.18 %	
Shift from road to High Scenario			4.86 %	8.10 %	

Source: TRANS-TOOLS modelling output)

The growth in 2020–2030 is significantly higher, for both the EU15 and the EU12 (see Fig. 2). This shows that a possible shift (for distances greater than 300 km) of 30 % from road could result in considerable growth for rail freight. From 2020 to 2030, where the highest average growth takes place as a result of the White Paper, the EU27 moves from less than 2 % average annual growth to 3 %, for the Low scenario, and to almost 7 %, for the High scenario. After 2030, growth rates are more closely aligned to those from 2010 to 2020. EU15 and EU27 growth is very similar. Conversely, for EU12, growth rates follow a different pattern. Average growth from 2010 to 2020 is much higher than that of either the EU27 or the EU15. However, the change is comparably small, from 2020 onwards.

The EU27 growth rates are closer to the EU15 because volume demand stems from the EU15, which strongly influences the overall trend. As Fig. 1 illustrates, the EU12 contributes approximately one third of the total volume, in btonne-km. This share is lower in both the Low and High scenarios, due to country tonne-km definitions that reflect origin of flow, with the point of origin being mainly within the EU15 group.

3.1 Modal split based on freight demand

The modal split is described for the White Paper scenario in order to clarify the rationale of the changes in rail freight demand. The modal split is defined for road and rail only. Additional modes such as inland waterways are not considered. In Table 4, the Reference scenario describes a modal split where road still maintains its leading position in freight transport in the EU27. In the Reference scenario, only 7 % of the total demand is attributed to rail (in terms of tonnes) reaching up to almost 9 % in 2050. On average, the share of rail for the Reference scenario, throughout the years, is 8 %. Regarding the White Paper Low and High scenarios, this growth in road demand is now partially allocated to rail (based on the distance, the network and its use). Assuming the implementation of the White Paper (EC 2011) targets, this is the projected split between these two modes.

Table 3 Average rail freight commodity growth per annum for the EU27 against the REF scenario

NSTR	NSTR 0	NSTR 1	NSTR 2	NSTR 3	NSTR 4	NSTR 5	NSTR 6	NSTR 7	NSTR 8	NSTR 9
White paper low scenario										
EU27	1.81 %	2.19 %	1.72 %	1.86 %	1.48 %	1.36 %	1.91 %	1.54 %	1.65 %	1.81 %
EU15	1.49 %	2.16 %	1.01 %	1.31 %	1.10 %	1.20 %	1.46 %	1.03 %	1.58 %	1.65 %
EU12	2.46 %	3.05 %	2.43 %	2.44 %	2.47 %	2.50 %	2.50 %	2.43 %	2.57 %	2.51 %
White paper high scenario										
EU27	3.48 %	7.55 %	1.75 %	2.73 %	1.75 %	2.58 %	3.03 %	1.78 %	3.61 %	3.97 %
EU15	3.59 %	7.39 %	1.07 %	2.87 %	1.43 %	2.43 %	3.20 %	1.37 %	3.51 %	3.94 %
EU12	3.16 %	10.79 %	2.44 %	2.54 %	2.63 %	3.73 %	2.73 %	2.51 %	4.86 %	4.09 %

Source: TRANS-TOOLS modelling outputs

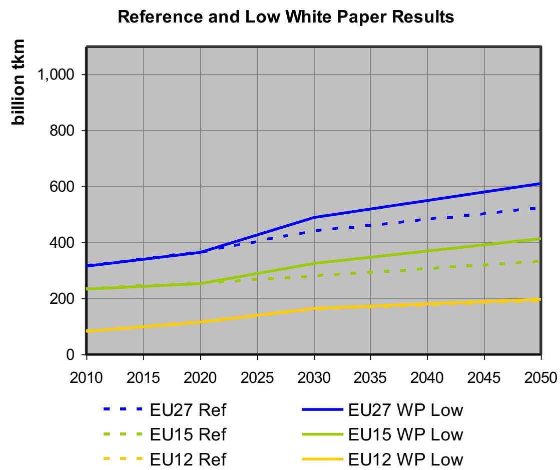

Fig. 2 Rail demand for the EU72, EU15 and EU12 in btonne-km (Source:TRANS-TOOLS modelling outputs)

For the split in tonnes, the results show clearly the differences between the two scenarios. While the rail share grows less than 1 % in the case of the Low scenario, it increases by 6 % for the High scenario, in 2050.

