TI 2000-102/3
Tinbergen Institute Discussion Paper

A Multi-layer Scenario Analysis for Sustainable International Transport

Barry Ubbels
Caroline Rodenburg
Peter Nijkamp

Tinbergen Institute
The Tinbergen Institute is the institute for economic research of the Erasmus Universiteit Rotterdam, Universiteit van Amsterdam and Vrije Universiteit Amsterdam.

Tinbergen Institute Amsterdam
Keizersgracht 482
1017 EG Amsterdam
The Netherlands
Tel.: +31.(0)20.5513500
Fax: +31.(0)20.5513555

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31.(0)10.4088900
Fax: +31.(0)10.4089031

A Multi-layer Scenario Analysis for Sustainable International Transport

Barry Ubbels
Caroline Rodenburg
Peter Nijkamp

Department of Spatial Economics
Vrije Universiteit Amsterdam
De Boelelaan 1105, 1081 HV Amsterdam
The Netherlands

Abstract
It is 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 gain insight into the future development of the transportation sector. It presents the development of the transport sector based on four globalisation scenarios. On three different scale levels (global, European and Dutch) four future images of the transportation market are constructed. The expected implications of these scenarios are mapped out in a clear description of the various relevant aspects, such as modal split and spatial organisation. In addition, this paper also provides empirical insight into expected transport flows of passenger (passenger kilometres) and freight transport (ton-kilometres) in 2020, based on data from 1995. It appears that globalisation leads in all scenarios and on each scale level to a considerable growth of transported volumes.

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 an essential element of 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 GNP is estimated to be between 4 and 6 per cent (OECD, 1993 and 1994). The contribution of transport for the Netherlands is estimated at around 8%, while for Europe as a whole this figure is around 7% (Geerlings, 1997). However, this figure underestimates the importance of transport, since the significance of this sector is perhaps better demonstrated by noting that no economic activity can flourish without transportation. Facilitating 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 influence developments in the transportation sector. The distance between production and (intermediary and final) demand is one of the factors determining the size of trade and respectively the demand for transport. Because globalisation affects the volume of consumption, production and the place of production, it has considerable impact on the volume of transport. Other influencing factors include the role of transport policy, but also non-transport policies and societal changes will have an impact. The increasing attention on market incentives in general and the move towards harmonisation (a recent policy trend of the European Union) are aspects that may have 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 gain insight into the future developments of the transportation sector in 2020 on various geographical scale levels caused by globalisation. First, four possible developments of globalisation were designed by applying a scenario approach. These global scenarios on the future development of the economy were developed in an earlier phase of the GITAGE research and discriminating on several economic variables[1]. These future developments of the global world form the input for the transport scenarios, elaborated on three scale levels (global, European, Dutch) in this paper. Outcomes of the assessment of these globalisation scenarios made on the basis of the Worldscan model of the CPB (Dutch Central Planning Agency) are used as input for establishing the transport scenarios (see CPB, 1999). We will not only describe scenarios; their consequences will also be expressed in 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 (see Olsthoorn, 2000). Transport movements can have substantial effects on environmental quality. The intensity of transport, the distances and the used modes of transport can have immense environmental impact. This is an extremely important challenge since all countries have committed themselves to the Kyoto agreement with the aim 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, and some theoretical aspects will be discussed as well.

[1] Referred to as Globalisation, International Transport and the Global Environment (GITAGE). In a first phase four globalisation scenarios were developed, the consequences for transport were translated into transport scenarios as being one of the tasks of this project funded by NWO (The Netherlands Organisation for Scientific Research), see also van Veen-Groot *et al*, 1998.

Also, the four global scenarios will be subsequently described using a common structure. Section 3 will explain how we will arrive at transport outcomes for 2020. Consequently, the subsequent section will briefly present the current situation in transport, and thereafter the results for 2020 will be outlined. This paper will close with some concluding remarks made in Section 5.

2 Globalisation

Globalisation refers to the broad area of increasing internationalisation of markets, changing consumption patterns and shifting industrial activities all over the world. Here this term is interpreted as the growing economic interdependence of countries world-wide through the increasing volume and variety of cross-border transactions in goods and services and of international capital flows and also through the more rapid and widespread diffusion of technology (CPB, 1999). It affects capital flows, trade patterns and location choices of firms at a global and regional level. It could result in a drastic shift of production activities to specific regions. Moreover, increasing linkages between regions could affect the dissemination of new technologies and consumer preferences.

One way to deal with the (uncertain) impacts of globalisation is to construct several scenarios. The construction of these future images can be a useful tool for exploring the uncertain future. In the context of GITAGE, the globalisation issues are identified in four scenarios. These address in various ways the process of globalisation, its effects on the various regions, political cooperation between regions, the pace of technological progress (see Nederveen et al., 1999), changing consumption patterns, and developments in the transport sector. The following will shortly outline each constructed globalisation scenario. Based on an identification of driving forces behind globalisation (by making use of the Delphi technique among several experts) the global scenarios were constructed. This led to a geographical distinction between OECD and non-OECD countries. The scenarios are in such a way composed that they describe developments in both areas. Below, the four identified globalisation scenarios will shortly be described, see for a complete overview Veen-Groot et al., 1999 and CPB, 1999).

In the *Schumpeterian* scenario, the high and accelerating speed of technological development is the most important force behind globalisation. Strong competitiveness and internationalisation of business are essential elements in this dynamic process, leading to high economic growth in nearly all regions in the world economy. Economic systems are increasingly market-oriented, induced by a strongly liberalised international trade. This scenario predicts favourable circumstances for high growth in OECD as well as non-OECD countries.

In the *Malthusian* world, the OECD economy flourishes while non-OECD countries lag behind. This leads to strong polarisation between these regions. The prosperous economic situation in the OECD is the consequence of high technological progress and the liberalisation of trade and capital. In non-OECD countries, unstable political systems, overpopulation and low incomes stimulate large migration flows towards the OECD countries.

The third scenario, the *Developing* world, foresees strong economic centres in the non-OECD countries. In this scenario, growth will for the greater part take place in the non-OECD countries (at high environmental costs) instead of the OECD countries. This happens mainly as a result of liberalisation of goods, services and capital markets, and market oriented and outward looking government policies. The non-OECD countries go further in opening up and strengthening markets. Trade blocks will arise as a result of liberalisation of trade and finance and the adoption of free market principles. On the other hand, the OECD countries are confronted with low economic growth rates caused by a limited availability of resources,

labour shortage, and slow technological progress. In the end, the developing countries catch up with the developed ones.

Fourth is the *Ecological* scenario in which the qualitative and non-material aspects of life are more important. The emphasis is on happiness, the local environment and efficiency rather than an increase in income and the physical amount of goods. Norms and values are heading towards more awareness of environmental problems. Production and consumption are localised instead of internationalised.

These globalisation scenarios form the input for the transport scenarios outlined in the next section. Herewith use has been made of the quantification of these global scenarios carried out by the CPB (CPB, 1999). The Worldscan model has been used which is a good tool to analyse scenarios in which trade and trade liberalisation and differences between regions are important. The quantitative outcomes were important in order to establish transportation flows in the future (see Section 4).

