

Globalisation and the Global Environment:

four quantitative scenarios

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Abstract

This paper presents four scenarios, which are constructed to analyse the effects of globalisation on transport and the environment. These scenarios contain different assumptions on the degree of globalisation, technical progress, migration and energy policies. These assumptions are quantified using WorldScan, a general equilibrium model for the world economy. Here we present the results on economic growth, trade and specialisation patterns and the volume of energy consumption and emissions within the four scenarios between 1995 and 2020. These results show that emission levels double with high economic growth in the absence of any new energy-efficient technologies and environmental legislation. However, in an ecological scenario which combines energy-efficient technologies, environmental legislation and modest economic growth, global emissions hardly increase.

1. Introduction

Globalisation is an ongoing trend. Although the benefits of globalisation for developing countries are sometimes doubted, globalisation is still seen as a prerequisite for further development. It can be interpreted as the growing economic interdependence of countries worldwide through the increasing volume of cross-border transactions in goods and services and variety in traded goods and services, through larger international capital flows and also through the more rapid and widespread diffusion of technology. It affects trade patterns, capital flows and location choices of firms at a regional and global level. Globalisation could raise economic growth of developing regions substantially, leading to a drastic shift of production activities to these countries. Moreover, increasing links between regions could affect consumer preferences and the dissemination of new technologies.

The distance between production and (intermediate and final) demand determines the size of trade, and in turn, the demand for transport. Because globalisation affects the volume of consumption, production and the place of production, it has great impact on the volume of transport. Transport movements can have considerable consequences on environmental quality. If globalisation persists, its impact on the environment will probably increase. The intensity of transport, the distances and the used modes of transport can have immense environmental influence. This could lead to a policy response, which would put new restrictions on transport technology directly or indirectly.

The result of the process of globalisation and its environmental effect is uncertain. Will the process of globalisation accelerate, or will it be slowed down by political and social tensions? Will all regions benefit from globalisation, or does it work in favour of developing or just developed countries only? Do countries take environmental quality seriously or is economic growth the overwhelming goal?

These issues are identified in four scenarios. In various ways they address the process of globalisation, its effects on the various regions, political cooperation between regions, the pace of technological progress, changing consumption patterns, and developments in the transport sector. Van Veen-Groot and Nijkamp (1998) have constructed these scenarios. Seven driving forces are distinguished. These driving forces are economy, politics, technology, demographics, the use of resources, firm strategies and consumer preferences. The first scenario is the *Schumpeterian scenario*, which emphasises globalisation and high economic growth throughout the world. In the *Malthusian Scenario*, the OECD economies flourish, but non-OECD countries lag behind. This results in strong polarisation between these regions. In the *Developing World*, strong economic centres in non-OECD countries arise. High economic growth rates in these areas are accompanied by severe ecological problems. On the other hand, the OECD countries are confronted with stagnating economic growth. In the *Ecological Scenario*, the non-material aspects of life are more important: the emphasis is on welfare and environment, rather than on an increase in income and the amount of physical goods.

This paper aims to present the quantification of the four scenarios.¹ For that purpose we use WorldScan. This is an applied general equilibrium model for world economy. It focuses on economic growth in the long run and trade patterns between twelve regions. WorldScan is a good

¹This research is part of the project Globalisation, International Transport and the Environment. It aims to map out the implications of current globalisation trends on transport and the effects of international transport on environmental quality. This project is carried out in the framework of the Dutch National Research Programme on Global Air Pollution and Climate Change, registered under nr. 953242, titled 'Globalisation, International Transport and the Global Environment (GITAGE)'. CPB (1999a) presents the results more extensively.

tool to analyse scenarios in which trade, trade liberalisation and differences in growth rates between regions are important. Moreover, it distinguishes several sectors including the energy sectors such as oil, gas and coal. Therefore the macroeconomic analysis can be combined with policies that affect energy. We will stress the economic outcome of scenarios and their implications for growth in energy and emissions.

Ubbels *et al.* (2000) use the results on economic growth, consumption, and trade in the four scenarios to derive the volume of (international) transport between and in the various regions. Given the volume of transport and scenario assumptions on spatial organisation, the modal split, routes and distances, and environmental-friendly technological progress in the transport sector, Olsthoorn (2000) determines the emission of greenhouse gasses by the transport sector. These results will be used to evaluate policies aimed at restricting the emission of greenhouse gasses by the transport sector.

Section 2 describes the scenarios and their driving forces. Section 3 translates these driving forces into exogenous inputs in our simulation model WorldScan. Section 4 to 6 concentrate on the quantitative results. Section 4 focuses on economic growth in the various regions and the causes of growth between 1995 and 2020 by a growth-accounting exercise. Moreover, we present the changes in consumer spending patterns and we show the developments in trade at a regional and worldwide level. Section 5 concentrates on the growth in energy and emissions. Section 6 presents more regional detail on trade patterns. Section 7 summarises the main results and draws some conclusions.

2. Qualitative scenarios

The four scenarios address in various ways the process of globalisation, its effects on the various regions, political cooperation between regions, the pace of technological progress, changing consumption patterns, and developments in the transport sector. Van Veen-Groot and Nijkamp (1998) describe the construction of the scenarios. They also present the scenarios and their driving forces extensively. This section summarises the features of the qualitative scenarios.

The *Schumpeterian scenario* is optimistic about the economic progress in developed and developing regions. It emphasises globalisation tendencies and market-oriented policies in the world economy. Therefore, it is akin to the High Growth scenario, which CPB and OECD constructed for their collaborative study on globalisation and the consequences for the OECD countries (OECD, 1997). In this scenario fast development outside the OECD area and complete liberalisation of goods and capital markets produce closer economic integration of rich and poor countries.

To attain and sustain high growth rates, developing countries should pursue sound domestic policies. Countries that do not create favourable conditions for market-based development are likely to fail. Governments must also promote or at least not discourage (private) savings, invest in public infrastructure and human capital and at the same time try to control or even curb fiscal deficits and public debt. Finally, developing economies must open up to allow foreign goods and foreign investment. Liberalising trade of goods, services and capital allows countries to specialise, exploit economies of scale and create competition. Moreover, open markets stimulate the dissemination of new technologies in developing regions.

In this scenario, trade liberalisation is not confined to trade blocks, but applies globally. The OECD countries further open up their markets. Whereas barriers to trade in manufacturing goods

are already low, agriculture is still heavily protected. Mainly developing countries benefit from partial liberalisation of agriculture. Moreover, there is more competition in the goods and services markets than in other scenarios.

Fast economic growth in the developing regions, together with a strong trend towards internationalisation, also lead to a convergence of consumer preferences in the OECD. Moreover, rising incomes per capita in the OECD countries create a higher demand for services and a relatively lower demand for manufacturing goods and agriculture. Despite the relative decline of manufacturing in the OECD, increasing demand in the developing regions, population growth and the development of transport and tourism will put a heavy strain on the use of energy and environment. Improvements in energy efficiency are necessary to limit the increase in CO₂ emissions. Energy prices will rise and environmental pollution will continue. From an environmental perspective, the scenario is thus less optimistic, although it does not foresee an environmental disaster.