The results in tonne-km depict the importance of the distance factor. For the Reference and Low scenarios, the average growth rates are not significant. However, the growth rate of the High scenario is more than double, compared to the Reference scenario. In short, while only slightly more than 1 % is expected to shift from road to rail in the Low scenario (compared to the Reference scenario), a modal shift of 10 % is anticipated in the High scenario, by 2050 for the EU27.

4 Discussion

Let us now discuss some of the limitations of this study. As mentioned previously in this paper, TRANSTOOLS is built from several components, described as modules. These modules have taken statistical input from a variety of existing data sources. Data for the passenger module is more comprehensive than for the freight and logistics modules. This is reflected in the output level of the model, which outputs passenger transport data at NUTS level 3 (councils or districts) and freight transport data at NUTS level 2 (county and regional).

Of particular interest as model input data are trade commodity data. The TRANSTOOLS model uses NST/R commodity data, which is grouped into 10 categories and ranges from solid mineral fuels to foodstuffs. This level of data is, for the most part, sufficient, however the NST/R commodity classification has subsequently been replaced by a new NST 2007 classification in 2008. The revised classification includes 10 additional categories.

TRANSTOOLS has yet to be revised to include the NST 2007 classification.

By definition, any forecast provides a degree of uncertainty, and that is certainly true of this research where the forecast year is distant, 2050. The uncertainty in forecasting has been highlighted by a number of studies. Piecyk and McKinnon (2010) reported that truck empty running would reduce by 20 % between 2006 and 2020 through a Delphi survey with 00 logistics experts. Regarding the forecast, McKinnon (2014) found that the empty running had increased by 9 % by 2010 – significantly earlier than the forecast period. This again highlights the difficulties faced by forecasters and the inherently uncertain nature of forecasts as demonstrated by a leader in this field.

Let us also consider some emerging trends, which are not fully accounted for in this research and which may impact on the accuracy of the forecast.

4.1 Demographic

The average household size in the EU27 is declining (Eurostat 2014); at the same time the population is increasing. It is estimated that the population of the EU28 will increase to 518 million by 2030 and 525 million by 2050 (Eurostat 2014).

Table 4 Rail proportion of total rail and road volume in tonnes and tonne-km (Source: TRANS-TOOLS modelling output)

	Rail freight volume in tonnes				Rail freight volume in tonnes-km			
	2010	2020	2030	2050	2010	2020	2030	2050
Reference Scenario	7.4 %	7.7 %	8.2 %	8.8 %	10.1 %	10.1 %	10.1 %	10.8 %
White Paper Low Scenario	7.4 %	7.7 %	8.6 %	9.6 %	10.1 %	10.1 %	11.2 %	12.7 %
White Paper High Scenario	7.4 %	7.7 %	11.8 %	15.0 %	10.1 %	10.1 %	16.1 %	20.8 %

Together, these statistics suggest that an increased number of people are living alone, or cohabiting in smaller groups than previously. According to INCPEN (2004), smaller households result in a larger number of product consumptions per person per year, resulting in an increased demand for transport and logistics services. A person living alone results in about double the environmental impact of a person living in a large household. Detailed impacts of demographic change are noted in Table 5.

4.2 Reshoring

According to the Financial Times (2014), there is a small but growing trend of "reshoring" of manufacturing from those manufacturing bases typically seen as low cost, such as Eastern Europe, Brazil and China. According to the EEF (2014) report "Backing Britain – A Manufacturing Base for the Future", 1 in 6 of the 271 companies surveyed in 2013 indicated that they had brought some part of their manufacturing operation back to the UK. This is in part due to rising wages in China, but also due to increased operational efficiency in UK manufacturing and a desire to reduce transport costs. In the US, reduced energy costs - as a result of Shell gas exploitation and pressure on US multinational companies to preserve US jobs - have also resulted in a significant amount of reshoring. Reshoring will lead to an increase in inland transport in the EU, as a result of an increased number of freight trips between manufacturing sites, suppliers and warehousing facilities.

