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Different perspectives on the global development of transport

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Abstract
It may be clear that the future of the transport sector is fraught with uncertainties, as the system can be influenced by many factors that can develop in various ways. The aim of this paper is to get insight into the future development of the transportation sector seen from a world-wide perspective. This is done by applying a scenario approach and design four possible development paths of transport. These future developments are presented here by sketching four global contrast images based on outcomes of earlier research. The outcomes for the transport sector, expressed in transported volumes for both passenger transport and freight transport, are first qualitatively described based on expected developments of several indicators. Next, based on those descriptions, quantitative numbers of transported volumes are calculated with the time horizon being 2020. It appears that all scenarios foresee a growth in transport volumes (for both passenger- and freight transport) world-wide.
The achievement of sustainable mobility based on the outcomes presented in this paper may seem difficult and will be confronted with several hurdles. But policy changes and (unexpected) technology developments offer possibilities to realise this objective. Policy makers are thus faced with formidable policy challenges to achieve the Kyoto objectives in the next 20 years.

1 Introduction

An efficient transport system is a crucial precondition for economic development and an asset in local, regional and international mobility. Mobility of passengers and free transport of goods is considered as an essential element for a modern society. With the integration of the world market, economic growth and higher levels of income, transport has become a major economic sector, which is characterised by qualitative and quantitative growth. For example, for the U.S. and Japan the contribution of the transport sector to GDP is estimated to be between 4 and 6 percent. This gives an indication of the importance of transport. The significance of this sector can even go beyond these proportions, as no economic activity can flourish without transportation activities. It may be clear that mobility has become a prerequisite for the proper functioning of modern societies.

The transport sector is subject to drastic changes. Various (globalisation) trends and underlying factors will influence the transportation sector. Changes in modal split and growth i.n mobility will have a direct impact on the transport system in the nearby future. Another influencing factor is the role of transport policy. The increasing attention for market incentives in general and the move towards harmonisation (a recent policy trend of the European Union) are aspects that may have a significant impact on the development of transportation. So the future of the transport sector is fraught with uncertainties, as the system can be influenced by many factors which can develop in various ways.

The aim of this paper is to get insight into the future developments of the transportation sector in 2020 seen from a world-wide perspective. This is done by applying a scenario approach and by designing four possible development paths of the transport sector. Starting point for the construction of these transportation scenarios are four globalisation scenarios, constructed in an earlier phase of our research[1]. These globalisation scenarios will form the input for the transport scenarios, which will here be elaborated for a global scale. Outcomes of the assessment of these globalisation scenarios made on the basis of the Worldscan model of the CPB are used as a guiding tool for establishing the transport scenarios. We will not only describe scenarios; their consequences will also be expressed into quantitative numbers of transported volumes in 2020 (in ton-kilometres for freight and passenger-kilometres for passenger transport). This enables us to obtain more insight into the size of transport flows with a view to the estimation of future emissions of transport. This is an extremely important challenge, as all European countries have committed themselves to the Kyoto agreement with the task to drastically cut CO_2 emissions. Thus, the achievement of sustainable transport is a major policy objective, and therefore an exploration of alternative futures is needed.

This paper is organised as follows. The second section will deal with general remarks concerning transport and scenarios, in which some theoretical aspects will be discussed as well. Also, the four global scenarios will be subsequently described using a common structure. Section 3 will explain how we will arrive at transport figures for 2020. Consequently, the subsequent section will as a baseline first present briefly the current situation in transport, after which the outcomes for 2020 will be outlined. This paper will be ended with some concluding remarks made in section 5.

2 Theoretical Background of Transportation and Scenarios

A transport scenario seems to be an easy understandable term; one might describe it as an image of the future world of the transport sector. Looking in more detail at those two words it seems that these need some clarification to understand the meaning and contents of this term. So in order to describe and present transport scenarios, one needs more insight into this term. This section will try to clarify these matters in describing scenarios as a theoretical starting point for the rest of this paper, leading to a clear understanding of how we approach the term transport scenario.

2.1 Scenarios

Scenarios are descriptions of future developments based on explicit assumptions that can have an important role in the decision-making process. Decision-making relies heavily on information, which may be provided by scenarios. In reality, existing information is never enough: it often does not fulfil the needs of decision-makers in either quantity or quality

[1] Globalisation, International Transport and the Global Environment (GITAGE), writing transport scenarios is one of the tasks of this project funded by NWO, see also van Veen-Groot et al., 1998.

(Rienstra, 1998). This leaves people with uncertainty regarding the likelihood of future developments.

Uncertainty always exists in open systems such as the transport system, the system cannot be fully controlled but is subject to impacts of many factors. Therefore it is difficult to predict which developments in these systems are likely in the future. This uncertainty can be reduced in various ways, for example decision-makers have decision-support tools. One of these tools are scenarios, which have the following functions (see e.g. Steenbergen, 1983):

- The signalling function; scenarios provide greater insight into uncertain situations.
- The communications and learning function; scenarios stimulate thinking about alternative futures and provide decision-makers with options.
- The legitimisation function; scenarios mobilise people and start processes of change when they show the impacts if nothing is done or when the future situation in the scenario seems beneficial.
- The exploring and explaining function; scenarios show how solutions for specific problems may become reality, given certain policy priorities.
- The demonstration function: scenarios show the consequences of specific decisions.

Scenarios enable us to reduce complexity and facilitate discussions about future events by arranging and classifying information and preventing information overload (Rienstra, 1998). Scenarios may help in gaining insight into the consequences of strategies and enable to compare the consequences of the choice for a certain strategy. Scenarios in this way can provide us new insights into possible paths and policies and their impacts on the future.