Table 2.1. Characteristics of Schumpeterian and Malthusian scenarios

	<i>Schumpeter</i>	<i>Malthus</i>
1. Economy	high economic growth	high economic growth in OECD, non-OECD countries lagging behind. increasing polarisation
2. Politics	stable in OECD and non-OECD increasing market-oriented policies	stable in OECD, non-stable in non-OECD strained political relations due to large migration flows
3. Technology	strong technological development catching up of non-OECD	strong technological development in OECD hampering diffusion of technologies to non-OECD
4. Demographics	Overpopulation in non-OECD Diminishing population in OECD	overpopulation in non-OECD diminishing population in OECD large international migration flows
5. Resource Use	Innovations improving energy efficiency Volume growth exceeds efficiency gains	improving energy efficiency in OECD modest increase of energy use in non-OECD
6. Firm strategies	Internationalisation of business Strong competitive forces	internationalisation of business relocation of polluting activities
7. Consumer preferences	Convergence of consumer patterns	no global convergence of consumer patterns

This table presents the qualitative characteristics. The translation into the quantitative exogenous variables of the model necessary to mimic economic growth, resource use, and consumer preferences is presented in Table 3.1.

The rather optimistic picture for the developing countries, which is sketched in the Schumpeterian scenario, is abandoned in the *Malthusian scenario*. This scenario assumes that governments in developing regions are not able to pursue market-oriented and outward-oriented policies. The political situation in most of these countries is not stable and leads to an inward-looking attitude. This does not stimulate international cooperation on trade and environmental policies. The lack of trade liberalisation and the neglect of infrastructure and education harm economic growth substantially in these countries. The high technological advances in the OECD are not disseminated to the developing regions. This reduces economic growth even further, which in turn attributes to the political tensions in those countries.

The lack growth potential on progress does not facilitate structural changes in developing economies. Labour reallocation is modest and contributes to depriving conditions for a large part

of the population. Because the OECD countries succeed in managing their economies well, people in the developing countries have a tendency to migrate in this scenario in spite of stricter controls at the OECD borders. The trend towards globalisation seems to be reversed in this scenario, in particular for the developing countries. As a result, consumer preferences in the developing countries will not converge with those in the OECD. The reduced growth perspectives are of course also important in this respect.

The *Developing scenario* sketches an opposite picture. Growth perspectives for the OECD countries are meagre, while non-OECD countries grow fast at high environmental costs. The Developing scenario assumes that the OECD countries experience problems. Demand for social protection and other risk averting behaviour enforce rules and institutions, which hamper structural growth. The lack of flexibility on the labour and product markets within the OECD keep unemployment levels high. Moreover, established interests and inflexible institutions oppose effective solutions for the financial burden of ageing. As a result, labour taxes increase, raising unemployment levels even further. Economic crises inside the OECD strengthen protectionist sentiments. Disagreement on trade issues about agriculture and services between the United States, European Union and Japan restrains all globalisation tendencies in the OECD. This relative autarky together with expanding welfare states, affect the expectations of producers. They reduce investment and curb research and development. Technical progress slows down. The social and economic tensions dominate environmental problems. As a consequence, energy efficiency and environmental legislation are unimportant issues now.

Table 2.2 Characteristics of Developing and Ecological scenario

	<i>Developing</i>	<i>Ecology</i>
1. Economy	High economic growth in non-OECD Economic crises in OECD	low economic growth
2. Politics	Stable in non-OECD, unstable in OECD Increasing market-oriented policies in non-OECD	stable in non-OECD and OECD increasing market-oriented policies
3. Technology	high rate of imitation and innovation in non-OECD limited technological development in OECD	focus on environmental-friendly technology
4. Demographics	overpopulation in non-OECD: smaller families diminishing population in OECD	smaller increase population in non-OECD
5. Resource Use	severe ecological problems rapidly increase of resource use in non-OECD	sustainability strict environmental legislation
6. Firm strategies	internationalisation of non-OECD firms	localised production and consumption
7. Consumer preferences	convergence of consumer patterns strong youth culture in non-OECD	preference for environmental-friendly products and for local products

This table presents the qualitative characteristics. The translation into the quantitative exogenous variables of the model necessary to mimic economic growth, resource use, and consumer preferences is presented in Table 3.1.

The developing countries do not face these problems. They continue to open up and strengthen markets. Their policies are outward oriented. They invest in infrastructure and education and copy technologies from the OECD countries at a fast pace. In spite of protectionist measures from the OECD, the developing countries liberalise trade and capital in their own regions, thereby creating their own trade blocks. In their efforts to raise welfare at a quick pace, countries

do not worry about the environment. Moreover, the lack of energy-extensive innovations in the OECD implies an imitation of energy-intensive technologies in non-OECD countries. As a result, the demand for energy increases substantially, generating a sharp increase in emissions.

In the *Ecological scenario* consumers and producers value environmental quality. Economic growth as such is less significant. Well-being and environmental quality are important issues while technical progress is less important and directed towards energy-efficiency improvements. Positive environmental effects instead of higher productivity levels motivate new innovations. Moreover, consumers prefer to save energy, and consequently spend less on electricity. Governments also enforce strict environmental legislation by the introduction of energy taxes. The emission targets agreed upon in the Kyoto protocol will be reached by 2010 and thereafter emissions will be lowered by 1% per year. Environmental legislation is only possible in a sphere of political and social harmony. Countries will agree to cooperate on environmental legislation without free-rider behaviour. The agreements in the Kyoto protocol are only binding for industrial and transition (is Eastern Europe and Former Soviet Union) countries. Developing countries are permitted to grow with the help of energy-efficient technologies, but without strict environmental limits. The reverse of the coin is low economic growth, and therefore a slow rise in standards of living in non-OECD countries.

In this scenario, people value the consumption of local products. Globalisation is of little significance in this respect. For that reason, there are few incentives for eliminating trade barriers. Firms stay in their own regions, and the need for transport is more limited than in the other scenarios.

3. The exogenous trends

Later in this paper, the qualitative scenarios presented in Section 2 are quantified and for this purpose we use WorldScan, an applied general equilibrium model for world economy. The model was developed for the building of scenarios. This section presents quantified exogenous variables in WorldScan. Because the values of these variables differ in the four scenarios, the results of the model will vary. The subsequent sections present these results and focus in particular on economic growth and trade.

CPB (1999b) explains quite extensively that WorldScan relies on the neoclassical theories of growth and international trade.² The standard neoclassical theory of growth distinguishes three factors to explain changes in production: physical capital, labour, and technology. WorldScan augments the simple growth model in three ways. First, WorldScan allows overall technology to differ across countries. Secondly, the model distinguishes two types of labour: high-skilled and low-skilled labour. Sectors differ according to the intensity with which they use high-skilled and low-skilled labour. Countries can raise per capita growth by schooling and training the labour force. Thirdly, in developing countries part of the labour force works in a low-productivity, informal sector. In this sector workers do not have access to capital and technology. Reallocation of labour from the low-productivity sector to high-productivity sectors enables countries to raise per capita growth as well.

²An Armington trade specification amends the neo-classical trade theory. This is to explain two-way trade and to allow for market power to determine trade patterns in the medium run, while allowing for Heckscher-Ohlin mechanisms in the long run

This version of the model consists of 12 regions and eleven sectors. Appendix 1 lists these sectors and regions together with a mapping to the original GTAP data, which we use to calibrate the model.

The scenario results vary because of our different assumptions of the driving forces. These assumptions are based on the qualitative description of the scenarios in Van Veen-Groot and Nijkamp (1998) as summarised in Section 2. We specify the driving forces of the four scenarios as input in the model to quantify economic growth, trade and CO₂ emissions. Table 3.1 compares these exogenous trends and variables for all scenarios.