4.3 3D printing

3D printing has seen vast media attention in recent years and has been described by some as the second industrial revolution. There are however some reservations regarding the true potential of 3D printing and its ability to transform manufacturing. The UPS Store (2014) informs that it is testing 3D printing services in-store, in limited participating locations, to start-ups, small businesses and retail customers. The first six test locations are located in: San Diego, CA; Washington DC; Frisco, TX (near Dallas); Menlo Park, CA (near San Jose); Lisle, IL (near Chicago); and New York, NY.

Table 5 Impact of demographic changes

Element	Four member household	Two member household	One member household
Consumption kg/year	1000	1200	1600
Packaging kg/year	70	90	120
Energy use through the Supply Chain per person GJ/year	80	120	190

Data source: INCPEN 2004, p. 12

Currently there is a small number of useable materials, accuracy is questionable and the size of parts is also limited. Keeping these limitations in mind, Kückelhaus (2014, p.21) suggests that 3D printing is expected to change future freight transport and logistics services that will demand specific networks for materials delivery, but that it will also offer new business opportunities for logistics providers, such as digital warehousing and 3D model hosting. Innovative logistics providers will have a great opportunity to become thoughtful-leaders and specialists in the integration and orchestration of complex networks, including traditional and 3D manufacturers. Thus we can assume that 3D printing has a huge potential and, given the 2050 horizon year presented in this paper, we can be confident that many of the limitations that exist at present will be overcome or reduced, by that time. In terms of its impact on transportation, the wholesale uptake of 3D printing is likely to lead to an increased volume of raw materials being transported, which may play to the inherent strengths of rail transportation. Kückelhaus (2014, p. 21) warns the logistics service provider to: 'Be thought leader in new, potentially disruptive technology, become orchestrator of complex and fragmented supply chains.' The constraints of mass usage of 3D printing are detailed by McKinnon (2014, p. 10):

- Very expensive relative to scale economies of batch production;
- Need to attach high value to customised products;
- Technical difficulty in producing all but simple parts;
- Limited range of materials used – constrains functionality; and
- Layering and bonding process causes intrinsic weakness.

Presented under the headings of demographic, reshoring and 3D printing, we have discussed three emerging trends that add uncertainty to the forecast presented in the paper. Each of these trends presents a different challenge to transport and logistics. Table 6 summarises the impact in terms of modal shift to road, or rail, as a result of these three future trends.

5 Conclusions and recommendations

Over the last 40 years the rail freight market share has steadily declined. This may in part be attributed to its historical background and lack of response to market needs, as well as to the changes that have occurred in the rail freight industry over the last four or five decades (Zunder et al. 2013). Inherent weaknesses (e.g. dependency on road for door-to-door service; lower priority of freight train in path allocation; speed) and aging rolling stock, have also played their part.

Despite numerous actions, initiatives and measures, rail freight transport has failed to gain market share in Europe.

Table 6 Future trends and their suitability to road and rail transport modes in Europe

Trend	Description	Modal shift to:
Demographics	Reduced household size and increased consumption of goods per person	Road
Reshoring	Reshoring of manufacturing from economies considered low cost manufacturing bases, such as China and Brazil, back to Western Europe	Road/Rail
3D printing	Flexible manufacturing from raw materials (metals and plastics)	Rail

EU27 gross domestic product (GDP) (year 2000 prices and exchange rates) grew at 1.9 % per annum between 1995 and 2011, while freight transport grew at 1.4 % over the same period. At the same time, growth in rail freight transport was only 0.4 % (European Commission 2011, 2014).

Traditionally, rail freight transport has performed better (making it first choice for shippers/consignees) when serving high volume markets, including cargoes such as solid mineral fuels (CER 2013). There is a significant and fundamental change in the manufacturing and consumption pattern in Europe (and other developed countries) meaning that the share of raw material for heavy manufacturing as a proportion of the total freight transport has declined (Network 2013a, b, c). By contrast, the share of 'semi-finished' and finished products has increased. The increase in a market in which rail freight transport is traditionally weak is a significant contributor to rail's loss of freight market share.

