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WELFARE AND EMPLOYMENT EFFECTS CAUSED BY INTERNATIONAL TRADE:

A qualitative and quantitative analysis with regard to innovation friendly policies

Study as part of the IPTS project on
"*Impact of Technological and Structural Change on Employment: Prospective analysis 2020*"

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Executive Summary

This report describes the model-based analysis of economic development and employment impacts of three alternative technology policies in the European Union. The analysis is supported by the use of the integrated assessment model ASTRA, which is extended in the course of this project to become the ASTRA-E model.

In the analysis three policy scenarios are compared to a *Baseline Scenario*. The *Baseline Scenario* is based on the assumption that the current patterns in R&D and innovation policies, consumption and labour productivity will continue. While all alternative policy scenarios involve an equal overall increase in innovation and R&D expenditures, they differ from each other in the way the increase is distributed among the sectors of the economy. As a consequence of the R&D expenditures the sectoral productivity is altered depending on the distribution of the R&D expenditures. The three technology policy scenarios that are compared to the *Baseline Scenario* are characterised as:

- *Uniform scenario* assuming a uniform increase of sectoral productivity supported by a sectoral balanced technology policy.
- *Diversified scenario* assuming an increase of sectoral productivity that is allocated to sectors that already demonstrate strong performance at least on a regional basis. This scenario comes close to current regional economic structures and diversification strategies.
- *Concentrated scenario* focusing the increase of sectoral productivity on the economic sectors, which show the highest growth potential. The policy is accompanied by a change in consumption patterns towards new products invented by the technology policy.

Theoretical and empirical analysis demonstrates that three impacts have to be considered in the analysis: *labour force savings and output growth* by process innovation, employment increase by improved *competitiveness driving exports* and employment changes by *induced demand for new products*. It is aspired to incorporate those mechanisms in the model.

Absolute GDP and employment increase in all scenarios. Comparing the policy scenarios with the *Baseline Scenario* GDP growth is fostered in all policies, while in the *Uniform* and *Diversified Scenario* employment growth just reaches the level of the *Baseline Scenario*. The *Concentrated Scenario* is most advantageous being the best in terms of economic growth and employment. Additionally a positive effect on international competitiveness can be identified by the model. However, in terms of percentual changes this effect is lower than the impacts of labour savings and output growth as well as the changes of individual demand. The effect of labour savings and the induced demand effect are highly relevant. The latter effect overcompensates the former such that at the end of the day the employment is increasing in the *Concentrated Scenario*. However, the probability for induced demand effects to occur may be substantially lower than that of the labour saving effects.

1 Introduction

In the framework of the IPTS project "*Impact of Technological and Structural Change on Employment: Prospective analysis 2020*" on behalf of the European parliament the ASTRA model is applied to produce quantitative forecasts of employment figures considering different alternative technology policy strategies. The ASTRA results are compared with results from GEM-E3 a computable general equilibrium (CGE) world model also applied for this study. Based on the results of the two models qualitative analysis on the required skills of the future labour force is carried out.

In this report only the work done on the ASTRA model and the ASTRA results are described. The report commences with a brief description of the ASTRA model focusing on the macroeconomics module of ASTRA. For the purpose of the IPTS project three model parts of ASTRA have been strengthened or newly developed to form the so-called ASTRA-E[1] model:

- The impact of improved competitiveness through technological improvements that changes the export-import position of the exporting European countries with the rest-of-the-world regions (exports-RoW);
- The impact of increasing labour productivity that tends to reduce employment and on the other hand leads to an increase in output paired with increased income (process innovation);
- The impact of new products that are invented by technological research and lead to new demand (product innovation).

This is part of chapter 3 in which the model completions and the adjustments of exogenous assumptions taken over in ASTRA-E for the IPTS project are described. The main modelling task in ASTRA-E is the development of a sophisticated export-model to analyse the competitiveness effects of the policies. Hence, a theoretical analysis is undertaken to work out the relevant theoretical background for export and foreign trade modelling in the context of ASTRA. This is followed by a description of the implemented export-(import) model. The two models to reflect process innovation and product innovation have been already implemented in detail in ASTRA during previous projects. In this project the statistical baseline and the exogenous forecast of these models have been adapted to the IPTS project needs. This is decribed in the subsequent sections of chapter 3.