The driving forces are economy, politics, technology, demographics, resource use, firm strategies and consumer preferences. Driving forces such as politics, technology, and demographics are directly or indirectly exogenous in our simulation model WorldScan. The microeconomic variable firm strategies are not present, because the model focuses on macroeconomic outcomes. Resource use is endogenous in the model, although the adoption of energy-saving production techniques is exogenous. Consumption patterns are endogenous, because the allocation of the consumer budget over the various categories of goods depends on income per capita.

Table 3.1 Exogenous trends in all scenarios until 2020 (in %)

Scenario	Schumpeter		Malthus		Developing		Ecology	
Region	O	N	O	N	O	N	O	N
Technical progress*	1.5	2.0	1.2	0.7	0.6	2.0	0.6	0.9
Technical progress Trade & Transport sector*	2.0	2.2	1.6	0.7	0.6	2.3	0.6	0.8
Population growth*	medium scenario United Nations 0.3% in O and 1.4% in N							
Migration (from N to O)	no		yes		no		no	
Schooling*	0.1	2.8	0.6	2.1	0.1	2.8	0.1	2.8
Trade liberalisation in manufacturing and services*	100%	100%	100%	0%	0%	100%	50%	50%
Trade liberalisation in raw materials and agriculture*	50%	50%	50%	0%	0%	50%	25%	25%
Capital market integration	high		standard		standard		standard	
Consumer preferences converge towards	services	those in O	services	those in O, but limited	stable	those in O	`green' products	those in O, but limited
Degree of competition	high		standard		standard		standard	
Energy efficiency*	0.5	1.0	0.5	0.0	0.0	0.0	0.0	2.0
Energy taxes	no	no	no	no	no	no	yes	no

O and N are abbreviations for the OECD and non-OECD.

* numbers are average annual growth rates.

* numbers refer to the breakdown of the original tariff rates in 1995.

One of the most important driving forces for economic growth is technical progress. If the speed of technical progress is high, economies grow fast, such as in the Schumpeterian scenario for all countries, in the Malthusian scenario for the OECD countries, and the Developing scenario for non-OECD countries. In cases where regions globalise rapidly, the rate of innovation in the Trade

and Transport³ sector is even higher. This reflects the idea that sharp falling costs in transportation and communication benefit trade substantially.

Schooling and labour reallocation from low to high-productivity sectors also significantly contribute to growth. The pace of schooling and reallocation is low in the Malthusian scenario, which is the most devastating for the non-OECD. In this scenario people also migrate to the OECD at a rate of 0.5% of the OECD population per year. In terms of the non-OECD population this is fairly low, but larger inflows would probably lead to social tensions in the OECD.

In all scenarios we combine abundant growth with increased international links, partly as a result of trade liberalisation. Tariff reductions in agriculture and raw materials are limited to 50%, because these levels are very high for some regions, and so far much less progress has been made in lowering these barriers. Even in the Ecological scenario, trade liberalisation takes place at a modest scale, because regions are willing to cooperate on trade policy as they also do on environmental policy. The Schumpeterian scenario also contains a high degree of capital market integration. Moreover, we assume that the degree of competition is larger than in the other scenarios (except for Raw Materials). The long-term substitution elasticity between goods of different origin is twice as high as in other scenarios.

Because per capita incomes rise in the non-OECD, consumption patterns will change. Consumers will spend relatively more on services and less on agriculture. This convergence to OECD consumption patterns is of course less pronounced in the Malthusian scenario, in which the growth rate per capita is low. In the Schumpeterian and Malthusian scenarios, OECD consumers will also spend more on services because their per capita incomes rise. In the Ecology scenario, all consumers will save energy in line with their environmental awareness.

In all scenarios with high economic growth, sustainable production is only possible if energy-efficient technologies are introduced. For that reason the OECD countries save 0.5% yearly on energy per production unit in the Schumpeterian and Malthusian scenarios. In the former scenario, non-OECD countries even save 1% on energy each year. Due to the quick dissemination of technology from OECD to non-OECD countries, it is relatively easy for the latter to copy more environmental-friendly policies. In the Ecological scenario, the environmental awareness of these countries is much higher. Production technologies become even 2% more energy-efficient each year with a much lower dissemination of technology from the OECD. The efforts to reduce energy are thus much higher.

OECD countries save less in the Ecological scenario because technical progress is meagre, which makes it more difficult to implement energy-saving technologies. Reduction in energy demand is achieved by introducing energy taxes. Industrial and transition countries levy these taxes according to the Kyoto protocol and even agree to further reduce the emissions by 1% per year after 2010. In the Ecological scenario, industrial and transition countries have the possibility to trade in emission rights in order to reach emission targets. The other non-OECD countries do not participate.

³The sector Trade and Transport in WorldScan includes the retail trade, hotels and restaurants, communication costs and transport (ISIC code 6 and 7). Details can be found in the description of the database, see McDougall *et al.* (1998).

4. Economic growth

This section presents the macroeconomic results of the four scenarios. The differences can be traced back to the variation in exogenous trends as discussed in Section 3. We concentrate here on the differences in economic growth and the causes of these differences. We also present shifts in consumption spending and changes in trade.

Schumpeterian scenario

In the *Schumpeterian scenario* many poor countries partly catch up with the rich countries. Due to education, population growth, and labour reallocation from the low-productivity to the high-productivity sectors, labour is one of the engines of growth (see Figure 4.1). Moreover, capital accumulation is fairly important in the developing regions. The liberalisation of capital markets and the high saving rates in Asia contribute substantially to the supply of capital in the non-OECD. Because of stable schooling levels and the lack of population growth in the OECD, technology is the most important contributor to economic growth.

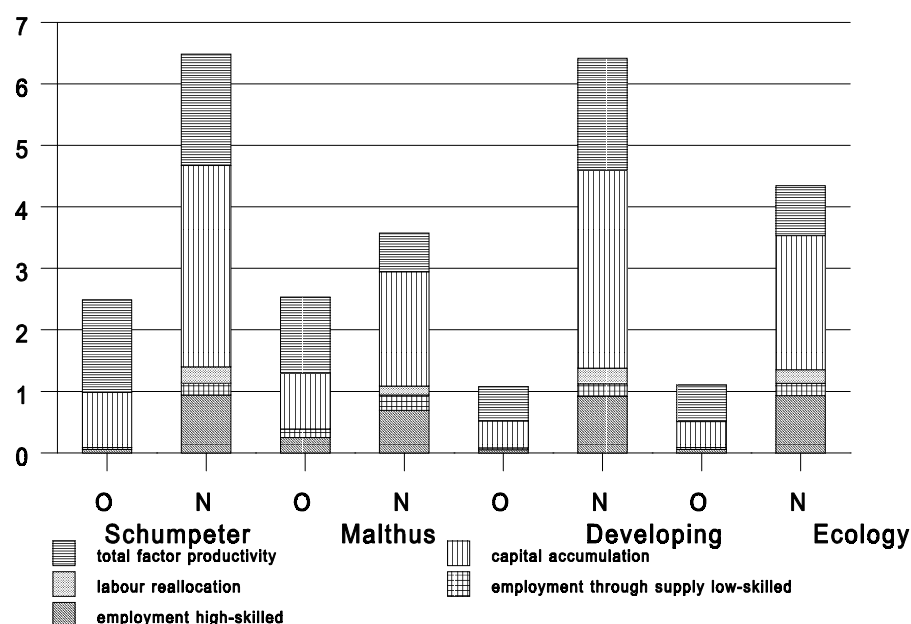
Non-OECD countries grow at a per capita rate of 4.7%, while OECD countries grow on average at a rate of 2.2% per capita (Table 4.1). This paints an optimistic picture because only a few countries have been able to maintain growth rates of about 4% per capita for two decennia or more.