There is a fundamental difference in the ways these two types of cargoes are transported. The transport of raw material can typically afford longer transit times permitting a less accurate transport schedule and is subject to lower transport costs. The transport of semi-finished and finished products can demand a higher transport cost but this premium demands a faster, more reliable service particularly when considering the total transport chain, namely door-to-door delivery. This market is for the most part served by road freight, suggesting that the customer requirements of this market are best served by road.

If the rail freight sector is to achieve the EC policy objective for a 50 % modal shift by 2050, it must capture a significant share of this high value freight market. It cannot continue to rely on the traditional rail freight markets of coal, ore and other bulk cargoes. Rail freight actors (to include infrastructure managers, operators and regulators) must to consider these changes in market demand and adjust its service operations and strategic planning, accordingly.

The TransVision (2009 p.22) study suggests that 'despite using the best technical modelling tools there is an inherent uncertainty about any long term predictions'. Also 'the uncertainty increases as future scenarios significantly change compared to base year. A long term forecast to e.g. 2050 will be more uncertain than a forecast to 2010' (same ref. page 123). Any forecast can be seen as optimistic, pessimistic or pragmatic. The EU Transport White Paper 2011 has set a modal shift target (from road freight to rail freight) that is considered achievable by many (either optimistic or pragmatic views) but is also considered unlikely by others (pessimistic view). The current research investigated the potential of rail freight demand trajectories to 2050 for the EU27, using a range of projected scenarios based on specific socio-economic and relevant freight transport trends. Assuming 2010 as the base year, three scenarios were developed: the Reference scenario, where no major policy change occurs in the future, and two White Paper scenarios which assume that there will be a significant shift in freight demand from road to rail across the period 2020 to 2050. This average growth rate will increase significantly in the White Paper High scenario, strongly affecting the modal split and doubling rail freight demand. In the White Paper Low scenario, total demand increases by almost 20 % in 2050, compared to the Reference scenario. In the White Paper High scenario, the total demand is expected to almost double, favouring long-distance transport.

The implications for the rail freight sector, in terms of wagon fleet capacity and capability in general, are significant, as is the availability of infrastructure (e.g. line capacity and train paths) to accommodate the much higher expected demands. Recently, a Strategic Freight Network (SFN) has been put in place to benefit the British rail freight industry. This facilitates opinion gathering from stakeholder groups that include ports, shipping lines, manufacturing, logistics service providers, retailers, quarrying, construction and British rail freight service users. The SFN is a rolling programme of planned investment in infrastructure to allow the efficient operation of longer, larger and more freight trains, to meet the forecast growth in demand (Network Rail 2010 p.35). The SFN consists of a series of linked schemes, with a rolling programme of investment in more productive locomotives, wagons and terminals, aimed to improve the performance, economic efficiency and capacity of freight on rail (Network Rail 2013c). The current research recommends that, in combination with this freight forecast, similar action be taken at the European level and SHIFT2RAIL (http://www.shift2rail.org) has kicked off its journey towards this.

However, some of the future trends identified in the discussion section will impact on both road and rail modes of transportation. The requirement to transport a larger volume of raw materials, for instance, is likely to play to the strengths of freight transportation by rail and the advantages it can bring through economies of scale.

Flexibility in the transport of a variety of commodities will be necessary, if and when the White Paper Low and High scenarios are realised. The forecasted changes, in terms of projected cargo types in rail freight transport, total freight transport demand and the corresponding development of service, will influence customer service expectations. They will also directly impact on the flexibility and ability of rail operations and their integration with other transport modes (e.g. pick-up service at origins and delivery service at destinations) to meet customer demands and expectations. The flexible ability to offer such door-to-door, as well as terminal-to-terminal, services will influence rail transport in general, and rail infrastructure in particular, at a national and a European level. It is important that the rail industry and governments maintain a policy of development and investment, if the EU Transport White Paper targets are to be achieved.

Considering this, the authors believe that tripling rail freight demand by 2050, in the EU27, is both ambitious and optimistic - but not beyond the realms of possibility.

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