Chapters 4 and 5 present ASTRA-E results for the *Baseline Scenario* and the Policy Scenarios focusing on effects on output, employment and exports. Results are presented to show regional and sectoral differences. For the *Concentrated Scenario* an analysis of the contributions of process innovation, competitiveness and product innovation to the overall changes is undertaken.

The report closes with a brief comparison between the GEM-E3 and the ASTRA-E results and a set of conclusions. An annex is added to describe the transfer of data from databases with different standard classifications (e.g. ISIC 2, OECD STAN) into ASTRA sectors.

[1] the "E" indicates the focus of this ASTRA application on employment.

2 Brief description of the ASTRA model

The ASTRA model was developed in the project on Assessment of Transport Strategies (ASTRA) financed by the European Commission former DG VII (now DG TREN).[2] The objective of ASTRA was to develop a tool for analysing the long-term impacts of the European common transport policy (CTP). The spatial scope for ASTRA covers the EU15 countries and the time horizon is the year 2026. As assessment tool an integrated system dynamics model comprising four modules is implemented that is based on state-of-the-art models of four different research disciplines: macroeconomics (MAC), regional economics and land use (REM), transport (TRA) and environment (ENV). The aim of the ASTRA MAC module is to provide an aggregate macroeconomic environment in which the REM, TRA and ENV modules are embedded. Together with the population model in the REM the macroscopic information on national and continental level influences is integrated into the model. This has the advantage that feedback loops, which commence on the micro- or meso-level in one of the other modules (e.g. transport expenditures for one mode in one distance band in the TRA) and then end up with an effect on the national level, can influence the originating module such that the feedback loop is closed by the integration of the MAC module. Closing the feedback loop then implies to establish either macro-micro-bridges (e.g. from GDP to goods flows) or vice versa micro-macro-bridges (e.g. from transport investments in vehicle fleets to overall investments). The structure of the models in ASTRA is presented in Figure 1.