The increase in labour productivity in the non-OECD is also apparent in Table 4.1. Firstly, labour reallocates quite quickly from low-productivity to high-productivity sectors. Secondly, education levels increase (see Table 3.1). The supply of high-skilled labour is much higher than the average population growth (2.8% compared to 1.4%, respectively). Technical progress contributes also to economic growth in the non-OECD. The high growth rate of total factor productivity in the non-OECD compared to that of the OECD represents technological catching-up.

High productivity growth rates match rapidly increasing demands from non-OECD countries. The reduction and elimination of trade barriers contributes to this process. International specialisation becomes more and more pronounced during the scenario period in response to the liberalisation of goods markets and lower transport costs. International trade flourishes, as is indicated by the substantial increase in the trade to GDP ratio. The OECD specialises more in high-skilled, labour-intensive goods such as capital goods and services. Non-OECD countries specialize in consumer goods, which are low-skilled labour intensive (see Section 6 for more details).

Changes in production structure are not only affected by specialisation, but for the greater part by the general trend towards the production of high-skilled, labour-intensive goods. In particular, consumers in non-OECD countries change their consumption patterns from agricultural goods towards services. In the OECD this trend also continues but to a moderate extent. This implies that in spite of specialisation, non-OECD countries now produce many more services. In this scenario, the non-OECD share in world production increased from 22.9% to 41.6%. This is remarkable but still far below their share in total population.

Figure 4.1 Growth accounting: average annual contributions of the productive factors



Malthusian scenario

The lack of a market-oriented environment in most non-OECD countries in the *Malthusian scenario* is extremely harmful to economic growth. First of all, less expenditure on education hampers the growth of high-skilled labour supply. Although younger generations are better educated, on average the progress in schooling is modest. The skilled labour force grows at a rate of 2.1%, exceeding population growth by only 0.7% (Table 3.1). In effect it will take more than a century to reach the current education levels in the OECD. As a consequence, high-skilled labour also contributes less to economic growth than in the Schumpeterian scenario as can be seen in Figure 4.1. Moreover, less technological progress slows down the widening gap between high and low productivity sectors. This process hampers labour reallocation, as is evident from the size of the informal sector in 2020 (Table 4.1).

There is substantial immigration to the OECD. In 2020, population in the OECD has increased by 10% due to migration. This also appears in Figure 4.1, where labour now contributes to growth in the OECD. Without migration this is not the case. Europe has to cope with large inflows from Africa, the Middle East and Eastern Europe. Asian migrants try to find their luck in the United States, Japan, and the Pacific OECD. From the perspective of OECD countries, these large flows have nearly no effect on the population in non-OECD countries, but double population growth in the OECD.

The restrictions on the markets for capital, goods and services harm the supply of capital and the dissemination of technology. Total factor productivity in the non-OECD regions grows at a lower pace than in the OECD, suggesting that the technology gap only widens. Due to the relative less abundant supply of production factors, the productivity increases are less substantial than in the Schumpeterian scenario. Moreover, lower economic growth leads to a smaller increase in savings, which in its turn affects investment negatively (see Table 4.1).

In spite of the unfavourable market circumstances in non-OECD countries, the macro growth rates are higher than in the OECD. This reflects the enormous potential of these countries, which will develop to some extent even when the circumstances are not beneficial for economic

development. Per capita growth is 2.2%, 0.5% above the average per capita growth in the OECD countries.

Less economic growth is also reflected in the consumption patterns. In non-OECD countries, the shift away from food towards services is less pronounced than in the Schumpeterian scenario. This also implies that the changes in production structure - from Agriculture to Services - are more limited than in the Schumpeterian scenario.

Table 4.1 Development of macroeconomic variables between 1995 - 2020

Scenario	Schumpeter		Malthus		Developing		Ecology	
	O	N	O	N	O	N	O	N
<i>average annual growth 1995 – 2020</i>								
GDP growth	2.6	6.2	2.6	3.6	1.2	5.9	1.2	4.0
GDP growth per capita	2.2	4.7	1.7	2.2	0.8	4.4	0.9	2.5
employment growth	0.1	3.0	0.6	2.2	0.1	3.0	0.1	2.7
<i>Percentage shares</i>								
labour reallocation (share labour supply)		-19.1		-7.9		-18.1		-14.5
savings ratio (ratio national income)	17.8	23.5	17.9	16.6	14.7	24.4	14.9	18.9
consumption share on services	77.9	70.6	77.2	65.2	75.7	68.6	75.7	64.9
consumption share on food services	6.5	12.6	7.1	17.0	7.6	13.4	7.7	16.6
ratio of value of trade to GDP¹	22.9	43.6	12.5	22.6	15.0	25.5	14.6	24.7
world share of GDP	58.4	41.6	72.5	27.5	51.9	48.1	63.2	36.8

O and N are abbreviations for the OECD and non-OECD.

¹ This includes intra-regional trade. Growth rates are average annual growth rates between 1995 and 2020. Percentage shares are the values in 2020.

Source: WorldScan.

Prosperous economic conditions in the OECD and less prosperous conditions in the non-OECD also imply that most production still takes place in the OECD. This does not mean that firms and / or capital are not mobile. Within the OECD all trade barriers are eliminated. Trade within the OECD is thus stimulated, but not extensively. This is no surprise. The existing trade barriers are already fairly low, except for trade in agriculture and energy. As a consequence, the benefits of liberalisation are modest. The trade restrictions imposed by non-OECD countries hamper trade significantly. The ratio of trade to GDP becomes even lower in non-OECD countries during the simulation period and specialisation in manufacturing becomes less pronounced.

Developing Scenario

The lack of technical progress in the OECD in the *Developing scenario* has much impact on the economy, as it is the main contributor to economic growth in this area. Economic growth is thereby substantially reduced. Savings and investment are also reduced due to a lack of confidence within the OECD. As a consequence, the growth rates hardly exceed 1% per year. The other regions benefit from the increase in labour productivity by schooling and labour

reallocation. Table 3.1 shows that high-skilled labour supply grows by 2.8% per year and Table 4.1 shows that about 20% of the labour force reallocates from low to high productivity. These two factors raise economic growth by about 2%. Moreover, the variation in labour supply growth of high-skilled workers contributes significantly to the differences in growth rates.

Developing countries catch up considerably with developed countries. Table 4.1 shows that the difference in GDP per capita is 3.6% per annum. The deviations in the growth of total factor productivity are also striking. While, the rate of technological progress is nearly zero in OECD countries, non-OECD countries are able to improve their technologies at a quick pace.

These huge disparities in growth implicate a big shift in the location of production. The share in world production of the non-OECD doubles from about 25% to nearly 50%. This is an enormous reallocation of activities in 25 years time. Trade as such does not increase substantially compared to GDP. This is the result of the trade barriers between the OECD and the non-OECD. Consequently the specialisation pattern is not so pronounced as in the Schumpeterian scenario where the linkages were increased between regions with different comparative advantages.

Consumption patterns converge rapidly. High growth in non-OECD countries increases consumption expenditures and induces a shift from agricultural goods (income elasticity less than one) to services (income elasticity larger than one). In 2020, the average consumer will spend nearly 70% on service goods, while the share of agriculture in total consumption is lowered to about 10%.