3 Transport scenarios

This section presents the different transportation scenarios. There are scenarios on a global, European and national (Dutch) level. The construction of these scenarios will give insight into the future developments of the transportation sector. It is important to bear in mind that the foreseen developments in transport are directly derived from those global scenarios. Following these scenarios a distinction has to be made between two regions (OECD versus non-OECD on a world scale). This given fact led to the decision to maintain the distinction between two geographical areas also on a lower scale level (for reasons of consistency). As a consequence in the description of transport scenarios, distinctions have been made on a European level (EU (members of the European Union (+ Iceland, Norway and Switzerland) versus non-EU) and on a national level (Randstad (the Western part of The Netherlands) versus non-Randstad). This division down to a Dutch level may seem difficult as globalisation might have the same consequences for both identified areas. But in The Netherlands a strong economic distinction is recognisable between the core region (Randstad, where most of economic activity takes place) and the more peripheral zone (non-Randstad). Globalisation might have different impacts although we are aware that the size of difference (between Randstad and non-Randstad) is smaller compared to the other levels. This reason (and consistency) made us maintain the division of two regions also on a Dutch level.

We have chosen to describe the scenarios in terms of transport flows (enabling us to establish emission results of transport in a following stage). Each scenario ends with an overview of changes in transported volumes (expressed in ton-kilometres for freight transport and passenger kilometres for passenger transport within a geographical area) as the main result. In order to describe changes in transport volume properly, four main aspects of transport form the background of the scenario descriptions: spatial organisation, distance, technological development and modal split. Changes in these aspects are likely to have impact on growth in transport (see also other scenario studies in this field such as Ministry of Transport, 1998 and Rienstra, 1998). These indicators formed the basis of the scenario description and resulted in an overview of (expected) impacts on transported volumes. The tables at the end of each subsection are filled with indicators (+, 0, -) expressing the potential expected impact on transported volumes of the various developments described in the scenarios (and thus based on changes in the four aspects). The scenarios are caused by global developments, therefor we minimised policy interference.

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 indicate that it is expected that the volume of goods or persons (expressed in ton-kilometres and passenger-kilometres) transported by a certain mode within a certain area will grow compared to the reference situation. As a

consequence, double plus means that a stronger positive development is expected. It is important to bear in mind, however, that the plusses do not necessarily have the same meaning for the various scenarios or within scenarios. They can only be regarded as indicators of a positive or a negative development (in case of a minus). In the description here, a zero 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.

The following subsections will give a compact description of the various transport scenarios resulting in changes in transport volumes. The starting point will be the global level, followed by the European and Dutch scenarios. For a more broad and concise overview we refer to Nijkamp et al. (2000).

3.1 Global transport scenarios

3.1.1 Global Growth

This scenario assumes a high level of economic growth in both OECD and non-OECD countries. A second assumption is that speed and flexibility of transport will not suffer from any barrier. All these expected developments, mainly as a result of the high economic growth, will support growth of the transport sector.

The spatial organisation largely will be left to the market and will result in 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.

An assumed effect of the trend towards globalisation of production and consumption is an increase in the average distance covered by the various transport modes in both geographical blocks. 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, especially in the non-OECD.

The implementation of new technologies in combination with high economic growth rates will facilitate a considerable growth in mobility and transport. At all levels governments aim at stimulating economic growth and transport is considered necessary for this. Progress of new technologies is expected to be somewhat faster in non-OECD countries so they can catch up with OECD countries. Worldwide 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 possibilities, such as shopping and leisure.

This scenario projects a continued increase in freight transport concerning volume, speed and distance, especially for air and sea transport. With regard to passenger transport, we would expect 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. The developments described above, based on the main aspects (transport technology, spatial organisation, distance and modal split), form the basis for forecasting the development in terms of volume (ton- and passenger-kilometres), as shown in Table 1.

TABLE 1: Expected changes in transported volumes for Global Growth

		Volume	
		OECD	Non-OECD
Freight transport	Air	++	++
	Road	+	++
	Rail	+	++
	Seaborne shipping	++	+
	Inland shipping	+	+
Pass. transp.	Air	++	++
	Road	+	++
	Rail	+	+

Source: Nijkamp et al., 2000

3.1.2 Global Core-growth

The difference in development between the two areas will affect the transportation sector. Within the OECD-sector a concentration of trade and transport will occur, whereas trade between those two blocks is decreasing. As the economic progress is situated among OECD countries, demand for transport is high in these countries. Consequently, this leads to increased flows in freight and passenger transport. There is only a modest demand for transport in non-OECD countries, and therefore for some modes a relatively small increase of volume.

There is only limited international trade, also due to restrictions in import and foreign investments. Transportation networks in OECD countries 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, mainly due to the non-market orientation and inward orientation of the government policies.

In a growing economy, as expected in the OECD countries, there is often progress of new technologies too. Especially air and rail technology will improve the current achievements of these sectors and become more important. As for passenger traffic, technological development will support the introduction of high-speed rail and thereby take over parts of the short distance air transportation market in 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 for transportation of people. Non-OECD countries will rely heavily on more conventional transport modes and techniques. Road transport retains its dominant position, mainly due to 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 transport the majority of goods and to cover the new routes and reach new destinations. Technological progress will play an important role in facilitating this development, which will not be disseminated to non-OECD countries. As a result non-OECD countries will rely on already available transportation modes and techniques. Road transport is still the dominant mode for passenger and freight transport in both OECD and non-OECD countries. Table 2 shows the expected relative changes in transported volumes.

TABLE 2: Expected changes in transported volumes for Global Core-growth

		Volume	
		OECD	Non-OECD
Freight transport	Air	++	+
	Road	+	+
	Rail	++	+
	Seaborne shipping	++	+
	Inland shipping	+	+
Pass. transp.	Air	++	+
	Road	+	+
	Rail	++	+

Source: Nijkamp et al., 2000

3.1.3 Global Peripheral Growth

In this scenario, growth will for a greater part take place in the non-OECD countries (at high environmental costs). The trend towards globalisation of production and consumption causes an increase in the average travelled distance, mainly attributed to non-OECD countries. Goods will be transported to a greater extent within the OECD and non-OECD regions, rather than between them.

In this scenario, non-OECD countries will implement technologies imitated from OECD countries, which are still far ahead in terms of transportation technology. This means that more efficient transport can take place (for passengers as well as freight) and that the use of ICT will increase in non-OECD regions. The OECD countries are losing their lead, since there is no incentive for technological development due to the restrained economic and political situation. They 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 stimulate growth of transport by road, air, and shipping. Transport by sea and air will benefit from new available techniques and the liberalisation of trade. In OECD countries, on the other hand, there is medium growth in air and shipping.

The share in world production of the non-OECD doubles from about 25% to nearly 50% (CPB, 1999). Global convergence of consumption patterns occur, which will lead to a rise in covered distance by the various modes. These changes in technology (see above) and spatial organisation have an impact on transported volumes of goods and passengers. Because of the catching up of non-OECD countries with the OECD, their transport volumes show an overall increase for both passengers and freight. There are, however, some variations between the various modes: road use will remain dominant by far, although sea and air transport will benefit from the liberalisation of trade. Their transported volumes will increase but slightly less compared to road (and sea even more than air). Rail transport will grow, but far less. In OECD countries, volumes will not increase that much, in contrast to the previously described scenarios. Road transport remains the dominant mode expressed in volumes, especially in terms of freight. Table 3 shows a complete overview of changes in transported volumes.