It should be noted that scenarios can be constructed in various ways, using different methods, leading to different contents of the scenarios. They may be intuitive, a literary product, idealistic or qualitative expert assessment based. Scenarios can also be designed on the basis of a variety of approaches (e.g. the compound package approach). All these types will not be discussed here as this would be too comprehensive (see for a more detailed overview Rienstra, 1998).

The purpose and advantage of scenarios is that they are a kind of structured brainstorming method, created to widen the perceptions of policy makers and researchers regarding future possibilities and policy options, other related developments and impacts. They may increase the willingness to at least consider a broad spectrum of developments, since the resulting future is presented in an attractive way. In conclusion one may say that the scenario methodology is a very interesting way of analysing the future of uncertain situations, and hence also for analysing the complex future of transport systems.

2.2 Transport scenarios

In the foregoing subsections, we have described the transport system and scenarios separately from each other to gain some insight in these terms. Transport refers to the movement of people/persons, information and goods in space and has become one of the key activities in modem societies. Scenarios are descriptions of future developments based on different assumptions. Scenarios can be constructed and used in various ways, different methods can be applied. They form an interesting way of analysing the future of uncertain situations, for example for the complex future of the transport system.

Transport scenarios are here seen as pictures of the future within the pre-specified framework of the movement of goods and persons. The scenarios can be described based on different characteristics of transport (e.g. volume, spatial organisation, modal split, transport technology, distance and emission factors). The construction of these scenarios will give insight into the future developments of the transportation sector. These developments will be translated into quantitative numbers of flows for both passenger and freight transport.

3 Transportation Scenarios on a Global Level

After having described the underlying principal behind the development of transport scenarios, in this section the four different transportation scenarios on a global level will be presented. The four different, previously developed, globalisation scenarios of the GITAGE project form the basis for these global transportation scenarios (see van Veen-Groot and Nijkamp, 1999 and CPB, 1999). In these scenarios, a distinction is made between OECD and non-OECD countries enabling us to make a more precise description of the different paths of development in transportation on a world-wide scale. This distinction is here maintained in describing the future developments in transport.

The way the scenarios are constructed largely depends on the possibilities of different models, which will be used for quantification of the scenarios. In order to be able to say something about emissions in the different scenarios, the amount of kilometres covered by different transport modes and the consumption of fuel to cover these kilometres is important. Therefore, the scenarios have to be discriminating in terms of transportation variables.

The same structure will be followed consequently in the following subsections describing the various scenarios. Every time a section will be started with a general introduction describing the starting points based on the four globalisation scenarios developed in an earlier phase of our research. In order to describe changes in transport volume (used here as a characteristic to express changes in transport in ton- and passenger-km) properly, four aspects of transport are consequently described. Spatial organisation followed by distance, technology development and modal split will all have a certain impact on transported volumes and can be seen as indicators. These subsections will be ended with an overview of (expected) impacts of the various aspects on the modalities in the distinguished regions (OECD vs. non-OECD) in table-form. The development of modal split is not included in these tables but is taken into account in establishing the impact on transported volumes as major outcome. These tables are filled with indicators (+, 0, -) expressing the potential expected impact on modalities of the various developments described in the scenarios. As a starting point we take the situation as it is in 1995, this is the reference situation. A plus in transport volume for example will only say that it is expected that the volume of goods or persons (expressed in ton-kilometres and passenger-kilometres) transported by a certain mode will grow compared with the reference situation. As a consequence, double plus means that a stronger positive development is expected. Important to keep in mind, however, is that the plusses do not necessarily have the same meaning for the diverse aspects, various scenarios and within a scenario (a plus for technology impact on transport volume is not comparable with a plus for distance/spatial organisation). They can only be regarded as indicators of a positive and a negative development (in case of a minus). In the description here, a 0 does not mean that the situation will not change during the period of time. It only indicates that compared with the reference situation no significant change is to be expected.

3.1 Scenario 1: Growth

This scenario is an optimistic scenario from an economic perspective. It predicts economic growth in both OECD and non-OECD countries. There is a trend towards globalisation and market-oriented policies in the world economy. As a result of the economic progress in both regions, the linkages between the OECD and non-OECD countries intensify. Growth of developing countries and complete liberalisation of goods and capital markets results in closer economic integration of rich and poor countries (CPB, 1999).

The main driving force behind this scenario is the high level of economic growth. The economic development will take place in OECD as well as non-OECD countries. For transport, a very important point is that speed and flexibility will not suffer from any barrier.

All developments in this field, as a result of the high economic growth, will support the growth and development of the transport sector.

The spatial organisation will be largely left to the market and will result in the lower barriers to the import of goods, services and capital. These lower barriers and the reduction in transportation costs and trade tariffs stimulate international trade and transport. This trend is facilitated by the strong increase in the usage of conventional transport modes and the construction of the high-speed rail network in Europe.

A logical effect of the trend towards globalisation of production and consumption is an increase in the average distance covered by the various transport modes. This means that more kilometres will be covered by transport modes for the transport of freight as well as the transport of passengers. Not only as a result of the change in transport flows, but also as a result of growing welfare and the development of new technologies, world-wide mobility will increase.