Ecological scenario

The relative insignificance of economic growth in the *Ecological scenario* is illustrated by 0.9% and 2.5% GDP growth per capita in the OECD and non-OECD, respectively (see Table 4.1). The main reason for low economic growth is the lack of technical progress. Figure 4.1 shows that in the non-OECD, growth is mainly driven by the growth in labour supply and induced capital accumulation. Labour reallocation of about 15% of total labour supply and higher education levels push up productivity. Given the modest economic growth, the size of labour reallocation is high. This reflects the social objectives of the governments in non-OECD countries to reduce poverty by stimulating people to work in the high-productivity sectors.

The stable schooling levels in the OECD imply that capital accumulation and technical progress are solely responsible for economic growth. However, less technical progress also reduces the productivity increases in capital and consequently the accumulation of capital.

Less economic growth per capita reduces the changes in consumer spending. Even in the OECD, consumers spend relatively more on agriculture and less on services compared to the other scenarios. The fact that government policies do not focus on globalisation or increasing linkages is reflected in the trade to GDP ratio (see Table 4.1). The lack of fast technological progress in the Trade and Transport sector also contributes to the modest increase of trade.

Together with low economic growth, most of the production still takes place in the OECD. The shift to non-OECD regions is modest.

5. Energy and Emissions

Schumpeterian scenario

High and persistent economic growth in the *Schumpeterian scenario* feeds energy demand. Some of the potential demand is substituted by energy-efficiency improvements in the production processes of 0.5% and 1% per annum in the OECD countries, and non-OECD countries

respectively (see Table 3.1). Because of these energy-efficiency improvements and increasing prices in the OECD, emission and energy consumption growth do not accelerate. Emissions grow fast in non-OECD countries, but at a global level, emission growth is less than 2% per year. The total level of emissions is about 11.1 million kilo tonnes of C(arbon). Due to the one-to-one relation with emissions, the growth rate in emissions exactly replicates the volume growth rate in energy.

The shift in production activities from the OECD to the non-OECD implies also a shift in polluting activities. Fortunately, by copying the technologies from the OECD and the energy-efficiency improvements in the non-OECD, the energy to GDP ratio decreases significantly in this scenario. But still these techniques are not sufficient at all in reversing the trend of increasing emissions in the OECD. Given high economic growth rates in non-OECD countries, rapidly increasing emissions seem to be unavoidable. Only very strict environmental legislation could reduce the growth of emissions.

Table 5.1 Development of energy prices and emissions between 1995 - 2020

Scenario	Schumpeter		Malthus		Developing		Ecology	
	O	N	O	N	O	N	O	N
relative energy (producer) prices *	1.5	0.3	0.7	0.2	1.6	-0.1	0.7	0.0
volume of emissions *	0.8	3.6	1.1	2.8	0.3	4.6	0.0	1.4
world share of emissions (%)	32.7	67.3	38.4	61.6	25.4	74.6	40.2	59.8

O and N are abbreviations for the OECD and non-OECD.

- numbers are average annual growth rates.

Source: WorldScan

Malthusian scenario

Less economic growth in the non-OECD does not reduce the growth in energy use and emissions proportionally in the *Malthusian scenario*. The reason is that those countries take fewer measures to improve energy efficiency, and new technologies are not quickly disseminated. Due to the unstable political situation and unfavourable economic conditions, the reduction of emissions has no priority in non-OECD regions. Energy efficiency does not improve. As a consequence, the differences in emission growth between the OECD and non-OECD countries increase strikingly. This difference of about 2% per year is much larger than the difference in GDP growth of about 1% (see Table 4.1). There are two reasons for this result. In the first place, production processes in the OECD are already more energy-extensive. Secondly, firms in the OECD are able to innovate their technologies in such a way that production processes become less polluting. The energy-efficiency improvement is 0.5% per year.

Developing scenario

The growth in energy and emission volumes closely follows the economic developments in the *Developing scenario*. Without energy-saving technologies or environmental legislation, emission volumes accelerate in the non-OECD regions by nearly 5% per annum. Trade liberalisation within non-OECD countries and a lagging demand in the OECD exert a downward pressure on energy prices. Consequently 75% of the emissions is produced in non-OECD countries. Due to meagre economic growth, emission growth in the OECD is lower than in the scenarios, with high

growth rates and energy-saving technologies. In itself this increase is sustainable but the already high level of emissions in the developed countries together with the huge increase in emissions in the developing countries pose a large burden on the environment. Although the worldwide growth of emissions is not much higher than in the Schumpeterian scenario, the environmental prospects are more worrisome. High economic growth in the Schumpeterian scenario was combined with energy savings technologies in the OECD. This is not the case now as non-OECD countries, without environmental-friendly technologies, produce a larger part of the emissions.

Ecological scenario

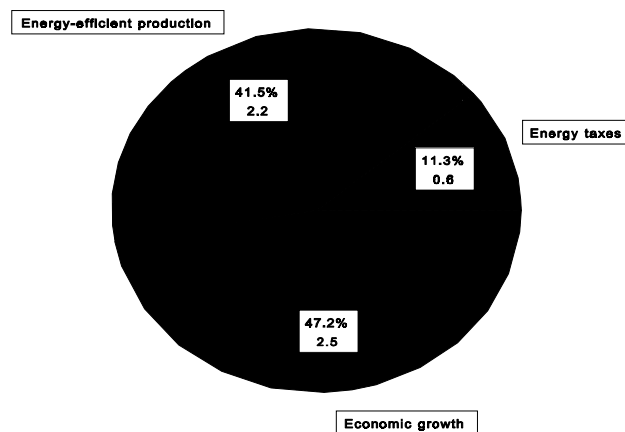
The *Ecological scenario* distinguishes itself by a very modest increase in the demand for energy and growth of CO₂ emissions of 0.8% per year. As a result, total emissions are about 40% lower than in the Developing scenario. In the OECD, emissions do not even increase. This is caused by three factors. First of all, the OECD and transition countries agree to reduce the emissions according to the Kyoto protocol. This scenario assumes that the countries reach these targets in 2010. Non-OECD countries do not participate with binding emission targets because the OECD take the responsibility for its high abatement levels per capita. Non-OECD countries limit the growth of energy demand by energy-efficiency improvements in production and a reduction in consumer demand. This reflects their preferences for environmental quality. Non-OECD regions do not prefer strict emission limits as in the Kyoto protocol because it restricts economic growth too drastically. After 2010, the emissions in the OECD and transition countries are reduced by 1% per year, reflecting the ongoing environmental concerns in this scenario. As a result, the taxes on coal in the OECD are about 25% of the consumer price in 2020, and the energy taxes on gas and oil are about 10% of the consumer price. This reduces the demand for energy substantially. The consumer price for energy rises yearly by 0.4% more over annual growth in the OECD producer price.

Moreover, we assume a 2% per year improvement in energy-efficiency of production in non-OECD countries. This reflects the idea that non-OECD countries copy the more energy-efficient technologies from the industrial countries. It is also much harder to develop more energy-efficient technologies because technical progress is much lower. For that reason these improvements are only possible in high-growth scenarios such as the Schumpeterian and Malthusian scenarios. Finally, consumers reduce their relative spending on energy. As a result, the total energy demand by the OECD remains stable until 2020. The demand in the non-OECD regions rises because of the growth in GDP. Due to energy-saving technologies the rise in energy demand is very modest compared to other scenarios.

Starting from the Developing scenario, we eliminate the differences with the Ecological scenario one-by-one in order to analyse the relevance of the three factors, which determine the difference in emission levels. These differences depend above all on the assumptions made regarding non-OECD regions, in particular in relation to technological progress, which drives economic growth and energy-efficiency in production.⁴

⁴The various assumptions on trade liberalisation, the pace of labour reallocation from the low-productivity sectors and the decreasing consumption share on electricity cancel each other out.