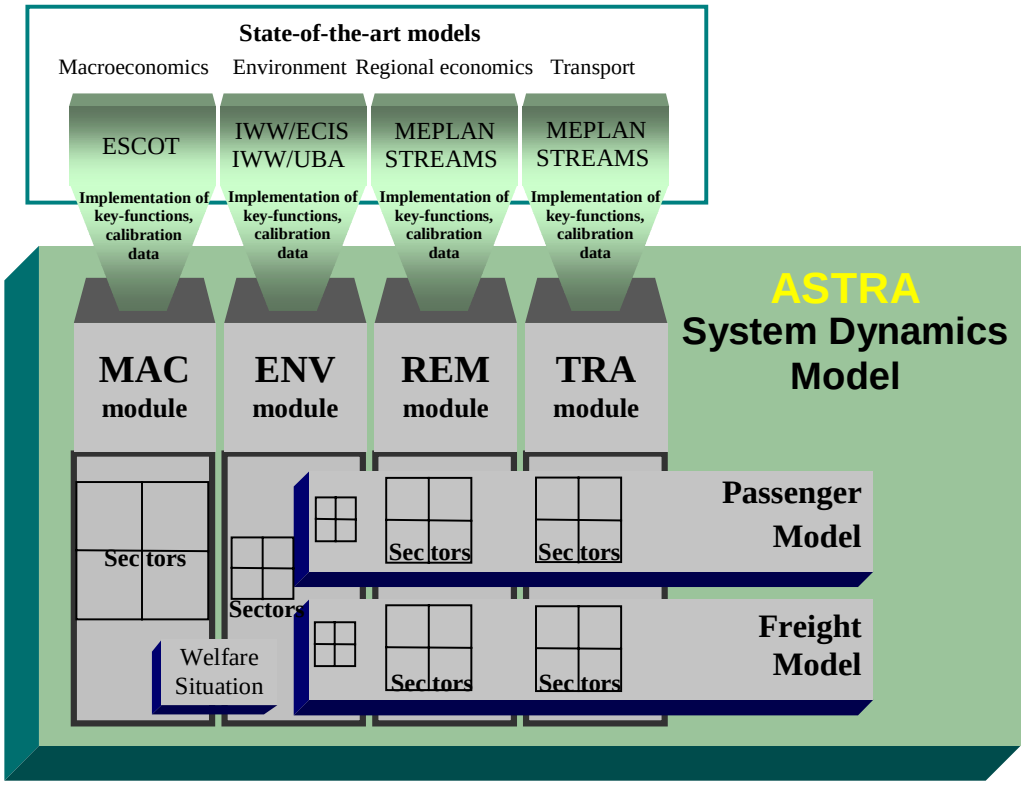

Figure 1: Basic structure of the ASTRA model

[2] ASTRA (2000)

For the purposes of analysis the EU has been split into 4 macro regions. These have been chosen to provide regions of approximately the same size and containing national economies with roughly similar characteristics.

- Macro region E1 = EUeast: Germany and Austria.
- Macro region E2 = EUwest: France, Belgium, the Netherlands and Luxembourg.
- Macro region E3 = EUsouth; Italy, Spain, Portugal and Greece.
- Macro region E4 = EUnorth: UK, Ireland, Sweden, Denmark and Finland.

Each of the four regions is modelled using the same macroeconomic framework, which is adapted to regional specifics by different parametrisations. All monetary values are calculated in real values of 1995 EUROs. Most variables are calculated net of all taxes as taxes are treated separately. The MAC works on a yearly time basis.

The MAC module is constructed as a demand-supply interaction model. In the short run the demand side is dominating (Keynesian approach) while in the long run the supply side determines the path of development. It follows a similar approach as the macroeconomic module within the ESCOT model, which has been developed as part of the project on Environmentally Sustainable Transport (EST) of the OECD.[3] It consists of three major elements:

- supply side model based on supply of production factors,
- demand side model based on the elements of final demand and
- sectoral interchange model based on an input-output table.

The interaction between supply and demand side can be adjusted such that the model can simulate supply-demand balanced economies but also either a supply side driven or a demand side driven economy. In the base run both sides are treated as their influence is of the same importance. The basic structure of the MAC including the completions for the ASTRA-E model is presented in the following Figure 2. The subsequent three sections describe the three elements in more detail

[3] SCHADE B. *ET AL.* (1999), SCHADE B. *ET AL.* (2000)