The implementation of some new technologies in combination with high economic growth rates will cause a considerable growth in mobility and transport. All authority levels (both in OECD and non-OECD countries) over the world aim at stimulating economic growth; transport is assumed to be necessary accommodating this. Technological development is assumed to support the development of transport to further stimulate the economic growth in future. The progress of new technologies is expected to be somewhat faster in non-OECD countries so that they will catch up with the OECD countries. Concerning passenger traffic, the economic development supports the introduction of high-speed rail and with this taking over parts of the short distance air transportation market. This development will especially take place in Western Europe where technological progress in e.g. high-speed rail will cause a replacement of transport modes. In the long run the high-speed rail network will even be enlarged. For passenger transport, this means that intercontinental air transport and high-speed rail transport will become more popular compared to road transport and in particular conventional rail transport. For freight transport, these developments mean that (intercontinental) freight transport by air will grow. Another development is the increase in intermodal transport.

World-wide consumption and production of products will lead to increased flows in freight transport. Also passenger transport will grow in terms of trips made and distance. Higher income levels will allow people to make more journeys for consumption opportunities, such as shopping and leisure.

This scenario projects a continued increase in freight transport concerning volume, speed and distance. The amount of kilometres covered will increase for all transport modes, but especially for air and road freight transport. Concerning passenger transport we could expect a continued growth in personal mobility. In the absence of strong regulatory policies (more market oriented), this leads to the supremacy of the car over marginalised public transport in urban regions and fierce competition between high-speed trains and aircrafts in European travel. High-speed rail (mainly in Europe) and (intercontinental) air will be the fastest growing modes concerning transportation of people (also due to the growing tourist sector). Negative consequences can be expected in terms of environment and congestion (as a shortage of capacity).

The above described developments, together with the previous subsections (transport technology, spatial organisation and modal split), form the basis to forecast the development in volume (ton- and passenger-kilometres), as shown in Table 1.

TABLE 1: Scenario 1: Growth

		Spatial organisation/ Distance		**Transport technology**		**Volume**	
		OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
Freight transport	Air	++	+	+	+	++	++
	Road	+	++	+	++	+	++
	Rail	+	+	+	+	+	++
	Seaborne shipping	+	+	+	+	++	+
	Inland shipping	+	+	+	+	+	+
Pass. transp	An-	++	+	+	+	++	++
	Road	+	++	+	++	+	++
	Rail	+	++	+	+	+	+

3.2 Scenario 2: Core-growth

This scenario makes a sharp distinction between countries belonging to the OECD and non-OECD countries. High economic progress in the OECD countries exists, whereas the non-OECD countries lag behind. The same holds for the level of technological innovation and development. As a result of a political unstable situation, overpopulation, and low incomes in non-OECD countries and high economic progress in OECD countries, large international migration flows come up from non-OECD to the OECD countries. This leads in the end to a strong polarisation between world regions.

This division in two will also affect the transportation sector. Within the OECD-sector a concentration of trade and transport will occur, whereas trade between those two blocks is decreasing. There is only limited international trade, also due to restrictions in import and foreign investments. The flourishing economy in the OECD-countries will cause increasing mobility in qualitative as well as quantitative terms. This means that the transportation networks will develop considerably, including the transfer points. Consequently, harbours and mainports will become crucial with regard to the efficiency of these networks. They will perform as regional points of transhipment where different transport modes will meet each other. The development of networks in non-OECD countries is lagging behind and there is no real concentration of spatial activities. Infrastructure will not be structured in networks and mainports will not be developed, mainly due to the non-market orientation and inward orientation of the government policies.

In a growing world economy as expected in the OECD countries, there is often progress of new technologies too. Especially, air and rail technologies will improve the current achievements of these sectors and become more important. Concerning passenger traffic, technological development will support the introduction of high-speed rail and herewith taking over parts of the short distance air transportation market in the OECD countries. In the long run the high-speed rail network will be enlarged.

High-speed rail and (intercontinental) air will be the fastest growing modes concerning transportation of people. This is all facilitated by the progress in transport technology. Non-OECD countries, on the contrary, will rely heavily on conventional transport modes and techniques. Here, road transport will remain its dominant position, mainly caused by the lack of new technologies for other modes. This situation will not change because unfavourable market circumstances in the non-OECD will hold up the dissemination of new technologies from the OECD.

Because of the growing volume of transport flows, other/new modes will be used to be able to transport the bigger amount of goods and to cover the new routes and reach new destinations. Technological development will play an important role to facilitate this development. These developments will not be disseminated to the non-OECD countries. As a result these non-OECD countries will rely on already available transportation modes and related techniques. Road transport is still the dominant mode for passenger and freight transport in both OECD and non-OECD countries.

As the economic progress is situated among OECD countries, demand for transport is high in these countries. It is obvious that this leads to increased flows in freight and passenger transport, although less than we have seen in scenario 1. Due to an unstable political situation in the non-OECD countries, intercontinental trade is not stimulated which will have a negative impact on the overall volumes of goods and passengers transported. The non-OECD countries are growing slowly and inward oriented. Consequently, there is only modest demand for transport, which causes a relatively small increase of volume (see Table 2).

TABLE 2: Scenario 2: Core-growth

		Spatial organisation/ Distance		**Transport technology**		**Volume**	
		OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
Freight transport	An-	++	+	++	+	++	+
	Road	++	++	+	+	+	+
	Rail	++	+	++	+	++	+
	Seaborne shipping	+	+	+	+	++	+
	Inland shipping	+	+	+	+	+	+
Pass. transp	Air	++	+	+	+	++	+
	Road	+	++	+	+	+	+
	Rail	+	+	++	+	+	+

3.3 Scenario 3: Peripheral growth

In this scenario, growth will for the greater part take place in the non-OECD countries (at high environmental costs) in stead of the OECD countries (see scenario 1 and 2). The lack of technological progress has a large impact on the economy, because this is an important contributor to economic growth. The developing countries do not face these problems. They go further in opening up and strengthening markets. Trade blocks will arise in the non-OECD countries as a result of liberalisation of trade and finance, the adoption of free market principles and more outward oriented government policies. They will invest in infrastructure and education and copy at a fast pace technologies from the OECD countries. The high economic growth rate in the non-OECD countries is accompanied by severe ecological problems. Transport will grow without severe limitations and with the use of current energy intensive technologies as imitated from the OECD standard. Compared to the OECD countries, economic growth is relatively higher as a result of limited availability of resources and a slow down in technological progress in OECD countries (van Veen-Groot et al., 1999). In the end, the developing countries catch up with the developed ones.