Figure 5.1 Contributions to global emission gap in Developing and Ecological scenario



The global emission level is about 5.3 million kilo tonnes C lower in the Ecological scenario than in the Developing scenario. Notice that in 1995 the emission level is 6 million kilo tonnes C. Nearly 90% of the difference in emission levels can be attributed to differences in economic growth driven by technological progress and energy-saving production techniques. In particular, these different assumptions are made for non-OECD regions. For the OECD, the introduction of energy taxes in the Ecological scenario is an important element. However, Figure 5.1 shows that on a global level, a very strict environmental legislation in the OECD and transition regions is far from sufficient for stable global emission levels in the scenario period. Only 11% of the difference is due to energy taxes in the OECD and transition countries.

Summary

The environment does not benefit from high economic growth. In the Schumpeterian and Malthusian scenario emissions grow substantially but do not accelerate, due to energy-saving technologies. Even in these scenarios the annual global emissions grow by about 70% between 1995 and 2020. In the Ecological scenario, demand for energy and consequently CO₂ emissions are stable due to strict environmental legislation in the OECD between 1995 and 2020. The global increase in emissions is about 20%, which seems very modest given economic development in non-OECD countries. The growth of emissions in the Developing scenario does accelerate due to fast growing developing regions. These regions ignore environmental quality. As a result, emissions increase by 200%, and the global volume of emissions doubles. This scenario shows that high economic growth and a non-accelerating emission growth is possible with sufficient energy-saving technologies, such as an energy improvement of about 2% per year. If energy growth is not allowed at all, economic growth has to be low, as in the Ecological scenario or a more strict environmental legislation is necessary.

The differences in emission growth in the non-ecological scenarios are not very pronounced. In these three scenarios emission growth is substantial. Whether these increases are sustainable or not is hard to tell. Except that the quantitative effects of pollution on the environment are unclear, simulation paths of 25 years are relatively short to analyse emission paths. Therefore CPB (1999a) presents some scenarios results for the year 2050.

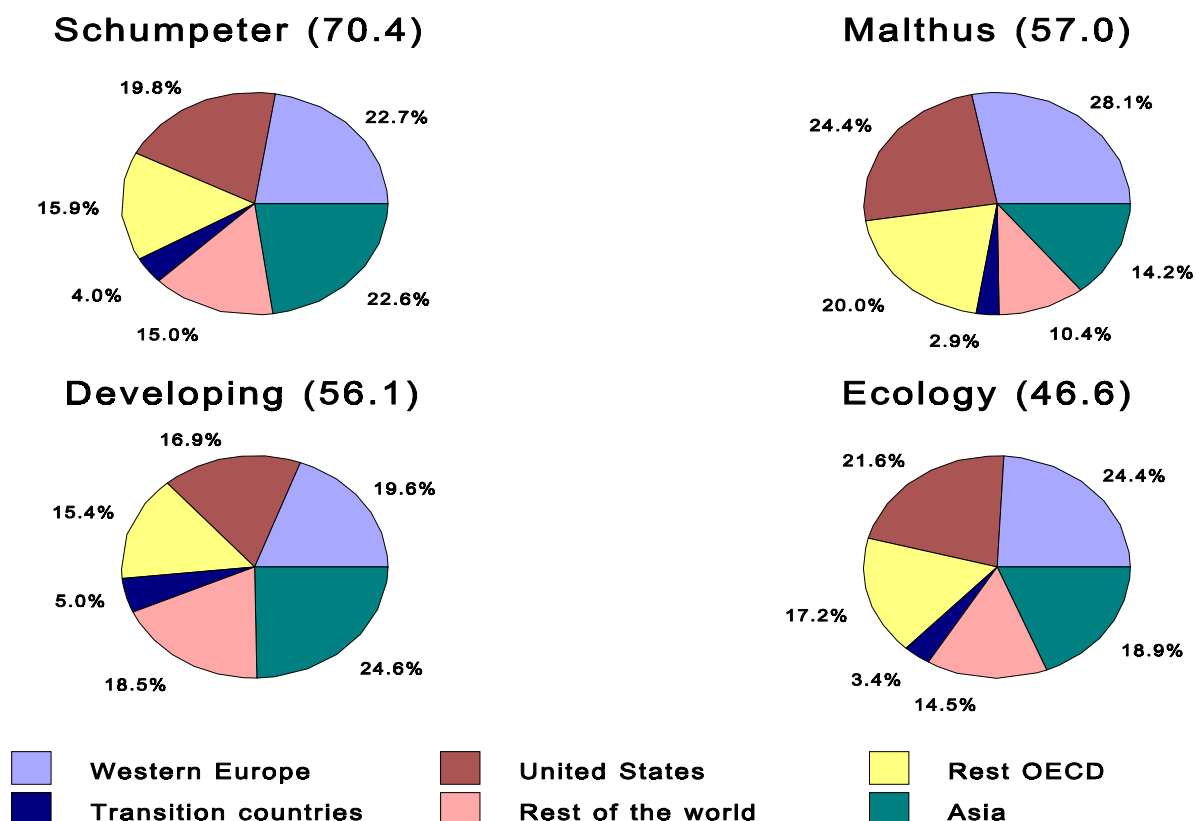
6. Trade and specialisation

Sections 4 and 5 have presented the quantitative results of the four scenarios. These sections focussed only on the aggregates OECD and non- OECD in order to present the main differences between the scenarios without providing too much detail. The growth in GDP, consumption and trade has great impact on the transport volumes between and within regions. However, the aggregates ‘OECD’ and ‘non OECD’ are very broad and the simulation results provide much more regional detail such as developments in GDP and trade for all twelve regions. These regional differences in GDP are of course very important for the shifts in the location of production. The size and direction of trade flows are important for transport development and infrastructure. Therefore this section presents more detailed results on GDP, and trade patterns.

Figure 6.1 presents the value of GDP for six regions in the four scenarios. The size of these regions adds up to the whole world. The total size of the world economy is largest in the Schumpeterian scenario (70 trillion US dollars) and about a third lower in the Ecology scenario. In the Malthusian scenario the United States, Western Europe and the Rest OECD (Japan, Canada, and Oceania) make up three quarters of the whole economy, while this is substantially lower in the Developing scenario. The transition countries (Eastern Europe and Former Soviet Union) contribute 3-5% to the world economy, while this varies between 14% and 25% for Asia. In the Developing scenario, relatively many economic activities take place in Asia while the absolute size of production is larger in the Schumpeterian scenario.

Figure 6.1 Shares of world GDP in 2020

number in parentheses is global GDP in trillion US dollars

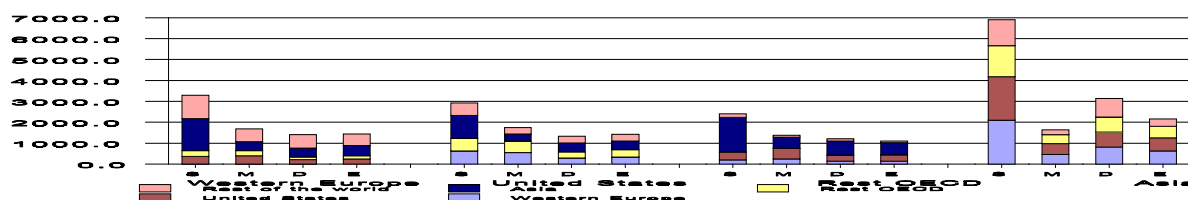


All scenarios suggest a relative shift in economic activities from Europe and the United States to Asia. Production will shift to Asia, but demand will also increase substantially. As a result, transport to and from Asia will become more important. This is more pronounced in the Schumpeterian scenario than in the Ecological one.