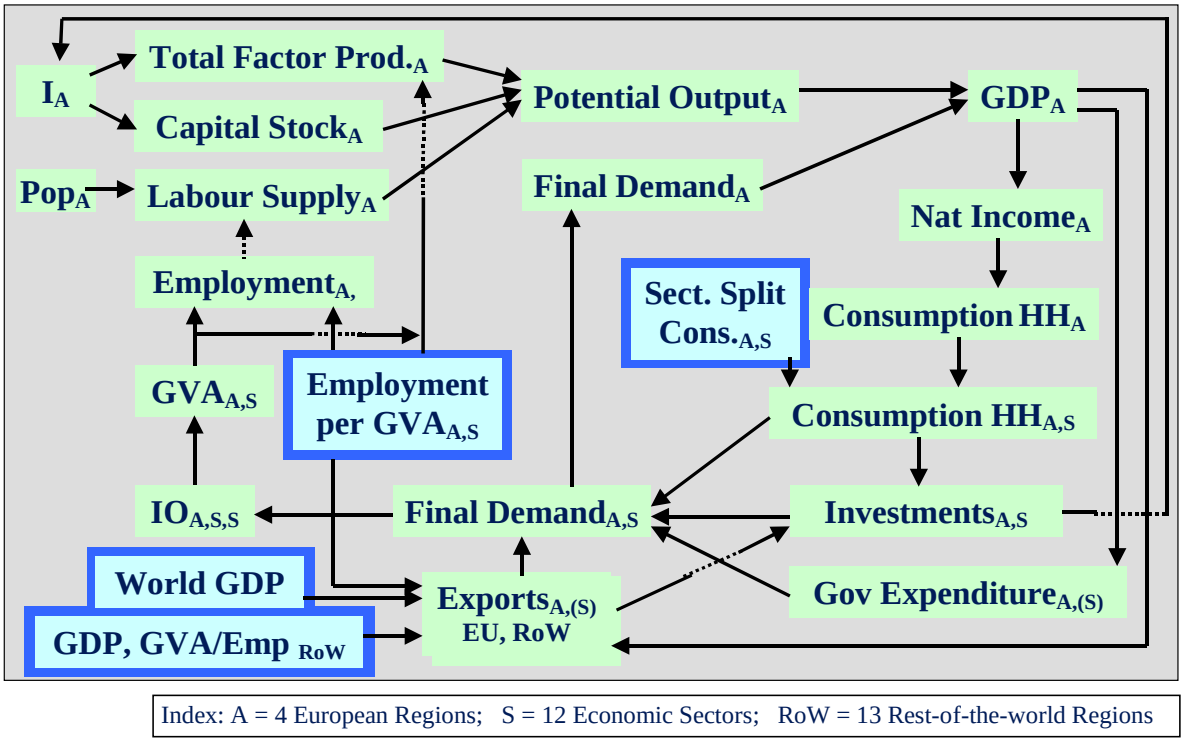

Figure 2: Basic structure of the models in the MAC module in ASTRA

The boxes with the bold (blue) frames in Figure 2 indicate the major exogenous variables that are provided by experts of the IPTS project for the forecasting period. Especially "Employment per GVA" and "Sectoral Split Consumption" are applied to define the differences in the policy scenarios of the project.

2.1 Supply side model

Basic element of the supply side is a production function of Cobb-Douglas type that incorporates the three major production factors labour supply, capital stock and natural resources as well as technical progress referred to as total factor productivity (TFP). Labour supply, capital stock and total factor productivity are calculated endogenously. The influence of natural resources is yet considered exogenously. Labour supply in the Cobb-Douglas function stands for the total number of yearly worked hours. As such it is based on total employment calculated within the employment model and the number of average yearly worked hours. The capital stock depends on the initial gross capital stock, the investment (capital goods including transport investments) and the scrappage of the capital stock. Total factor productivity in ASTRA-E has been endogenised, at least partially, considering the exogenous sectoral labour productivity changes weighted by the endogenous sectoral gross-value-added (GVA) as well as the endogenous sectoral investments that have been weighted by the sectoral innovation potential.

It should be pointed out that technical progress is only included on the supply side, such that if the supply-demand balance is moved strongly towards the demand side the technical progress has only a minor influence on the economic development in the model. However,

empirical research has shown that in the long run technical progress drives the economic growth to a large extent, such that a balanced or a supply side driven development is simulated.

2.2 Demand side model

The aggregated variable on the demand side is the final demand, which is driven by consumption, investments, government expenditures and export-import balance. The basic approach is to calculate those variables on the sectoral level and then aggregate them where necessary to regional level. Consumption and investment are split into a share that is independent from transport (macroscopic view) and a share that is dependent on the development of the transport markets given by the TRA and the ENV (microscopic view). Government expenditures develop according to GDP development, while export is driven by the aggregated demand for the three other variables in the original ASTRA model. For ASTRA-E the update of the export-import model is implemented making it dependent on relative sectoral productivities, GDP growth of the importing countries and world GDP growth. This model is explained in more detail in section 3.2.

Future expectations on the demand side indicate further growth of national income respectively personal income, which will lead to growing consumption. In the base run a reduction of the share of government expenditures on GDP is not expected though it could be a reasonable and probable policy in the future. Exports in general will grow stronger than GDP.

An important model on the demand side is the consumption model that determines the sectoral consumption of private households. The baseline for the consumption model is given by national income that is derived from GDP subtracting depreciation, indirect taxes and subsidies. The former two influences are calculated endogenously while subsidies are taken exogenously. National income is used to calculate the possible consumption of households considering private savings. Then consumption is disaggregated twofold: first the sectoral split into 12 economic sectors is performed and secondly a split into consumption for non-transport purposes and consumption for transport purposes is introduced. In fact, the latter split only affects sectors that are **directly** influenced by transport, which are the sector 3 including petroleum products, sector 5 including car manufacturing and sector 10 including passenger transport services (bus, rail, air).