The trend towards globalisation of production and consumption causes an increase in the average distance covered by the diverse transport modes in this scenario too. Nevertheless, the increase can mainly be attributed to the increase in distance covered in the non-OECD countries. Goods will be transported to a greater extent within the OECD and non-OECD regions, in stead of between those regions. But because of the growth within the non-OECD, an average increase in distance covered by modes for freight transport can be seen. This increase applies also for passenger transport as the growing population and the economic growth leads to a greater demand for transport. The total amount of passenger kilometres will increase as a result of the growing economy in the non-OECD countries.

In this scenario, the improvement of technology will mainly take place in the non-OECD countries. These countries will implement new technologies mainly imitated from OECD countries, which are still a way ahead concerning the implementation of transportation technology. This means that more efficient transport can take place (passenger as well as freight transport) and that the use of ICT will come up in these regions. The OECD countries are staying behind, since there is no impulse for technological development, due to the restrained economic and political situation. These countries will rely on existing techniques, new innovations are only made on a small scale.

The strong economic growth and the technological development in non-OECD countries cause a fast growth of transport by road, air, and shipping in those countries. Sea shipment and air transport will benefit from new available techniques and the liberalisation of trade. In the OECD countries, on the other hand, there is a medium growth of air and shipping.

The above mentioned changes in technology and spatial organisation driven by economic growth will have an impact of transportation volumes of goods and passengers. Because of the catching up of non-OECD countries with the developed countries (stimulated by the population growth) their transport volumes show an overall increase for both passenger and freight transport. There are, however, some variations between the various modes. Road will remain by far most used. In addition sea shipping and air will benefit from the liberalisation of trade, their volumes transported will increase but slightly less compared to road (and sea even more than air). Rail transportation will grow, but far less. In the OECD countries, the volume will not grow that much, in contrast with the previous described scenarios. Road transport will remain the dominant mode expressed in volumes, especially concerning freight. A complete overview of changes in transported volumes can be found in Table 3.

TABLE 3: Scenario 3: Peripheral growth

		Spatial organisation/ Distance		**Transport technology**		**Volume**	
		OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
Freight transport	Air	+	+ +	+	+ +	+	+ +
	Road	+	+ + +	+	+ +	0	+ + +
	Rail	+	+	+	+ +	0	+
	Seaborne shipping	+	+ +	+	+ +	+	+ +
	Inland shipping	+	+ +	+	+	+	+
Pass. transp.	An-	+	+ +	+	+ +	+	+ +
	Road	+	+ + +	+	+ +	0	+ +
	Rail	+	+ +	+	+ +	+	+

3.4 Scenario 4: Sustainable growth

The former scenarios pay little or no attention to the environment; economic growth can continue without any limitations imposed by the environment. Some energy improvements in production and transportation take place. However, environment as such is not an objective in these scenarios. This scenario does take environmental quality as an objective. People do not care about an increase in income or a physical amount of goods as much as in the other scenarios, but they care about happiness, the local environment and efficient use of natural resources. Economic growth is important though under certain restrictions of well being and environment. Technical progress as such is not high; it is directed to energy-efficiency improvements. Countries agree to co-operate on environmental legislation without free rider behaviour. So countries are permitted to grow but only with energy saving technologies.

Economic growth will be low (both in non-OECD and OECD countries) mainly due to the lack of technical progress which is aimed at environmental progress.

There is only modest trade between various continents; there are not many incentives to eliminate trade barriers. Firms stay in their own region and the need for transport is limited. This also limits the incentives for technological development in the transport sector (CPB, 1999). The stable political situation all over the world will guarantee successful international agreements. The emphasis will be placed on collective transport of people as being more important compared to individual mobility.

Transportation becomes more expensive as it is unfriendly from an environmental perspective. The length and direction of the transport flows will change towards shorter, more regional flows. Large transportation networks covering a whole continent will not be developed. Local traffic is important and carried out by cars (passenger) or lorries (freight). Trains will be used for the longer distance, being environmentally more friendly in comparison with air traffic. The covered distances in this scenario will relatively decrease in comparison with the others. Reason for this is the decrease of the use of leisure transport, due to the high prices.

In an ecological scenario, there is focus on environmentally friendly technology forced by ecological awareness. The OECD countries will export environmentally friendly technology towards the non-OECD countries. These developments will cause an increase in efficiency of traditional modes. Road transport will be one of the main attention points in making it more energy efficient as being the dominant mode in energy consumption. Technology will be aimed at facilitating the trend towards more collective transport. In this way there is a small distinction in technology development between the diverse modes, other countries copy new techniques very soon.

Technological development is assumed to play an important role in future. In absolute sense, the progress of new technologies is expected to be even faster in non-OECD countries so that they will catch up with the OECD countries. Although some aspects may hinder the implementation of new transport technologies, it is supposed here that in general new (transportation) technologies will be developed in high progress and applied in practice rather soon. In addition it needs to be stressed that the impact of new technologies on the transportation market depends on the potency of the new development and the introduction speed. Most improvements are to be expected on the rail market, especially the performance of freight rail (having a poor performance rate at the moment) can be increased (see also Nederveen et al., 1999).