TABLE 3: Expected changes in transported volumes for Global Peripheral Growth

		Volume	
		OECD	Non-OECD
Freight transport	Air	+	++
	Road	0	+++
	Rail	0	+
	Seaborne shipping	+	++
	Inland shipping	+	+
Pass. transp	Air	+	++
	Road	0	++
	Rail	+	+

Source: Nijkamp et al., 2000

3.1.4 Global Sustainable Growth

This scenario focuses on sustainability and the environmental quality in society. This puts restrictions on the use of transport. As a consequence, there is only modest trade between various continents; there are not many incentives to eliminate trade barriers. This also limits the incentives for technological development in the transport sector (CPB, 1999). Transportation is 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. The covered distances will decrease to some extent. The reason for this is the decrease in the use of leisure transport, due to steep prices.

In this ecological scenario, the focus is on environmentally friendly technology forced by ecological awareness. The OECD countries will export environmentally friendly technology to non-OECD countries. 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 an absolute sense, the progress of new technologies is expected to be even faster in non-OECD countries so that they will catch up with OECD countries. 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 speed of introduction. Most improvements are to be expected in the rail market; especially the performance of freight rail (currently having a poor performance rate) can be increased (see also Nederveen et al., 1999).

Concerning passenger traffic, technological development will support the introduction of high-speed rail and take 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. In general a movement can be seen from the use of individual modes towards the use of collective transport modes, which means that public transport will benefit from this trend.

In relation to freight transport, the use of seaborne shipping will increase, since ports will become more important. Rail transport also will become 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 for short distances, it is used increasingly, although in a restricted manner (within certain boundaries and congested areas) and more efficiently (technology push). Air transport will stabilise 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. The changes in volume are presented in Table 4.

TABLE 4: Expected changes in transported volumes for Global Sustainable Growth

		Volume	
		OECD	Non-OECD
Freight transport	Air	0	0
	Road	0	+
	Rail	+	+
	Seaborne shipping	+	+
	Inland shipping	0	+
Pass. transp	Air	0	0
	Road	+	+
	Rail	+	0

Source: Nijkamp et al., 2000

3.2 European transport scenarios

The above mentioned developments on a global scale have implications for a European level. Consequently developments in the OECD will have similar implications for transport in EU countries, the same holds for non-OECD countries and the non-EU. Nevertheless, there are differences, which are only to be seen on this continent. To give an example: a scenario might give a push to the HST-developments which might have a large impact in Europe. So, the contents of the scenarios might show some resemblance as again the same global scenarios form the input.

3.2.1 European Growth

This scenario assumes high economic growth rates in EU as well as non-EU countries. Production and consumption takes place on a European scale, resulting in a rise in transport flows within Europe. The non-EU countries should open up to allow foreign goods and foreign investment. By opening up, the dissemination of technologies from Western Europe will be accelerated. European countries will grow towards each other and closer economic integration between rich and poor countries will result. Finally, the distinction between non-EU and EU will become weaker and expansion of the EU will become realistic. Because of the 'Europeanisation' of production and consumption, it is likely that the average distance covered by the diverse transport modes will increase. The economic growth in non-EU countries will lead to a convergence of consumer preferences towards the EU (CPB, 1999).

The progress of new transportation technologies in combination with high economic growth rates will cause an increase in mobility and transport throughout Europe. Since transport is assumed to be necessary to accomplish economic growth, national governments will stimulate the construction of public infrastructure. Especially the introduction and expansion of high-speed rail will have its impact and will cause a shift between transport modes. There are improvements to be expected concerning fuel and engine technologies in road transport, but these will not have a significant impact on the use of the car as a means of transport. There will also be a trend towards intermodal transport. Because of the growing volume of transport flows, other/new transportation systems will be used to transport larger quantities of goods and to cover the new routes, as well as reach new destinations.

As a result of the prosperous economic situation in Europe, more expensive (but faster) transport modes will become more generally used. For passenger transport, this means that air and high-speed rail transport will be more widely used, and form a substitute for road transportation, mainly in Western Europe. For freight transportation, an increase in performance is to be expected, and with the progress in transport technology, freight transport by rail will benefit from this development.

International specialisation, together with the trend towards 'Europeanisation', will lead to increased flows in freight transportation. In passenger transport, growth also is foreseen.

Due to the rise in income, people will make more trips for consumption reasons, including leisure and shopping. This, together with the growth in production will lead to increased transport volume: more people have to travel to work, education and training.

The development of Trans European Networks (TEN's) will influence the spatial organisation in Europe since transport flows will concentrate on specific infrastructures, e.g. road and rail transport. As a consequence, transfer points in these networks will develop into large mainports, having the latest technology at their disposal. High-speed networks for rail transport will especially be implemented in the EU countries. The nodes in the TEN's will become the focal points of economic growth, production and population.

TABLE 5: Expected changes in transported volumes for European Growth

		Volume	
		EU	Non-EU
Freight transport	Air	+	+
	Road	++	++
	Rail	+	++
	Seaborne shipping	++	+
	Inland shipping	+	+
Pass. transp	Air	+	++
	Road	+	++
	Rail	++	++

Source: Nijkamp, et al., 2000

3.2.2 European Core-growth

This scenario assumes that Eastern European governments are not able to pursue market oriented and outward oriented policies. The political situation is unstable and leads to an introspective attitude in contrast to the EU development where high economic progress exists, resulting in a strong European Union. The EU will succeed in reducing missing links, e.g. completion of the Trans-European networks. Apart from efficiency goals, new infrastructure links are built to ensure cohesion in the EU space (equity). As the non-EU countries are inward oriented and unwilling to participate, they will not be included in these networks.

Airports will expand in the booming regions, since air transport will be far more efficiently organised, mainly facilitating intercontinental transport. Consequently, mainports will become crucial, acting as intercontinental, national and regional points of transhipment where different transport modes meet up. Economic activities will take place in and around these mainports and new techniques will be used to support the development of these transfer points. The development of networks in Eastern Europe lags behind, mainly due to the inward orientation of government policies, and there is no real spatial concentration of activities.

The covered distances for goods and passengers will increase within EU countries. The kilometres covered by air transport will show the fastest growth in freight transport, followed by the kilometres covered by passenger rail transportation. The distance covered by road transport is growing too, but to a lesser degree because of the technological development of other logistics in commuter transport. In Eastern European countries, road transport will flourish as a result of the lack of other innovative transportation.

The technological progress is one of the driving factors behind the economic growth in EU countries. Especially air and sea transport technologies will improve in these sectors. New ICT techniques will facilitate the efficient operation of high-speed rail networks. Air transport, in turn, will improve in efficiency because of new radar systems and improved communications. Technical progress will also take place in the motorcar system but will solely relate to a lower consumption of fuel. Electric cars will improve, but a major breakthrough is not anticipated. Eastern European countries will rely on already existing techniques. New techniques will be imported from other countries but on a small scale.

As a result of economic growth, more expensive (but faster) transport modes will become available for a wider public. This means that, for passengers, air and high-speed rail transport will become more popular compared to road transport. Freight will be organised more traditionally in the EU; road networks remain dominant, although the use of inland waterways increases. In terms of long distance freight transport, sea shipping and air transport become dominant supported by the development of networks and mainports. The demand for transport is paramount in the economic progress of the EU, leading to increased flows of freight and passengers. Eastern Europe has no flourishing trade. Governments do not stimulate infrastructure investments so they will still be mainly dependent on road transport.