Transport does not only depend on GDP growth but also on (international) trade. Figure 6.2 gives an impression of the trade flows in 2020. Because regions classified in WorldScan are fairly large and often represent continents, trade reflects long-distance trade, often transported by sea and air. For every region trade volumes are very large in the Schumpeterian scenario; at least twice as high as in the other scenarios. The underlying reasons are high GDP growth and far-reaching trade liberalisation. In particular, exports from Asia are very high. The reason is that Asia benefits more from the elimination of trade barriers than other regions. In this scenario exports from the other regions to Asia are also very high.

Exports from the OECD increase rapidly compared to GDP growth in the Schumpeterian scenario. The reason is that (high-skilled labour-intensive) goods and services from the OECD are in good demand in the rest of the world, in particular in Asia. If these regions do not grow as fast such as in the Malthusian scenario, export growth is much lower. In the Ecological scenario, export growth does not exceed GDP growth on average. This reflects a favouring of local products and the modest efforts made in reducing trade barriers. In the Developing scenario non-OECD regions, in particular Asia, exports many goods and services. However, less consumption growth in the OECD and trade barriers hamper trade to the OECD.

Figure 6.2 Export flows in 2020 (in billion US dollars (prices 1995))



Western Europe and the Rest OECD trade relatively less with each other. This is independent of the scenario. The reason is that both regions specialise in similar products: Intermediate and Capital Goods. The trade relations between the United States and Rest OECD and the United States and Western Europe are more intense. The reason is that the United States mainly specialises in agriculture and services. For Asia, Western Europe and the United States are relatively more important than the Rest OECD.

These observations are valid in all scenarios. The trade relations with the Rest of the World and Asia differ in importance in the scenarios. In the Schumpeterian scenarios trade flourishes. Also in the Ecological scenario trade with these regions is relatively more important. However, if trade between OECD and non-OECD regions is hampered, intra OECD and intra non-OECD trade flourishes.

Trade only flourishes if all countries reduce their trade barriers. Because OECD countries are endowed with high-skilled labour and capital and non-OECD countries are endowed with low-skilled labour, specialisation will increase if trade barriers between these regions are reduced or even eliminated. This is the case in the Schumpeterian scenario. The various OECD countries

have similar endowments of high-skilled labour and capital. Non-OECD countries look alike with respect to low-skilled labour. Therefore specialisation within the OECD or non-OECD will not be as pronounced as between OECD and non-OECD countries - given the level of aggregation in the model. The trade to GDP ratios is thus fairly low in the Malthusian and Developing scenario. Except for trade liberalisation, the high trade to GDP ratio in the Schumpeterian scenario depends also on a higher degree of international competition due to higher substitution elasticity in this scenario.

Except for the volume of exports, it is also interesting to analyse the composition of exports in the various regions. Table 6.1 presents some material on this. It only shows the results for the Schumpeterian scenario, because the pattern is the same for all scenarios. The size of sectoral export differs in the scenarios, but not the export pattern. In a globalisation scenario such as the Schumpeterian one, the differences between sectors are a bit larger than in other scenarios, due to far-going specialisation.

The reduction of import tariffs and export subsidies in the sector Agriculture benefits the land abundant and efficient producing regions. Examples are the United States and Rest OECD (Australia and Canada). Their exports towards Western Europe, and Asia drive many farmers from the markets in these regions.

Asia specialises in the production of Consumer Goods. In particular, the rise of South Asia & Rest is astonishing. All other regions lose their markets shares in this sector, but the effects for the transition countries are the biggest. They shift to (tradable) Services at the expense of Western Europe and Japan. Western Europe compensates this loss by exporting more Capital Goods. The export of Capital Goods is still very important in Rest of the OECD. Moreover, both countries export relatively more Intermediate Goods.

The size of the shifts in the export composition is much larger than in the other scenarios. This is the impact of the higher substitution elasticity in demand, which enforces competition at the international goods and services markets.

The totals for the world indicate that in particular trade in manufacturing will increase. This is not surprising, because the initial import tariffs are higher than in services (notice that we neglect the non-tariff barriers here). Moreover agriculture and raw materials become less important in final consumption and intermediate use, respectively. The reasons are low-income elasticity for agriculture and food, and the shift to more energy-efficient technologies.

Table 6.1 Average growth of sectoral exports in Schumpeterian scenario 1995 - 2020

country	Agriculture	Raw Materials	Consumer Goods	Intermediate Goods	Capital Goods	Services
Western Europe	3,4	4,3	5,7	8,2	6,0	3,9
United States	7,5	5,8	5,2	6,0	5,0	6,0
Rest OECD	5,8	3,8	4,7	7,4	4,8	2,8
Transition countries	4,5	1,8	3,6	6,4	6,4	7,2
Asia	3,2	5,6	12,4	10,2	10,6	7,9
Rest of World	4,8	3,0	7,3	8,1	9,5	7,5
World	5,2	3,6	9,0	7,9	7,2	6,0

source: WorldScan results.

7. Summary and conclusions

This paper presents the quantitative effects of four scenarios which are designed for a research project which analyses the effects of globalisation on (international) transport and consequently on the environment. We only present the economic outcomes of the scenarios. Ubbels *et al.* (2000) will use these results to quantify the demand for transport in the various scenarios and Olsthoorn (2000) will concentrate on emissions of international transport. We use our applied general equilibrium model WorldScan to quantify these scenarios.

In the *Schumpeterian* world, technological progress drives high economic growth in the whole world. Governments in the OECD and non-OECD regions pursue market-oriented and liberal policies, such that trade and business flourish. Globalisation is the bottom-line in this scenario. In the *Malthusian* scenario non-OECD countries cannot catch up with OECD. Social and political tensions in the former countries do not lead to open markets and prudent investment policies. Because of the increasing gap in wealth between the OECD and non-OECD many people migrate to the OECD. The *Developing* scenario assumes that developing countries catch up with the developed ones. Market-oriented and investment policies in the non-OECD lead to high growth rates, but the lack of cooperation within the OECD reduces the economic performance of the latter ones. However, countries do not focus on the environment. Environmental issues are, however, the primary concern in the *Ecological* scenario. People value the environment and well-being. For that reason, technological innovations are focussed on energy-efficiency, and less on economic growth.

An important driving force for economic growth is technical progress. Fast technical progress pushes economic growth as is the case in the OECD regions in the Schumpeterian and Malthusian scenarios, and for the non-OECD regions in the Schumpeterian and Developing scenarios. In high-growth scenarios, GDP per capita in 2020 is about 70% and 200% higher in OECD and non-OECD regions, respectively, while it is 20% and 80%, respectively, in low-growth scenarios. The differences in GDP levels between the scenarios are thus substantial, in particular for the non-OECD regions. Schooling and labour reallocation from low to high productivity sectors also contribute significantly to growth in the latter regions. The pace of schooling and reallocation is low in the most unfavourable scenario for the non-OECD: the Malthusian scenario. Here people also migrate to the OECD at a pace of 0.5% of the OECD population per year. In terms of the non-OECD population this is less than 0.1% per year.