Concerning passenger traffic, technological development will support the introduction of high-speed rail and taking over parts of the short distance air transportation market. The future of road transport is rather questionable in this respect. Substantial improvements can be expected concerning fuel and engine technologies. Leisure transport will decrease due to high prices. In general a movement can be seen from the use of individual modes towards the use of collective transport possibilities, which means that public transport will benefit from this trend.

With concern to freight transport, the use of seabome shipping will increase, because harbours will become more important. Rail transport will become also more important as it can be regarded as relatively environmental friendly, especially in Europe where the high-speed network for passengers will be expanded. As road transport is important on the short distance the use is growing although restricted (within certain boundaries and (congested) areas) and more efficient (technology push). Air transport will decrease in total although there are differences between regions. The emphasis on ecology will result in an almost constant level of transport in OECD countries and a modest growth of transport in non-OECD countries. Especially sea transport will grow in these countries, followed by air transport in certain regions.

TABLE 4: Scenario 4: Global: Sustainable growth

		Spatial organisation/ Distance		Transport technology		Volume	
		OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
Freight transport	Air	0	0	+	+	0	0
	Road	0	0	+ +	+ +	0	+
	Rail	0	0	+ +	+ +	+	+
	Seaborne shipping	+	+	+	+	+	+
	Inland shipping	+	+	+	+	0	+
Passenger transport	Air	+	0	+	+	0	0
	Road	0	0	+	+ +	+	+
	Rail	0	+	+ +	+ +	+	0

3.5 Comparison and conclusions

This subsection will give an overview of the major outcomes of the various scenarios. First, the four scenarios will be described based on four characteristics. These developments have their consequences in the end for the transported volumes. Next, the changes in volumes will be briefly summarised as being the most important output so far.

TABLE 5: Svnthesis of scenarios

	Scenario 1: Growth	Scenario 2: Core-Growth	Scenario 3: Peripheral Growth	Scenario 4: Sustainable Growth
Spatial organisation	• *Globalisation production and consumption*	• *Importance of harbours/ mainports* • *Concentration of trade/transport within OECD*	• *Concentration of trade/transport within non-OECD*	• *Localised production and consumption* • *Importance of harbours*
Distance	• *Major increase of average distance*	• *Major increase of average distance within OECD* • *Minor increase of average distance within non-OECD*	• *Major increase of average distance within non-OECD* • *Minor increase of average distance within OECD*	• *Minor increase of distance*
Transport technology	• *High progress of new transportation technologies* • *Innovations on management level: ICT facilities*	• *Progress in transport technology in OECD* • *ICT will be booming*	• *Improvement of technology especially in non-OECD* • *Increase of the use of ICT in non-OECD*	• *Increase of efficiency of traditional modes* • *More improvements than other scenarios*
Modal split	• *Growth of intercontinental air and continental high-speed rail transport* • *Increase of intermodal transport*	• *Increase of air transport* • *Rail only important within OECD* • *Overall importance of road transport* • *Sea transport important for freight*	• *Fast growth of road, air, shipping in non-OECD* • *Medium growth of air and shipping in OECD*	• *ICT is a substitute of physical transport* • *Use of seaborne shipping important* • *Less leisure transport (due to high prices)*

Volume	• *Overall growth volume **of** transport*	• *Increase **of volume** within OECD*	• ***Increase of volume** within non-OECD*	• *No spectacular increase **of** transport in OECD* • *Modest growth in non-OECD* • *Increase in information/data flows*

The above table (Table 5) summarises the four global transportation scenarios. From this table it becomes clear that there are major differences between the scenarios. The differences between the various characteristics finally result in the differences between the characteristic Volume. This characteristic determines the changes in volume of transport flows, and with this, the differences in emissions, which is the final characteristic we would like to have information about.

The change in volume of the total transport sector is a result of the change in volume of the various transport modes. In each scenario, the final change in volume is determined by the change in volume in transport by road, by rail, by air and by water, both for passengers as well as freight transport. In the next table, an overview is given of the changes in volume per mode and per scenario.

TABLE 6: Changes in Global Volume

		Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario** *4*	
		OECD	*non-OECD*	*OECD*	*non-OECD*	*OECD*	*non-OECD*	*OECD*	*non-OECD*
Freight transport	Air	++	++	++	+	+	++	**0**	**0**
	Road	+	++	+	+	0	+++	**0**	+
	Rail	+	++	++	+	0	+	+	+
	Seaborne shipping	++	+	++	+	+	++	+	+
	Inland shipping	+	+	+	+	+	+	**0**	+
Passenger transport	Air	++	++	++	+	+	++	**0**	**0**
	Road	+	++	+	+	**0**	++	+	+
	Rail	+	+	+	+	+	+	+	**0**

From this table it becomes clear that there are quite some differences between the transport volumes in the different scenarios on a global level. In scenario 1 growth in volume is the highest and pretty well balanced, whereas in scenario 2 and 3 the growth is concentrated in only one of the two areas. These inter-regional differences can be explained by the differences in growth of the Gross Domestic Product of the diverse regions and the differences in the other characteristics as described above (spatial organisation, transport technology, and so on). In scenario 4 the growth of the transport volume is small in comparison with the other three scenarios. Reason for this is the increasing public awareness for environmental care, which leads to environmental friendly behaviour.