TABLE 6: Expected changes in transported volumes for European Core-Growth

		Volume	
		EU	Non-EU
Freight transport	Air	++	+
	Road	+	+
	Rail	+	0
	Seaborne shipping	++	+
	Inland shipping	++	0
Pass. transp	Air	+	0
	Road	++	+
	Rail	++	0

Source: Nijkamp et al., 2000

3.2.3 European Peripheral Growth

In the first two scenarios, a rosy picture of the EU countries was described. In this scenario, however, the emphasis will be on Eastern Europe (the non-EU countries). The EU does not manage to generate important technology breakthroughs, which enables Eastern Europe to make up arrears on the basis of existing conventional technologies. This means that mainly the energy-intensive technologies from the EU countries will be copied, due to the lack of energy-saving innovations in non-EU countries. As a result, the demand for energy will rise substantially, resulting in an increase of emissions (Van Veen-Groot et al., 1999).

The EU countries will face a drop in economic growth, caused by a limited availability of resources and a slow-down in the progress of technological development. The Eastern European trade blocks will make sure that the main point of trade and transport shifts from the EU towards Eastern Europe. Moreover, they will start to develop their own networks, enabling them to meet the growing demand for goods and transport. As a result of the prosperous economy and growing trade in Eastern Europe, the demand for goods and passenger transportation as well as the covered distance will rise. In Western Europe, the growth will be lower, due to the unstable economic situation.

New technologies will not be invented because of the restrained economic situation in the EU. Non-EU countries will copy existing innovations and technologies from the EU before introducing their own. The attention of non-EU countries will mainly be on bigger and more luxurious road vehicles, which will have a negative influence on the environment. Improvements in air transportation are also to be expected, mainly because of the updating of current fleets to further ensure the safety of passengers. In rail transportation, there will be a change from fuel trains to electric trains.

Some major changes in modal split are to be foreseen. In Eastern Europe, the more expensive and faster transport modes will become available to a wider public. This means that a modal shift will take place from road passenger transport to rail, and especially air transport. Major investments will be made in rail infrastructure, so that trains can use double instead of single tracks, resulting in an increasing number of passengers, since travelling by train is becoming far more convenient and efficient. However, the main growth is to be expected in

road transport, being the transport mode with most capacity and lowest costs. It is also the mode that requires least effort in expanding, and meets the growing demand for transport of goods and passengers. EU countries will show a medium growth in air and shipping because of the strong trend towards these transport systems and the lower tendency towards road transport.

Due to the economic situation in Eastern Europe, the demand for goods will rise. Consumers in non-EU countries will change their consumption patterns in line with that of EU countries. This means that more goods will have to be transported, most likely over larger distances. In Eastern Europe, passenger transport is likely to increase as well. In Western Europe, the volume of transport flows will stay more or less the same.

TABLE 7: Expected changes in transported volumes for European Peripheral Growth

		Volume	
		EU	Non-EU
Freight transport	Air	+	++
	Road	0	++
	Rail	0	+
	Seaborne shipping	+	+
	Inland shipping	0	+
Pass. transp	Air	+	++
	Road	0	+
	Rail	0	++

Source: Nijkamp et al., 2000

3.2.4 European Sustainable Growth

In contrast to the previous scenarios, this scenario concentrates on the environment. Environmental quality within Europe is regarded as the driving force. Economic growth is not neglected but is only important within the constraints of wellbeing and (environmental) quality of life. Society as a whole is aware of the need to create a sustainable development.

Production and consumption continue to take place mainly in the EU. While local transport between regions predominates, development of the European-wide road networks stagnates. Trains will takeover long distance travel and collective transport grows. Especially rail/sea and air/sea movement will grow. Seen from this perspective, harbours and mainports will largely affect the efficiency of multimodal transport and are vital in this development.

All over Europe, one can see that transport distances will remain stable and transport flows will be bundled. Air transport may retain its share as it is mainly used for international travel and long distances. Within Europe, passenger rail transport will take over distances that were formerly covered by air transportation. For the transport of freight, the same holds true for inland and sea shipping. Road transport will also lose part of its share (more in passenger than in freight transport) because private transport will become more expensive.

This scenario foresees an important role for technological development in realising a more sustainable society. Growing environmental awareness will accelerate the acceptance of new, less polluting, applications, often aimed at energy efficiency. The EU will export its technology to non-EU countries. Innovations affecting road transport will be higher in Eastern Europe than in the EU as the latter already own cleaner cars and trucks. In the EU more attention will be paid to energy efficient techniques and the application of new telematics (e.g. dynamic route information) to increase capacity of existing infrastructure. Innovations in logistics will improve multimodal transport and give a push to the transportation of freight by rail and water. Railway and urban public transport will expand because of improved technological developments and increasing capacity of existing infrastructures. Environmental awareness will also be expressed by growth in collective transport modes in both EU and non-EU countries. The use of public transport (improvements in service and infrastructure) will

grow in densely populated areas and bigger cities. Individual transport will lose market share and become less important. The growth of air passenger transport will be limited because of the construction of subsidised HST tracks all over Europe. In order to save the environment and to overcome resistance from society, the HST is mainly using upgraded tracks. Seaborne shipping and inland shipping will become more important as multimodal transport is carried out more efficiently because it is regarded as environmentally friendly.

In this environmental scenario, transportation will change as it is generally seen as a significant contributor to the environmental problems in the society. It is anticipated that technology will help in reducing these negative effects and create a shift towards cleaner modes. Modest growth in transport is expected which is caused mostly by the modes water and rail.

TABLE 8: Expected changes in transported volumes for European Sustainable Growth

		Volume	
		EU	Non-EU
Freight transport	Air	+	+
	Road	0	0
	Rail	+	+
	Seaborne shipping	++	+
	Inland shipping	++	++
Pass. transp	Air	0	+
	Road	0	0
	Rail	++	+

Source: Nijkamp et al., 2000

3.3 Dutch transport scenarios

3.3.1 Dutch growth

The Netherlands benefits from an economical point of view optimally from globalisation. High growth rates throughout the country are typical for this scenario. In addition to the progress of technological development (aimed at facilitating economic growth), this causes a rise in demand for mobility and transport. The Dutch mainports benefit from the expansion of the infrastructure network, since they act as the most important transhipment points for different modes of transport. By stimulating growth of the mainports, intermodal transport will show an increase as well as international transport by air and high-speed rail.

In the process of globalisation tendencies in the field of commerce, production, knowledge and ICT, Europe plays the role of catalyst, thanks to the economic integration of Europe. The Dutch economy grows faster than the European average, thus increasing the importance and influence of The Netherlands within Europe. The Netherlands will start to co-operate more intensively with neighbouring countries. Reason for this development is the strong position of the Belgian region Antwerp-Brussels-Gent and the Ruhr area in Germany.

As a result of the strong economic growth and new technologies in The Netherlands, it is likely that the average mobility and the consumption level of Dutch people will increase since people will have higher incomes. With this, the average distance covered by the diverse transport modes will increase for both passenger and freight transport.