High economic growth leads to increasing wealth and capital accumulation. Both saving ratios and investment ratios are positively correlated with GDP growth rates. Savings rates in the OECD are generally lower than in the non-OECD. This is partly due to slowing population growth in the OECD, and partly to technological catching-up in the non-OECD. As incomes per capita rise, consumption patterns change. Consumers spend relatively more money on services and less on agriculture. The shifts in consumption patterns are large for the developing regions where initially spending on Agriculture and Food is relatively high. These shifts are of course less pronounced in the Malthusian scenario, in which growth per capita is low. In the Schumpeterian and Malthusian scenarios, consumers from the OECD regions will also spend more on services because their incomes rise. In the Ecology scenario, all consumers will shift away from energy-intensive consumption.

In the Schumpeterian scenario we combine high growth with increased international linkages, and consequently trade liberalisation. Specialisation will increase if the barriers to trade between OECD and non-OECD regions are reduced or even eliminated, because the OECD countries are endowed with high-skilled labour and capital, and non-OECD countries are endowed with low-

skilled labour. The differences in comparative advantage between the OECD and the non-OECD are much larger than within the OECD or non OECD only. Therefore, trade liberalisation within only the OECD as in the Malthusian scenario or only within the non-OECD as in the Developing scenario, has much less effect on specialisation than in the Schumpeterian scenario. The trade to GDP ratios are much lower in the Malthusian and Developing scenario than in the Schumpeterian scenario. Due to partial trade liberalisation for all regions in the Ecological scenario this ratio is higher than in the Malthusian scenario. The demand for international transport follows these trade patterns. It is high in the Schumpeterian scenario and much lower in the other scenarios.

High economic growth stimulates the demand for energy and therefore the emissions of CO₂. Without environmental legislation or energy-saving production techniques emissions grow very fast as is the case in the Developing scenario. Emissions double until 2020. In the other scenarios energy-saving techniques are introduced. In the Schumpeterian and Malthusian scenarios global emissions still increase by 70%. In the OECD energy intensity decreases at an annual rate of 0.5% in those scenarios. Non-OECD countries save even 2% on energy in the Ecological scenario per year, and 1% in the Schumpeterian scenario. The OECD countries do not change their energy intensity in the latter scenario. Because technical progress is modest, it is fairly difficult to implement energy-saving technologies. A reduction in energy demand can be reached by introducing energy taxes. The OECD countries and transition countries levy these taxes according to the targets in the Kyoto protocol for 2010 and reduce the emissions by 1% per year after 2010. In the Ecological scenario, industrial and transition countries trade in emission rights in order to reach the emission targets. The worldwide increase in CO₂ of about 20% is completely emitted in the non-OECD.

From the comparison of the emission levels in the Developing and Ecological scenario it follows that mainly modest economic growth and energy-saving technologies contribute to lower emissions of about 5.3 million kilo tonnes C in the latter scenario. For the OECD the strict environmental legislation is also an important element. On a global level, however, strict legislation in these regions is far from sufficient to reach stable emission levels in 2020.

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Appendix Regional and sectoral concordances for WorldScan

1	<u>United States</u>	1	<u>Agriculture and food production</u>
2	<u>Japan</u>		Paddy rice, Wheat, Grains, Cereal Grains, Non grain crops, Vegetables, Oil seeds, Sugar cane
			Plant-based fibres, Crops, Bovine cattle, Animal products, Raw milk,, Wool, Forestry, Fisheries, Processed rice, Meat products, Vegetable Oils, Dairy products, Sugar, Other food products, Beverages and tobacco
3	<u>Western Europe</u>	2	<u>Consumer Goods</u>
	United Kingdom, Germany, Denmark, Sweden, Finland, Rest of European Union, EFTA		Textiles, Wearing apparels, Leather etc, Wood products, Chemical, rubbers and plastics
4	<u>Pacific OECD</u>	3	<u>Intermediate Goods</u>
5	<u>Eastern Europe</u>		Pulp paper, Petroleum and coal refinery, Nonmetallic minerals, Ferrous metals, Nonferrous metals
6	<u>Former Soviet Union</u>	4	<u>Capital Goods</u>
7	<u>Middle East and North Africa</u>		Fabricated metal products, Transport industries Machinery and equipment, Electronic equipment Motor vehicles and parts, Rest of manufacturing
	Turkey, Rest of Middle East, Morocco, Rest of North Africa	5	<u>Services</u>
8	<u>Sub-Saharan Africa</u>		Gas manufacture and distribution, Water, Construction, Financial, business and recreational services, Public administration, education and health, Dwellings
	South African Customs Union, Rest of Southern Africa, Rest of Sub-Saharan Africa	6	<u>Trade and Transport</u>
9	<u>Latin America</u>	7	<u>Electricity</u>
	Central America and Carribean, Mexico, Argentina, Brazil, Chile, Uruguay, Venezuela, Colombia, Rest of South America	8	<u>Oil</u>
10	<u>China</u>	9	<u>Natural gas</u>
	China, Hong Kong	10	<u>Coal</u>
11	<u>South East Asia</u>	11	<u>Other Raw Materials</u>
	Republic of Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan, Vietnam		minerals
12	<u>South Asia & Rest</u>		
	India, Sri Lanka, Rest of South Asia, Rest of the World		

Data

WorldScan has been calibrated on the GTAP database, see McDougall *et al.* (1998). The calibration year is 1995. From this data base we derive not only demand, production and trade patterns, but also labour and capital intensity of the various sectors.

The data and projections for population size and labour supply are from various sources. The United Nations (1995) provide demographic projections until 2050. The ILO (1996) provides projection rates on participation rates until 2010. We extrapolate the regional trends in participation rates between 1950 and 2010 to 2050. The data for the supply of low-skilled and high-skilled workers at a regional level have been taken from Ahuja and Filmer (1995). Workers are labelled high-skilled when they have completed secondary education or a higher level. Ahuja

and Filmer provide projections for many developing countries. We lack projections for the OECD, Eastern Europe and the Former Soviet Union. Therefore we use the Barro and Lee (1996) data on education. We derive a trend between OECD and non-OECD regions between 1960 and 1990 and extrapolate this trend until 2050. The data on the size of the informal sector are obtained from the WorldBank (1995) and the ILO (1998). The IEA (1997) provides data on energy volumes and emissions for the base year 1995.

Substitution elasticities

The results of the model depend also on the substitution possibilities in production and consumption. The production possibilities are described by a nested CES function. The upper level distinguishes between value added and intermediate goods. The elasticity between these two broad categories is 0.8. At the lower level value added is described by Cobb-Douglas function of the primary productive factors: capital, low-skilled labour and high-skilled labour. The intermediate goods are described by a nested CES function with a substitution elasticity of 0.8. The first nest is a CES function which includes energy and raw materials such as Oil, Coal, Natural Gas, Electricity and other Raw Materials. The substitution elasticity between these inputs is 2.0. The second nest is also a CES function with again a substitution elasticity of 0.8. which includes the other intermediate inputs.⁵ The utility function, from which demand for different consumption categories is derived, has been given a Cobb-Douglas specification. The substitution elasticity between any pair of consumption categories is therefore unity.

Traded, foreign goods are not perfect substitutes for domestic goods, and this also affects the outcome of simulations. The substitution between goods from different origin is not perfect. WorldScan employs an Armington-type assumption. However, the price elasticities of demand considerably increase over time. The model employs different assumptions for Raw Materials, Agriculture, Manufacturing and Services. The long-run substitution elasticities in the benchmark case are 17, 13, 7 and 5 respectively.

⁵In case of the sector Electricity, the input Electricity is a part of the nest with other Intermediate inputs instead of the nest consisting of Energy and Raw materials.