With this approach substitution effects between transport and non-transport consumption are considered in a way that e.g. a decrease of consumption in transport sectors leads to a non-negligible increase of consumption in non-transport sectors. This does not mean that there will be a complete compensation because of complementarities between transport and other activities and incentive effects.

2.3 Sectoral interchange model

The objective of the sectoral interchange model is to consider the indirect effects of the sectoral developments e.g. of final demand in the ASTRA model. Its basic element is an aggregated input-output-table (I-O-table) with the following twelve economic sectors[4]:

1. Agriculture, forestry and fishery.
2. Energy, water-, mining products, crude oil.
3. Chemical-, mineral-, plastic- and petroleum products.
4. Ferrous and non-ferrous ores and metals.
5. Steel products, machinery, transport equipment.
6. Electrical-, optical goods, office and data processing, toys.
7. Textiles, clothing, paper, wooden goods.
8. Food, beverages, tobacco.
9. Building and construction.
10. Services for repair, wholesale and retail, transport, communication.
11. Other market services like lodging, catering, credits, insurances.
12. Non-market services.

The sectoral disaggregation is also applied for other economic variables like consumption to be able to consider the direct effects of transport developments within their corresponding sectors as well as the indirect effects in the sectors supplying intermediate products.

The data for the I-O-table is taken from the harmonised EUROSTAT R25 I-O-tables for 1995.[5] The structure of the tables is not kept constant over time, instead the change of final demand alters the third quadrant of the I-O-table. Updating the inverse input coefficients and recalculating the I-O-table leads to a change of the sectoral relationships within the first quadrant of the I-O-table.

Two major outputs from the sectoral input-output-model are the sectoral gross-value-added that is used for the calculation of employment and the GDP share for goods production that forms an input for the transport generation model within the REM.

In the future it is expected that the service sectors will increase stronger than the agricultural sector and the industrial sectors. In other words, the share on GDP of the service sectors will increase, while the goods sector´s share will decrease.

[4] The concept of an aggregated input-output-table is established in the German system of national accounts, where a detailed I-O-table with 58 economic sectors and an aggregated I-O-table with 12 sectors is used (e.g. STATISTISCHES BUNDESAMT 1997a).

[5] The EUROSTAT Input-Output-Tables can be ordered from the EUROSTAT datashop in Luxembourg in electronic format (EUROSTAT 1995)

3 Completing ASTRA to develop the ASTRA-E model

This chapter describes the model extensions to develop the ASTRA-E model and presents the relevant exogenous assumptions that have been taken over to adapt ASTRA-E to the *Baseline Scenario* of the IPTS project. The chapter starts with a qualitative analysis of the relationships between welfare, trade and innovation policies followed by the corresponding implementation of the foreign trade module in ASTRA-E. The chapter is completed by the adjustments implemented in ASTRA-E to model process innovation and related changes of Total Factor Productivity (TFP) as well as product innovation.

3.1 Qualitative analysis of welfare and employment effects caused by international trade with regard to innovation friendly policies

While in 1776 Adam SMITH argued in his famous masterpiece 'Wealth of Nations'[6] that economic growth and overall welfare is strictly related to the degree of the division of labour, which in turn determines productivity, RICARDO pointed in 'On the Principles of Political Economy and Taxation' to the risk of arising technological unemployment (RICARDO, 1817). After almost two centuries in particular the question whether technological development implies positive or negative net-employment effects is still discussed vividly among economists. Moving beyond the classical framework it is often referred to SCHUMPETER who identified the innovative entrepreneur as vital power for a growing economy (SCHUMPETER, 1911) that can be considered to be crucial for a satisfying level of employment[7]. Although MEADOWS et al. argued convincingly against unlimited growth in their famous reports for the Club of Rome 'Limits to Growth' and 'Beyond the limits', it is reasonable to assume that sustainable development can be realized without declining industrial output and shrinking population. Therefore in particular the material productivity must be improved significantly[8] (MEADOWS et al., 1992). However, improvements of material productivity can not be achieved without permanent process innovations, which simultaneously will indeed increase labour productivity, too. Pessimists assume that increasing labour productivity would consequently lead to a rationalisation of workplaces and would therefore intensify problem of unemployment. The inescapable drop of private consumption would speed up the negative feedback loop. Optimists do not deny dismissal effects but argue that on the one hand the sector developing innovative capital goods would add new jobs, and that due to higher productivity in all affected sectors (generating and