Technological developments in The Netherlands result from the strong economic situation. Most improvements are to be expected in the field of rail transport. The introduction and expansion of the high-speed rail network will have its impact and will cause a shift between the diverse transport modes for passengers. The main impact is that people will be inclined to live further away, e.g. in the northern part of The Netherlands, and use the high-speed train to go to work. Public transport will improve and be more efficiently organised due

to new techniques, but it will still be unable to compete with individual transport. Concerning road transport, growth can be expected. Mainly due to the individualisation of people, the individual motorised transport mode is by far the most intense used type of transport. Cars and trucks will still be polluting and technology is more aimed at convenience of transport than at energy efficiency of vehicles. For freight transport, the use of transport by air and sea will grow, since Schiphol airport and Rotterdam harbour are expanding. The Netherlands will grow in distributing goods to the rest of Europe. Especially for freight transport within Europe, the use of air transport will be chosen more often. Road transport remains dominant and most widely used by transport companies.

Because of the strong mainport position of Schiphol airport and Rotterdam harbour, more terminals are needed to facilitate growth. These terminals will be equipped with the latest technologies to attract and process the diverse transport modes and flows. Multimodal transfer points come into existence, often in combination with commercial activities as shopping centres and parking garages.

TABLE 9: Expected changes in transported volumes for Dutch Growth

		Volume	
		Randstad	Non-Randstad
Freight transport	Air	++	+
	Road	++	++
	Rail	+	++
	Seaborne shipping	++	+
	Inland shipping	+	++
Pass. transp	Air	++	+
	Road	++	++
	Rail	++	++

Source: Nijkamp et al., 2000

3.3.2 Dutch Core-growth

In this scenario the Randstad (the core region) is growing faster than the non-Randstad area. The mainports benefit from the globalisation and the liberalisation of trade in OECD and EU countries. The rising demand for goods and transport causes an increase in transport flows through The Netherlands. Rotterdam harbour as well as Schiphol airport will benefit from this expansion. Because of this mainport-growth, intermodal transport will show an increase, as will international air and high-speed rail transport. Activities concentrate in the core area, especially around the mainports. The peripheral area will only benefit partially from this growth.

The separation of The Netherlands in two parts will be strengthened in this scenario. The main economic activities take place in the Randstad, whereas the non-Randstad area lags behind. The northeastern part will even be more ‘isolated’ than it is nowadays, whereas the southeastern part is not able to attract important industries. The Randstad is regarded to be the engine of the economy with the two mainports as boosters. This will attract all kind of new industries and have a negative impact on living conditions. People want to live just outside the core and commute into the Randstad where they work. The amount of ton-kilometres covered will increase, thanks to the increasing demand for goods (a result of the prosperous economic situation) and the improvements in infrastructure. The importance of the mainports determines the spatial developments in infrastructure to a large extent.

Innovations in technologies only take place in the Randstad region, mainly in the field of transport technologies to support and stimulate the position of both mainports. Schiphol and Rotterdam will be equipped with new technological innovations improving the efficiency of handling of goods. In the non-Randstad, innovations hardly take place, as there is no substantial economic development. In passenger transport the use of high-speed rail increases,

being a convenient and fast transport mode between Amsterdam, Rotterdam, The Hague and Utrecht. Public transport becomes important in a congested Randstad to serve the underlying network. Technology makes it possible to operate an efficient light rail network in the Randstad.

Some changes in modal split take place in this scenario. In an absolute sense, the kilometres covered by road are increasing. In relative sense, however, the covered distance will decrease as a result of the pricing measures of the government and the introduction of comparable alternatives such as high-speed rail and Randstad rail. This causes an increase in passenger-kilometres covered by rail transport. With the expansion of Schiphol airport, more destinations and carriers become available, causing a rise in the use of air transport.

The construction of separate lanes for trucks contributes to a large extent to the growth in ton-kilometres. On the other hand, new distribution techniques will decrease this growth. Inland shipping and rail will also carry out some transport, as Rotterdam will have good transport infrastructure at its disposal to distribute goods. Schiphol will rely on road transport concerning freight.

TABLE 10: Expected changes in transported volumes for Dutch Core-growth

		Volume	
		Randstad	Non-Randstad
Freight transport	Air	++	0
	Road	++	+
	Rail	+	0
	Seaborne shipping	++	0
	Inland shipping	+	+
Pass. transp	Air	++	0
	Road	++	+
	Rail	++	+

Source: Nijkamp et al., 2000

3.3.3 Dutch Peripheral Growth

This scenario is the opposite of the rosy situation described in the previous scenario for the Randstad. As a result of the decline of Western Europe as a centre of gravity, The Netherlands has to give up its strong mainport and distributing position. In this scenario, the Randstad is a region in which there is economic growth, but not as much as in the intermediary zone and more peripheral region. The government stimulates the development of the more peripheral region by creating a favourable climate of establishment for firms, for instance by offering attractive locations to firms in this region. The size of the flows of goods changes relatively, but in an absolute sense they are still growing. This is mainly the result of the development of the eastern part of the country that is connected to Germany and part of the German transport network.

Industrial areas are located around the country but concentrated along corridors. The mainports are still important suppliers to the transport flows along these corridors, but their role compared to other European mainports is diminishing. Regional points of transfer will grow and become local centres of economic activities. The smaller, regional airports located outside the Randstad will become more important.

The distance covered by the diverse transport modes is growing, mainly as a result of the increasing economic activities in the non-Randstad region. The decrease of distance covered in the Randstad is not enough to compensate the growth in other areas. The main part of the growth is a result of the inclusion of the eastern part of The Netherlands in German transport networks. This counts for the transport network of both freight and passengers.

Technological improvements mainly take place in the non-Randstad as the focus of the government is on the development of this region. The few transport-related innovations that

take place will mainly be in the field of transport networks for different transport modes. Especially the rail network for passenger transport will benefit from this.

This scenario shows some changes in modal split. The use of air transport increases in the non-Randstad since there is growth in the use of regional airports; they enlarge their market share at the cost of Schiphol. In rail transport, a rise is to be seen in the more peripheral regions. A shift towards market intervention in rail transport leads to far more efficient connections, causing a substantial increase in the use of rail transport.

The use of seaborne shipping decreases, since Rotterdam harbour will loose its position as one of the most important players in the European mainport network. There is a substantial increase in the importance of Delfzijl harbour as a centre of gravity in the European network. The use of inland shipping increased to supply the new densely populated areas in the eastern part of the country. The overall transported volume increases in this scenario. The demand for transport is high in the non-Randstad as a result of the government stimulation of the development of industrial areas and transport networks. In the Randstad, volume does not rise that much. It is still slowly growing, but not as much compared with the previous scenarios.

TABLE 11: Expected changes in transported volumes for Dutch Peripheral Growth

		Volume	
		Randstad	Non-Randstad
Freight transport	Air	0	+
	Road	+	++
	Rail	0	+
	Seaborne shipping	0	0
	Inland shipping	+	++
Pass. transp	Air	0	++
	Road	+	++
	Rail	+	++

Source: Nijkamp et al., 2000

3.3.4 Dutch Sustainable Growth

Sustainable growth is the main driving force in this scenario. Citizens and firms are conscious of the fact that their behaviour directly influences the ecological and social wellbeing of the world. Firms implement new (sustainable) technologies as the focus is on sustainable development to remain ahead of their competitors. The strong social environmental awareness makes the distribution function of The Netherlands less prominent, although it is still present as the country has a favourable geographical position.