4 How to Asses Transport Figures in 2020?

This section aims to describe the calculation of quantitative transportation figures (in ton-kilometres and passenger kilometres for the various modes) for the year 2020 as an outcome of the four scenarios. This will form the input for the next step in the scenario development process. The information described in the previous chapters is used here as a starting point to calculate the transportation volume in 2020. Calculating this volume means not simply applying the various plusses onto the base data. The outcomes of the Worldscan model (CPB) (that is used to give a quantitative illustration of the globalisation scenarios, which form the input for the transportation scenarios) have to be taken into account (see CPB, 1999). These can be seen as a restriction to growth in transport and should not be forgotten. The following subsections will clearly describe the various steps made in order to determine the final figures. First, the growth in the volume of transport will be calculated following the Worldscan-data. This will be followed by an explanation of the allocation of plusses leading to volumes for each transport mode in 2020.

4.1 Growth in transportation

Calculating figures for the various transport modes would be easy if the growth figures for transportation would have been available. Unfortunately Worldscan does not contain these transport sector outcomes (our outcomes have to be consistent with the outcomes of this general equilibrium model used in an earlier stage of our research). So it is necessary to construct a link enabling us to relate Worldscan outcomes to the transportation data and scenarios. It is supposed that the GDP outcome and the growth in trade would be affective to growth in transport (also based on literature and Worldscan). It was suggested that there is a possible relation between the growth in GDP and the amount of transport. So the relationship between growth in GDP and growth in transport volume (varying over the various modes) has to be defined, e.g. one percent growth in GDP means X percent growth in transport volume for a certain mode over a certain period. When these figures are available we can allocate the growth to the various modes according to the plusses. First we will discuss the available growth figures in GDP. After this the growth in trade will be incorporated in the establishment of the growth factors.

In Table 7 an overview of the growth rates of GDP is given. This data is directly derived from Worldscan outcomes, presented in an earlier report (for more details and discussion see CPB, 1999). Only average annual growth rates between 1995 and 2020 are given by CPB. These outcomes are transferred into overall growth rates (accumulated growth) enabling us to calculate the overall growth in transport volumes in a next step.

TABLE 7: Average annual GDP growth rates and absolute overall GDP growth rates between 1995 and 2020 (in %)

Transport		Growth		Core Growth		Peripheral Growth		Sustainable Growth	
		Av.	Abs.	Av.	Abs.	Av.	Abs	Av.	Abs
Global	OECD	2.6	90.0	2,6	90.0	1.2	34.7	1.2	34.7
	Non-OECD	6.2	350.0	3,6	142.1	5.9	319.2	4.0	166.6

CPB, 1999

In order to define the relationship between growth in GDP and transport volume, literature is used as a guiding tool. Long-term transportation demand elasticities, as been used by Wohlgemuth (1997), provides useful insights. The following elasticities between income (consumer expenditures) and two transportation factors are presented below. It can be seen from Table 8 that the income effect on road transportation varies between 0,88 and 1,04. This indicates that a factor one (one percent growth in GDP is accompanied by a one percent growth in road transport) is not unusual.

TABLE 8: Long term transportation demand elasticities

	US/ income	Europe/ income
Distance travelled	0.88	1.04
Total freight (ton/km)	1.00	0.99

Source: Wohlgemuth, 1997

Another study (Raad voor Verkeer en Waterstaat, 1999) shows a decoupling (around 0,8) over 10 years for the Netherlands between growth of GDP and international goods transportation expressed in ton-kilometres (So factors between 1,5 and 0,5 for total transport seem reasonable).

Another aspect that has to be brought in here, is the growth in volume of trade as expected by the Worldscan model. The amount of transport depends, among others, on the amount of trade between countries. The following average annual growth in volume of trade can be derived from Worldscan (see Table 9, real trade expressed in US dollars compared with 1995 prices). It can be seen that especially in the Growth scenario there is large growth in trade due to large trade between OECD and non-OECD countries.

TABLE 9: Average annual growth in volume of trade between 1995 and 2020 (in %)

Transport		Growth	Core Growth	Peripheral Growth	Sustainable Growth
Global	OECD	5.6	3.1	2.5	2.4
	Non-OECD	8.6	3.2	6.0	4.0

Source: CPB, 1999

In establishing the growth factor (not to be confused with an elasticity), a distinction between the various scenarios and the scale levels is made. It can be expected that the factors will vary over scenarios and world regions, also due to growth in GDP and trade. The sustainable growth scenario, for example, is aimed at sustainability. It is therefore understandable to expect a relative decoupling between growth in GDP and the transport volume. Furthermore, one might assume that this decoupling would be stronger in OECD countries than in non-OECD countries because of earlier adaptation of new technologies. This clarifies the lower factors between prosperous and less prosperous regions. In addition, the trade figures suggest a higher figure in the Growth scenario compared to the others. Taking into account the foregoing aspects and based upon our own insights we derived the following factors, presented in Table 10 for the whole transportation sector (both passengers and freight). The figure 1.3 means here, for example, that the absolute growth in transport volumes is 30% higher compared to growth in GDP in OECD countries for the Growth scenario for this 25-year period. We will not make a distinction between modes and passenger and freight transport, as clear insights into this distribution are missing.

TABLE 10: Growth factors in the transport sector in the period 1995-2020

Transport		Growth	Core Growth	Peripheral Growth	Sustainable Growth
Global	OECD	1.3	1.1	0.7	0.6
	Non-OECD	1.2	0.8	0.9	0.8

The next step is to determine the overall growth in the transportation volume. This is done by multiplying the absolute growth figures (as presented in Table 7) with the factors from Table 10. The results are shown in Table 11. Herewith, growth in passenger and freight transport is determined. It can now be allocated onto the various modes, based on the outcomes of the various scenarios. This allocation will be explained in the following section.