[6] The full title is 'An Inquiry into the Nature and Causes of the Wealth of Nations'

[7] A brief overview of the historical aspects is e.g. given COOPER, 1994

[8] "*A transition to a sustainable society is probably possible without reductions in either population or industrial output. A transition to sustainability will require, however, both deliberate social constraints on further population and industrial growth and significant improvements in the techn ical efficiency with which the earths resources are used."* (MEADOWS et al., 1992, p. 206)
"*All those who had helped to shatter the myth of growth ... were ridiculed and figuratively hanged, drawn, and quartered by the loyal defenders of the sacred cow of growth. Some of those ... accuse the* [Limits to Growth] *report ... of advocating ZERO GROWTH. Clearly such people have not understood anything, either about the Club of Rome, or about growth. The notion of zero growth is so primitive – as, for that matter, is that of infinite growth – and so imprecise, that it is conceptual nonsense to talk of it in a living, dynamic society*." (PECCEI quoted by MEADOWS et al., 1992, p. 209)

absorbing process innovation) higher wages and salaries could be paid[9]. Furthermore process innovation is normally accompanied by product innovation, which should generally stimulate the consumption. Therefore optimists conclude that the compensation process of technological development will eventually ensure stable growth-rates and release the overall pressure at the labour market. Objections that refer to market saturation are often countered with the argument of globalization and increasing exports. However, taking international trade into account either the negative employment effects may just be shifted to less productive or less industrialized countries which in the long run could weaken foreign sales market and which may in some cases contradict the efforts of development aid, or a change of the production site may occur. Though innovation and productivity increases are probably crucial for qualitative growth of an economy the net effects on the labour market are hardly predictable. In 'The Employment Effect of Technical Change' KATSOULACOS concludes that although process and production innovation may finally cause positive employment effects, it is - if at all – only product innovation that influences the development of the labour market in the desired way in the short run (KATSOULACOS, 1986). GRUPP also underlines the importance of innovation for a healthy economy but points to the hardly predictable employment effects: "It would be erroneous to assume that a leading technological position will always lead to positive employment effects in a specific national economy. How the employment effect resulting from technical progress appears according to quantity and sign is a question left substantially unanswered by the available literature" (GRUPP, 1998, p. 257).

3.1.1 Technological Development and Trade

Public R&D expenditures are often justified by the need of 'International competitiveness'. However, a clear definition of 'International competitiveness' is often missing. Considering the R&D expenses the political goal could rather be described as achieving 'Structural competitiveness'. Though out of a wide range of industries, only selected sectors will benefit directly from public R&D development, other branches may, via (often-overestimated) multiplier effects, increase productivity and therefore (sectoral) competitiveness too. Consequently exports will rise, which will generate new jobs eventually. However, since these jobs obviously depend heavily on the export-performance, they are also sensitive to any disturbances on the world market. Furthermore sectors that are affected under average by this policy can, due to factor movements, be expected to decrease their outputs significantly. It makes sense to assume that the decreasing output is substituted to a large extend by increasing imports, which in turn will put the associated jobs at risk. Since it is likely that the induced structural change will eliminate 'low productivity sectors' first, political decision-makers should be well equipped to face these negative employment effects, induced by their indeed necessary impulse of structural change.