In order to decrease the physical transport of goods, the government stimulates spatial concentration of functions. The demand for new houses and industry locations requires the development of new cities in the vicinity of and along the corridors between existing cities. The new urban areas form spatial concentration points and important transport junctions.

As a result of the emphasis on the ‘quality of life’, the movement patterns of persons and goods will change. People are more aware of the impact of transport on the environment, so they try to use more environmentally friendly transport, e.g. public transport. People cover the distance between home and work three times a week at most so the average distance covered in passenger kilometres decreases. Nevertheless, the demographic growth annuls this decrease, and results in a small net increase. For goods, transport is mainly bundled, which leads to a decrease in the number of movements per product. The relative importance of Rotterdam as a port of transhipment decreases, since the accent moves to value added logistics.

The technological development in The Netherlands is enormous and almost completely devoted to the environment. The government will only accept new technologies if they give a substantial contribution to the solution of environmental problems. Improvements are to be

expected in the field of environmentally friendly modes such as rail transport. The introduction and expansion of the high-speed and light-rail network will cause a shift between the diverse transport modes for passengers. Mainly the international flights will be taken over by high-speed rail transport.

Infrastructure networks for freight transport will be used more efficiently and junctions will be optimised. Since flows of goods are more and more bundled, points of transhipment are utilised with the latest technologies. In rail transport, there is a development towards the use of rail shuttles and road trains with automatic guidance. Telematics will be widely implemented and used, offering new possibilities to substitute transport.

The shift in modalities is mainly a result of the environmental awareness of people. They have clear insight into the extent to which vehicles are polluting, so road transport will be negatively affected. In passenger transport a shift from the use of the car towards the use of the (high-speed) rail network is perceived. In addition public transport is used intensively for commuter and leisure trips. In freight transport, the flows of products are bundled so that transport modes are used more efficiently. The decentralisation of production and consumption requires efficient transport systems for middle-long and longer distances. Inland waterways and rail benefit from this development. Overall only a modest growth in transported volumes can be expected.

TABLE 12: Expected changes in transported volumes for Dutch Sustainable Growth

		Volume	
		Randstad	Non-Randstad
Freight transport	Air	0	0
	Road	+	0
	Rail	+	+
	Seaborne shipping	0	0
	Inland shipping	+	+
Pass. transp	Air	0	0
	Road	0	+
	Rail	++	+

Source: Nijkamp et al., 2000

4. Transport figures for 2020

4.1 Introduction

This section describes 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 twelve scenarios. The information described in the previous sections is used here as a starting point to calculate the transportation volumes in 2020. Calculating these volumes involve more than just applying the various plusses onto the base data. The results of the Worldscan model (CPB, used to give a quantitative illustration of the globalisation scenarios that 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. The following subsections will describe the various steps made in order to determine the final figures. First, the growth in the volume of transport will be calculated on the basis of the Worldscan-data. This will be followed by an explanation of the allocation of expected volume changes leading to concrete volumes for each transport mode in 2020.

4.2 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 results (the results have to be consistent with the results of this general equilibrium model used in an earlier stage of the research). So it is necessary to construct a link enabling us to relate the Worldscan outcomes to the transportation data and scenarios. Growth in GDP and trade were selected as being affective to growth in transport (based on literature and Worldscan). The correlation between GDP and transport is apparent although the direction of causation is less clear (see for example Button, 1993). Besides it is less easy to identify the exact relationship between growth in GDP and growth in transport volume. The latter is exactly what we need to define, i.e. one per cent growth in GDP means X per cent growth in transport volume for a certain mode over a certain period. This correlation varies per country and over time, but literature offers some insights. When these figures are available we can allocate the growth to the various modes according to the plusses. First we discuss the available growth figures in GDP. After this, the growth in trade will be incorporated in the establishment of the growth factors (number used to calculate growth in transported volumes from growth in GDP).

Table 13 shows GDP growth rates (average annual growth rates between 1995 and 2020). These data are directly derived from Worldscan conclusions and transferred into overall growth rates enabling us to calculate the overall growth in transport volumes in a next step. The numbers for The Netherlands cannot be derived directly from the Worldscan model. Based on CPB (1996) we assume that the labour force in The Netherlands will grow faster than the average growth in Western Europe in the Growth and Core growth scenario. This will lead to an annual average growth rate that is somewhat higher than the Western European level (see CPB, 1996). For the other scenarios no differences in growth of the working population are to be expected, so these will not change (see Table 13). As growth figures on the Dutch level are not really different and difficult to define, only the GDP growth for The Netherlands as a whole is mentioned. It is assumed that those figures are the same for both geographical areas.

TABLE 13: 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
Europe	Western Europe	2.3	77.4	2.3	77.9	0.6	16.1	0.8	21.4
	Eastern Europe	4.7	213.8	1.8	57.8	4.8	222.9	2.4	79.6
The Netherlands	Randstad	2.4	79.1	2.4	79.6	0.6	16.1	0.8	21,7
	Non-Randstad	2.4	79.1	2.4	79.6	0.6	16.1	0.8	21.7

Source: CPB, 1999 and own calculations

In order to define the relationship between growth in GDP and transport volume, literature is used as a guiding tool. A long-term transportation demands elasticity as provided e.g. by Wohlgemuth (1997) offers useful insights. An example of elasticity between income (consumer expenditures) and two transportation factors is presented below. Table 14 shows that the income effect on road transportation varies between 0,88 and 1,04. This indicates that a factor one (one per cent growth in GDP is accompanied by a one per cent growth in road transport per year) is not unusual. An overview of GDP growth (per capita) and travel and freight mobility provided by Button (1993) shows somewhat comparable results (growth factor 1).

TABLE 14: 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 GDP growth 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 mentioned here is the growth in volume of trade as expected by the Worldscan model. The quantity of transport also depends on the amount of trade between countries. The following average annual growth in volume of trade can be derived from Worldscan (see Table 15, real trade expressed in US dollars compared with 1995 prices, no numbers for the Netherlands available). It can be seen that especially in the Growth scenario there is large growth in trade.

TABLE 15: 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
Europe	Western Europe	5.9	3.0	2.5	2.5
	Eastern Europe	5.6	2.2	3.9	2.4

Source: CPB, 1999

In establishing the growth factor, 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 (1.5 only to be reached in The Netherlands because this area is expected to be most prosperous and therefore to have the highest factor). In addition the trade figures suggest a higher factor in the Growth scenario than in the others. Taking into account the foregone aspects and based upon our own insights we derived the following factors, presented in Table 16 for the whole transportation sector (both passengers and freight). The number 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 in this distribution are missing.

TABLE 16: Overall growth factors (cumulative elasticity for a 25-year period) in the transport sector with 1% growth in GDP

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
Europe	Western Europe	1.4	1.2	0.9	0.6
	Eastern Europe	1.2	1.0	1.0	0.8
The Netherlands	Randstad	1.5	1.5	1.0	0.5
	Non-Randstad	1.4	1.2	1.4	0.5

The next step is to determine the overall growth in transportation volume. This is done by taking the absolute growth figures as presented in Table 13 and multiplying these with the growth factors from Table 16. The results are shown in Table 17, where growth in passenger and freight transport is determined. It can now be allocated onto the various modes, based on the outcome of the various scenarios. This allocation will be explained in the following section.