TABLE 11: Absolute growth in volume of the transport sector (in %)

Transport		Growth	Core Growth	Peripheral Growth	Sustainable Growth
Global	OECD	117.0	99.0	24.3	20.8
	Non-OECD	420.0	113.7	287.3	133.3

4.2 Allocation of growth over the various modes

We now know the total growth in passenger and freight transport. The next step is the division of growth over the various modes of transport. We will use the same modes of transport as have been used in describing the scenarios. This means that passenger transport consists of air, road and rail, whereas freight transport is subdivided into air, road, rail, inland waterways and seabome shipping. The distinction between passenger and freight transport is necessary in the allocation of growth, since these are expressed in different units (passenger-kilometres and ton-kilometres).

In the following, the method used to determine the volume of the various modes will be explained by using an example. In addition it will be summarised in a mathematical formula. Two methods can be used to allocate the new numbers, keeping the scenario outcomes in mind. Firstly, one can allocate the total growth together with the starting values from 1995. Secondly, one can divide just the growth over the various modes. Here the second method will be used; only growth will be divided, as the plusses only deal with the growth during those 25 years.

The following simplified example will illustrate the method which will be applied on all our scenarios and data.

Q_{A0} = transported volume by air in 1995 Q_{At} = transported volume by air in 2020
Q_{R0} = transported volume by road in 1995 Q_{Rt} = transported volume by road in 2020
Q_{S0} = transported volume by rail in 1995 Q_{St} = transported volume by rail in 2020
Q_0 = total transported volume in 1995 Q_t = total transported volume in 2020
g = growth factor (as presented in Table 11)
A+= number of plusses according to the description in the scenarios (see Section 3)

For example, suppose that the total transported volume in 1995 is 3,5 million passenger-kilometres divided over the various modes. Air will grow with two plusses, road will not grow and rail transport is growing with one plus. Note that a plus means the relative growth with regard to the data in 1995. Growth will be 100%, so g is equal to 2. The total amount of transport in 2020 is then obvious, namely 7 million. The numbers that now need to be derived are Q_{At}, Q_{Rt} and Q_{St}. This is schematically shown in Table 12.

TABLE 12: Example of the calculation

Mode	Q_0 (0=1995)	Number of plusses (A+)	Q_t (t=2020)
Air	1 million	2	Q_{At}
Road	2 million	0	Q_{Rt}
Rail	0,5 million	1	Q_{St}
Total (Q_{t0})	3,5 million	3	7 million (g=2)

The following calculation scheme needs to be undertaken to identify the unknown variables, X being an unknown factor:

$$Q_{At} + Q_{Rt} + Q_{St} = Q_{A0}\,(1+ A^{+A}X) + Q_{R0}\,(1 + A^{+R}X) + Q_{S0}\,(1 + A^{+S}X) = (1+ 2X) + (2+ 0X) + (0,5 +0,5X) = g\ Q_{t0} = 7$$

From this, the value of the unknown X follows easily:
3,5 + 2,5X = 7
3,5 = 2,5X
x = 7 / 5 = 1,4
This means that: Q_{At} = 1+ 2,8 = 3,8 and Q_{Rt} = 2 and Q_{St} = 1,2.
As an illustration: in 2020 3,8 million passenger-kilometres will be flown, road traffic will not grow and rail traffic will be 1,2 million passenger-kilometres.

In a general mathematical notation the above exercise can be presented as follows (which can be applied on n modes, with Q being the transported volume in the base year and A^+ the number of plusses):

(1) $$\sum_m Q_{m,0} = Q_{t0}$$

(2) $$Q_{t,t} = g\ Q_{t,0}$$

(3) $$\sum_m Q_{m,0} A_m^+ X = (g - 1)\ Q_{t,0} = Q_{t,t} - Q_{t,0}$$

(4) $$Q_{m,t} = Q_{m,0} A_m^+ X + Q_{m,0}$$

(5) $$X = \frac{(g-1) Q_{t,0}}{\sum_m Q_{m,0} A_m^+}$$

From equation (5) it becomes clear what value can be assigned to x, as all the other variables are known. X can then be used to calculate the unknown values for Q (the various modes in 2020). This enables us to present all the values for the various modes expressed in passenger-kilometres and ton-kilometres. These outcomes will be shown in the next section.

5 Results for the Scenarios

The previous sections provided us with all the inputs necessary to present the final outcomes of the transport scenarios. First, an overview will be given of the data in 1995 that are used to calculate the values for 2020, divided between passenger transport and freight transport. Next, the same tables will be presented, but in this step with the estimated numbers for the year 2020.

5.1 Data in 1995

The following data are based on several publications, published by institutions such as the OECD, United Nations. It is very difficult to obtain a complete overview of these data, since statistics differ over the countries. Some only register national transport flows (origin and destination within one country), while others include also international and transit traffic (traffic that has origin and destination outside the country). For world totals this is very confusing. We tried to obtain data that include all traffic flows for 1995, because this gives the best indication with regard to their emissions. Although the data presented below may have some inconsistencies (concerning year and traffic), it is an overview of the most suitable data based on availability (e.g. some countries are not able to provide data).

TABLE 13: Data for freight transport (1995)

		Freight (billion ton-kilometres)					
		Air	**Road**	**Rail**	**Sea**	**Inland ww**	**Total**
Global	OECD	224^ **(1995)**	4,611*^ **(1996, 1997)**	**2,830" (1994)**	**17,865" (1995)**	1,007^ **(1997, 1996)**	**26,537**
	Non-OECD	70^ (1995)		**3,208"** (1994)	**14,617"** (1995)		**17,895**

* national + international transport
\# national transport
^ national + international + transit0 transport (= total)
*^ not clear, national, international and total numbers for different countries

Table 14 shows the 1995 data for passenger transport.