Since politicians and economists tend to take an idea seriously, only if it is modeled in a proper way (KRUGMAN, 1995), the general issues raised above will be discussed more formally in the following. However, it should be pointed at the beginning to the fact that there are only few models that deal with the main characteristics of innovation friendly policy - at

[9] In fact some recent wage settlements in Germany among unions and employer link wage increases to productivity increases.

least temporary imperfect competition and thus increasing instead of constant returns to scale which eventually induce structural changes, - in a really satisfying way [10]. Exceptions of the rule are e.g. the SOLOW-SWAN model with exogenous technological development (SOLOW, 1956; SWAN, 1956), a model taking into account 'learning by doing' effects developed by BARRO / SALA-i-MARTIN (1995), the HELPMAN-KRUGMAN approach developed in 1985 or the GROSSMAN-HELPMAN model (1991) with endogenous technological development. Though we are aware of these complex models, more research would be necessary to implement a similar model into the ASTRA-E approach. However, the applied simple model should, despite the assumption of perfect competition, provide some valuable results. Though innovation friendly policies will affect industrial, social and natural environment in many different ways the analysis will focus on two main impacts. First it is assumed that innovation policies via improvements of the educational system will increase human capital in the medium and long term. To model this effect the production factor labour is subdivided into skilled and unskilled labour [11]. The measure is not sector specific but aims to generally improve qualification of current and future workforce. The second variant focuses on process innovation of specific sectors. As mentioned already this measure is assumed to increase sectoral productivity and thus to achieve by purpose comparative advantages for selected sectors versus foreign competitors. Indeed both measures are established (and likely) to strengthen a lasting structural competitiveness[12]. GRUPP argues that "the resulting imbalance is not, however, equalized by international, but instead, leads to a stable technological specialization of the country based on the cumulative learning within its national economy, thus distinguishing the country from others. The accumulation of specific knowledge places the national economy in a position of being able to continually allocate R&D resources and to thus maintain the national specialization advantages" (GRUPP, 1998, p. 277).

Figure 3 gives a first (not yet formalized) insight of determinants of foreign trade that are, according to the model, directly or indirectly affected by technological changes.

[10] See e.g.HELPMAN / KRUGMAN, 1985, p. 31; KRUGMAN, 1995, p.14

[11] This classification traces back to the GROSSMAN-HELPMAN model, published in 1991, see also GRUPP (1998)

[12] As mentioned already the structural competitiveness will not yield automatically positive employment effects.