TABLE 17: Absolute growth in volume of the transport sector (in %)

Transport		Growth	Core Growth	Peripheral Growth	Sustainable Growth
Global	OECD	117	99	24	21
	Non-OECD	420	114	287	133
Europe	Western Europe	108	93	14	13
	Eastern Europe	256	58	223	64
The Netherlands	Randstad	118	119	16	11
	Non-Randstad	111	95	23	11

4.3 Allocation of growth over transport

We now know the growth in total transport. The next step is the division of growth over the various modes of transport. The distinction between passenger and freight transport is necessary in the allocation of growth since they are expressed in different units (passenger-kilometres and ton-kilometres). The method used to determine the volume of the various modes will be explained in a (random) example. In addition it will be summarised in a mathematical formula. Two methods can be used to allocate the new numbers (Table 17), keeping the scenario outcomes in mind. Firstly, one can apply the total growth on the 1995 values. This implies no change in modal split, which is not compatible with the scenario assumptions. Therefore we choose for the following method.

The following arbitrary example will illustrate the method, which will be applied in all our scenarios and data. Assume that:

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 17)
A^+ = amount of plusses according to the description in the scenarios (see section 3, 4 and 5)

For example, suppose that the total transported volume in 1995 is 3.5 million passenger-kilometres. Air will grow with two plusses, road will not grow and rail transport grows 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 18.

TABLE 18: Example of the calculation

Mode	Q_0 (0=1995)	Amount 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	3,5 million ($Q_{t,0}$)	3	7 million (g=2)

In a general mathematical notation the above exercise can be presented as follows (which can be applied on m modes, with $Q_{m,o}$ being the transported volume in the base year (for mode m) and A_m^+ the number of plusses for each mode m):

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

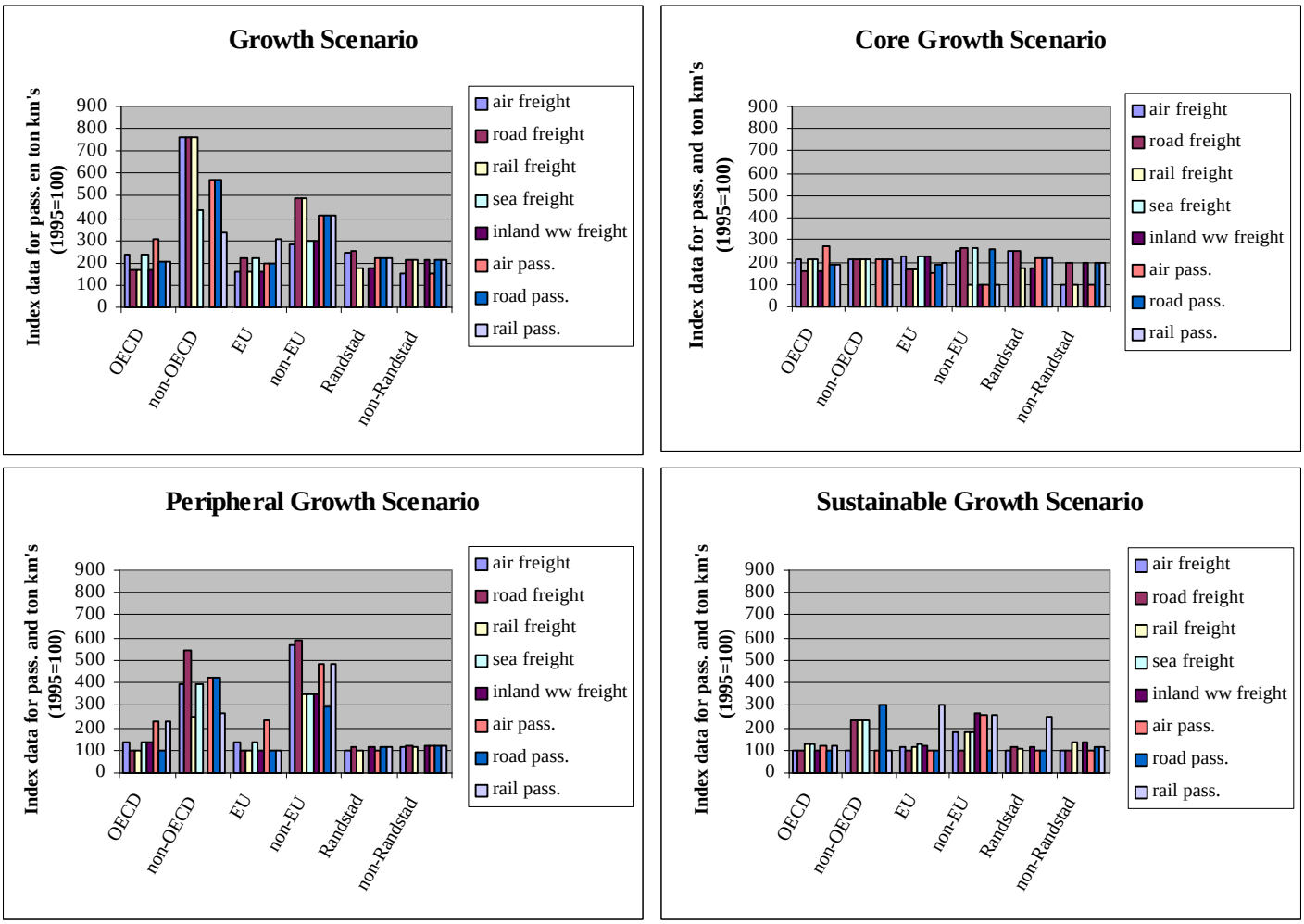
Equation (5) says what value is denoted to x, when all the other variables are known. X can then be used to calculate the unknown values for Q (transport by various modes in 2020). This enables us to present all the values for the various modes expressed in passenger-kilometres and ton-kilometres. In this illustration this leads to the following outcomes. In 2020 3,8 million passenger-kilometres will be travelled by air, road traffic will not grow and rail traffic will be 1,2 million passenger-kilometres.

4.4 Results

One prerequisite for carrying out this analysis is to have base data (in this case data from 1995 for all modalities in tonne and passenger kilometres). While gathering these data, it appeared that this information is not available in the required format. It was hard to obtain transport data especially for non-OECD countries. Also on the Randstad and non-Randstad level some assumptions had to be made in order to carry out the analysis. From various statistics (e.g. United Nations (1997, 1998 and 1998(I)), European Commission (1998 and 1999), Eurostat, (1994), AVV (1998), Ministry of Transport (1997) and CBS (1997 (a en b))) it appeared impossible to find inland waterway data for non-OECD countries. Besides, it was too complicated to allocate sea transport on a Dutch level. The figures below indicate this fact with a zero.

Figure 1 presents the results of the different scenarios on different scale levels in index-figures. So, for example, it is foreseen that road freight transport in Western Europe will grow in the Growth scenario by 118% (218 in figure) compared to 1995 data. As one can see, in most cases transport will grow in the next 25 years, while in some cases it remains unchanged. However, this does not mean that the transported volumes are constant during this 25-year period and fluctuations are likely to occur in between. We will now make some general remarks. It would be too detailed to analyse the results at the level of modalities.