TABLE 14: Data for passenger transport (1995)

		Passengers (billion passenger-kilometres)			
		Air	**Road**	**Rail**	**Total**
Global	OECD	**1,702" (1995)**	10,112# (1997,1996)	785^* (1994)	**12,599**
	Non-OECD	543^ (1995)		**1,014""** (1994)	**1,557**

* national + international transport
\# national transport
^ national + international + transit0 transport (= total)
*^ not clear, national, international and total numbers for different countries

5.2 Results for 2020

In this subsection, the results for 2020 will be presented. By using the 1995 data and the mathematical notation as described in section 4, the estimates for 2020 are derived for passenger as well as freight transport for the four developed scenarios. The new data will be presented per scenario and per type of transport in the following tables. Whenever there is a 0 in the data table, this means that the suitable data (see Table 13 and 14) were not available; so new data could not be calculated.

TABLE 15: Estimated volumes for freight transport (2020)

		Freight (billion ton-kilometres)					
		Air	**Road**	**Rail**	**Sea**	**Inland ww**	**Total**
Scenario 1	OECD	**535**	**7,818**	**4,798**	42,718	**1,707**	**57,576**
	Non-OECD	**482**	**0**	**22,185**	**57,856**	**0**	**80,523**
Scenario 2	OECD	**516**	**7,627**	**6,531**	**41,236**	**1,665**	**57,575**
	Non-OECD	149	0	**6,854**	**3 1,234**	**0**	**38,237**
Scenario 3	OECD	310	**4,611**	**2,830**	**24,765**	**1,395**	**33,911**
	Non-OECD	314	0	**8,831**	**65,865**	**0**	**75,010**
Scenario 4	OECD	224	**4,611**	**3,460**	**21,844**	**1,007**	**31,146**
	Non-OECD	70	0	**6,963**	**3 1,729**	**0**	**38,762**

TABLE 16: Estimated volumes for passenger transport (2020)

		Passengers (billion passenger-kilometres)			
		Air	**Road**	**Rail**	**Total**
Scenario 1	OECD	5,209	20,532	1,594	27,335
	Non-OECD	3,361	0	3,644	7,005
Scenario 2	OECD	5,209	20,532	1,594	27,335
	Non-OECD	1,161	0	2,166	3,327
Scenario 3	OECD	4,098	10,112	1,890	16,100
	Non-OECD	3,113	0	3,413	6,526
Scenario 4	OECD	1,702	12,142	943	14,787
	Non-OECD	543	**0**	1,014	**0**

In scenario 1, the most striking changes are that freight transport in the non-OECD countries exceeds the absolute numbers of the OECD countries. For passenger transport, the non-OECD countries increased their share of the total world passenger transport. The 2020 data for passenger transport in scenario 2 are quite different from those for scenario 1 and also from the 1995 data. Reason for this is the stable growth in the OECD, while the growth in the non-OECD is declining. This results in increasing differences between the OECD and non-OECD, compared to the 1995 data. In scenario 3, it is the other way round; the non-OECD is growing fast, while the OECD countries show almost no growth compared to the 1995 data. The fourth scenario is a sustainable scenario. This means that various actions are undertaken to diminish the growth in transport. If these data are compared to the total data in other scenarios, the differences are clear. Although an absolute growth, compared to 1995, is to be seen, the total amounts for freight and passenger transport are substantial smaller than the total amounts in scenarios 1, 2 and 3.

6 Concluding Remarks

There is growing awareness that in the long term, the development of society is characterised by substantial uncertainties. This often makes a prognosis-based approach inadequate. Scenario analysis is increasingly being used in long-range policy research, since it provides a way of identifying future issues and problems for policy making in an environment of qualitative uncertainty. Scenarios can be regarded as descriptions of possible futures that seem plausible under different sets of assumptions and provide a background against which policy assessments can be made. Scenarios are important tools for strategic policy analysis, especially in situations where policy makers have too much biased and unstructured information. The transport sector forms one of those fields where policy makers have to deal with many uncertainties, as it can be influenced by many factors. Despite these uncertainties, policy makers are faced with the objective of achieving sustainable mobility and need to have insight in future developments.

This paper presented these possible future developments by sketching four global contrast images based on outcomes of earlier research. The outcomes for the transport sector, expressed in transported volumes for both passenger transport and freight transport, were first qualitatively described based on expected developments of several indicators. Developments in transport technology, spatial organisation, distance and modal split have impact on the transported volumes. This development was illustrated by indicators (+, 0, -) expressing the potential expected impact on modalities. These indicators formed the input for our attempt to obtain quantitative insight into the future development of the transport modes distinguished. First, the growth in total passenger and freight transport was assessed based on Worldscan outcomes and expert insights. Next, this growth was divided over the various modes based on the earlier mentioned division of indicators. In this way the quantitative numbers of transported volumes were calculated with the time horizon being 2020. It appears that all scenarios foresee a growth in transport volumes world-wide. In a next stage of our research, these outcomes will form the input for the calculation of emissions in the various scenarios.

The achievement of sustainable mobility based on the outcomes presented in this paper may seem difficult and will be confronted with several hurdles. But policy changes (e.g. tax reform) and (unexpected) technology developments offer possibilities to realise this objective. Policy makers are thus faced with formidable policy challenges to achieve the Kyoto objectives in the next 20 years.

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