Figure 1: Overview of the outcomes in 2020 for the various scenarios (index, 1995 = 100)



The figures show clearly that the Growth scenario is likely to cause the largest growth in transported volumes for both passenger and freight transport and on each scale level. Especially the relatively less developed regions will show strong growth in transport. These regions will also show growth in passenger and ton-kilometres in the Peripheral Growth scenarios but not to the same extent as in the Growth scenario. The increase in volume in the Sustainable Growth scenario is relatively modest whereas the less developed regions may show some increase in transport. This growth is to be expected for the 'greener modes' whereas road transport is limited. The societal consciousness towards a more environmental friendly behaviour is the major cause of this development.

Looking at the various scale levels, it appears that growth in transport is in general larger on a global level. Especially air transport is expected to increase in terms of transported volumes. All four scenarios show that on a European level transport will not decrease. In particular, transport in the non-EU countries will show an increase. Even in the Core Growth scenarios some modes will grow faster than Western Europe. The passenger transport market is characterised on a European level by a significant growth of rail transport. The difference between growth in the Randstad and non-Randstad does not seem that big (except for air transport caused by the fact that the most important airports are located in the Randstad). This is, of course, mainly due to the growth in volumes as has been established in Section 4.2.

5 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 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 is one of those fields where policy-makers have to deal with many uncertainties. Despite these uncertainties, policy-makers face the pressure of having to achieve sustainable mobility and consequently need to have insight into future developments.

This paper presented possible future developments by sketching four global contrasting images. These future images result from expected developments driven by globalisation. On various scale levels the impacts are estimated on the transport sector, and expressed in transported volumes for both passenger and freight transport. After a qualitative description based on expected developments of several indicators, the results were quantified. This development was illustrated by indicators, which express the potential expected impact on modalities. This formed the input for our attempt to acquire quantitative insight into the future development of the distinguished transport modes. First, the growth in total passenger and freight transport was assessed based on Worldscan conclusions and expert insights. Developments in economic growth and trade were guidelines for establishing growth in transport. 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 worldwide compared to 1995. In general the strongest growth can be seen in the Growth scenario. This can be explained by the high economic progress in both parts of the world (OECD and non-OECD), which is likely to lead to a substantial increase in transported volumes. On the other hand, transport will grow modest or not at all (for certain modalities) in the Sustainable Growth scenario. This scenario also foresees a modal shift with train and water transport taking over a share of road and air transport. This is valid for freight as well as passenger transportation. Core Growth foresees strong growth in transported volumes for the developed regions, whereas Peripheral Growth expects a growth in transport to take place in the more developing regions.

The previous description of scenarios and the explicit mapping of consequences of these future images for the distinguished transport modes in terms of volumes would not have been possible without making various assumptions. Here we want to elucidate some of the choices made during the research process, which are important in this context. It is important to stress that the choices made are based upon available data and expert insights.

First, the scenario writing is based upon views of the future world, which implicitly and by definition contain various uncertainties. In the present paper we have tried to give due attention to probable developments in the transport sector based on four globalisation scenarios constructed in an earlier phase. Starting from these forecasts, we distinguished for each scale level (global, European, national) two geographical areas to be consistent with the foregone phases. In addition, the consistent use of the same framework in all stages adds to the clearness of the report. We are aware though that it might seem difficult to expect large differences for certain aspects on a Dutch scale level.

Another limitation is the availability of transport statistics for the various scale levels (desirable 1995 data) and modes. The results presented in Section 4.4 show some intrinsic

difficulties. Especially finding data (in terms of passenger-kilometres and ton-kilometres) for non-OECD countries appeared to be extremely problematic. Data also formed a bottleneck for the subdivision into two Dutch regions: the Randstad and the more peripheral part. It appeared that useful transport statistics were mainly available on a national scale and not on a more detailed level.

Finally, a remark has to be made about the calculation method used. Calculating the transport figures in the way we did in Section 4, is not unambiguous. First, we had to make a distinction between freight and passenger transport, since these are expressed in different units. Another point is the meaning of a zero (0) in the various growth tables. In our calculation method a zero means no growth. This signifies that compared to the 1995 figures the transported volumes in 2020 did not change. During this period, of course these volumes can change. Clearly, one might give another meaning to this zero, i.e. a trend value. But keeping in mind the scenario writing process and the meaning of the plusses, it seems to us more suitable to assume this value to be zero.

References

AVV, 1998, *Goods Transport – Facts and Figures*, 1998 Edition, Transport Research Center (AVV), Heerlen

Button, K.J., 1993, *Transport Economics*, Aldershot, Cambridge.

CBS, 1997 (a), *Zakboek Verkeer en Vervoer*, Voorburg

CBS, 1997 (b), Statistiek van het binnenlands goederenvervoer, Voorburg

CPB, 1996, *Omgevingsscenario's Lange termijn verkenning 1995-2020*, Den Haag

CPB, 1999, Globalization, *International Transport and the Global Environment: four quantitative scenarios*, Working paper No. 110, The Hague

European Communities, 1998, *Integrated Strategic Transport Infrastructure Networks in Europe*, Office for Official Publications of the European Communities, Luxembourg

European Communities, 1999, *Panorama of Transport, Statistical overview of road, rail and inland waterway transport in the European Union*, Office for Official Publications of the European Communities, Luxembourg

Eurostat, 1994, *International transport by air*, European Union, Luxembourg

Geerlings, H., 1997, *Towards Sustainability of Technological Innovations in Transport*, Den Haag.

Ministry of Transport, 1997, *Jaarrapport Goederenvervoer*, Adviesdienst verkeer en vervoer, Jellema Druk bv, Almelo

Ministry of Transport, 1998, *Questa, verplaatsen in de toekomst*, Den Haag.

Nederveen, A.A.J., J.W. Konings and J.A. Stoop, 1999, *Transport Innovations: An inventory of future developments in transportation*, TRAIL Research School, Delft

Nijkamp, P., C.A. Rodenburg and B. Ubbels, 2000, Transport Scenarios, Free University Amsterdam.

Olsthoorn, A.A., 2000, GITAGE: emissions, IVM, Amsterdam.

Organisation for Economic Cooperation and Development (OECD), 1993, *Environmental performance reviews: Germany*, OECD, Paris.

Organisation for Economic Cooperation and Development (OECD), 1994, *Environmental performance reviews: Japan*, OECD, Paris.

Raad voor Verkeer en Waterstaat, 1999, *Ruimtelijke Vernieuwing Internationaal Goederenvervoer*, Den Haag.

Rienstra, S.A., 1998, *Options and Barriers for Sustainable Transport Policies; a scenario approach*, Den Haag.

United Nations, *Statistical Yearbook, forty-second issue,* 1997

United Nations, *Annual bulletin of transport statistics for Europe and North America*, 1998

United Nations, *Review of Maritime Transport*, 1998 (I)

Veen-Groot, D.B. van, P. Nijkamp and J.C.J.M. van den Bergh, 1998-I, *Globalisation, International Transport and the Global Environment, an assessment of trends and driving forces*, ESI, Free University, Amsterdam

Veen-Groot, D.B. van, and P. Nijkamp, 1999, *Globalisation, International Transport and the Global Environment, a scenario approach*, ESI, Free University, Amsterdam

Wohlgemuth, N., 1997, *World transport energy demand modelling*, Energy Policy, Vol. 25, pp. 1109-1119.

World Bank, 1996, *Global economic prospects and the developing countries*, Washington D.C., A World Bank Publication