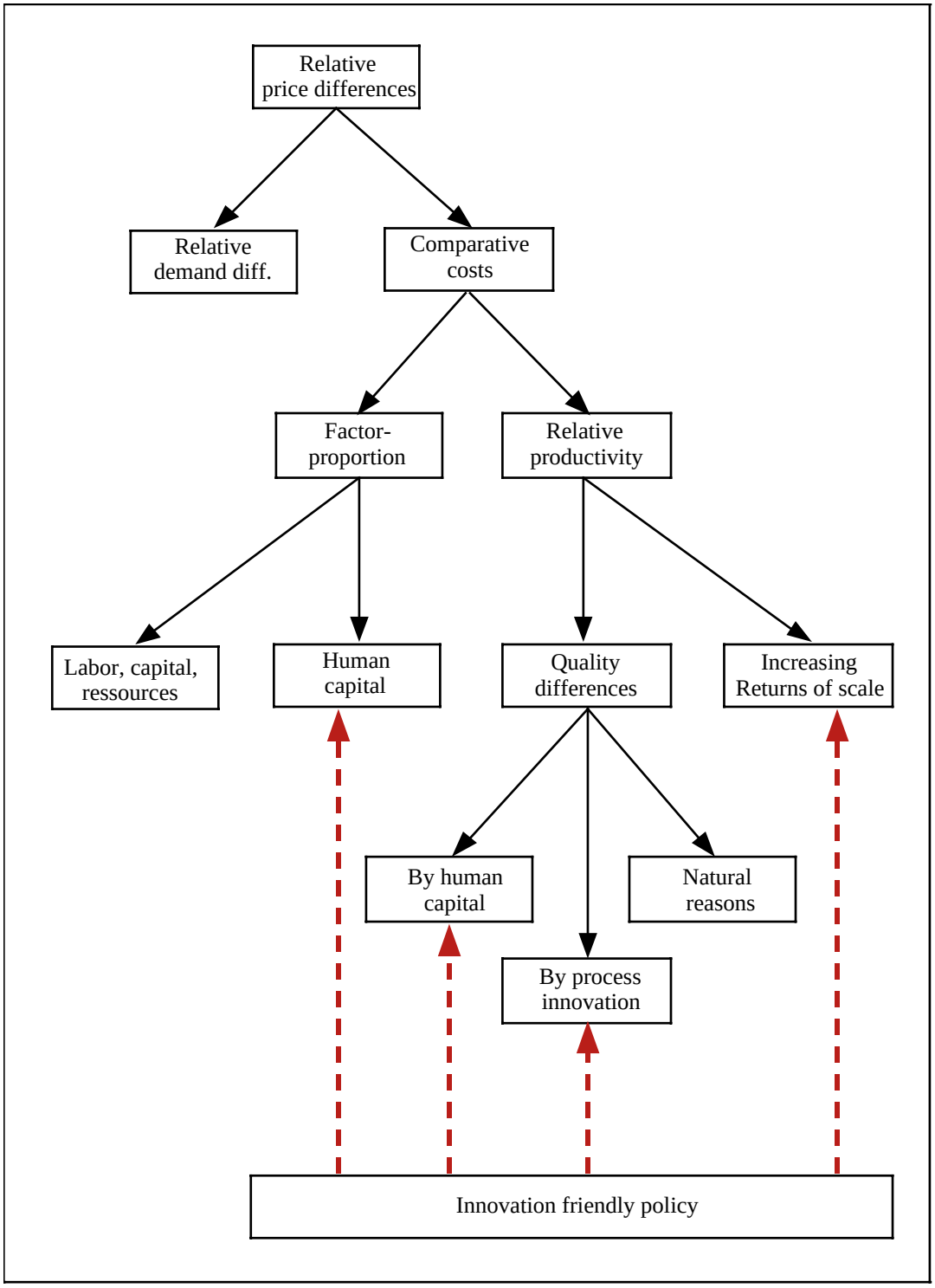

Figure 3: Determinants influencing foreign trade
Source: Based on a figure presented by GRUPP (1998, p. 275)

Simultaneously the figure provides an overview of the not-considered determinants. Most important the model neglects spatial aspects and transportation costs as well as monetary effects caused by a rising or falling €. Both issues have been elaborated in a very sophisticated way e.g. by BRÖCKER (1998), MUNDELL (2000).

Following the factor-proportion theorem developed by HECKSCHER and OHLIN[13], each country will focus its production and consequently its export on those goods, which depend heavily on the production factor the country is best equipped with. 'Capital rich' countries will export 'capital intensive' goods and 'labour rich' economies in turn focus on 'labour intensive' goods. Since the 'Human capital' (or skilled labour) is now introduced as separate production factor, it could be argued that economies with rich human capital endowment will eventually focus export on technological superior goods.

However, the HECKSCHER-OHLIN theorem is also based on the assumption of equivalent technology (and therefore productivity) for the trading countries. But since the technological advantage is one of the main goals of innovation friendly policy this assumption of the HECKSCHER-OHLIN theorem will be abandoned in this study. Instead the presented model, which follows an idea carefully described by KOWALSKI, includes the idea of comparative advantages, which, despite specified a long time ago by RICARDO[14], still can be identified as one driving force for international trade, if in contrast to RICARDO comparative advantages are not considered to be given exogenously but generated by well directed technological development.

Besides the already mentioned assumption of perfect competition, the model is dealing with two groups of goods and two economies, with relative prices and known aggregated preferences.

3.1.2 Alternative A: Increasing Human capital via improved educational system

The sectoral data for the European macro regions (see ASTRA-model) are subdivided by 12 sectors. The cumulative output of technological superior goods forms goods of group 1 while the output of the other sectors belongs to goods of group 2. The factors 'Resources', 'Labour (unskilled)', 'Capital' and 'Human capital' (Skilled labour') are fully employed to produce either goods of group 1 or of group 2. Any possible combination of output is given by the following transformation curve:

[13] The HECKSCHER-OHLIN model is described in detail e.g. by APPLEYARD, FIELD, 1997 or BREUSS, 1997 or SIEBERT, 1994

[14] The RICARDO model of comparative costs is described in detail e.g. by ROSE, 1981 or BREUSS, 1997

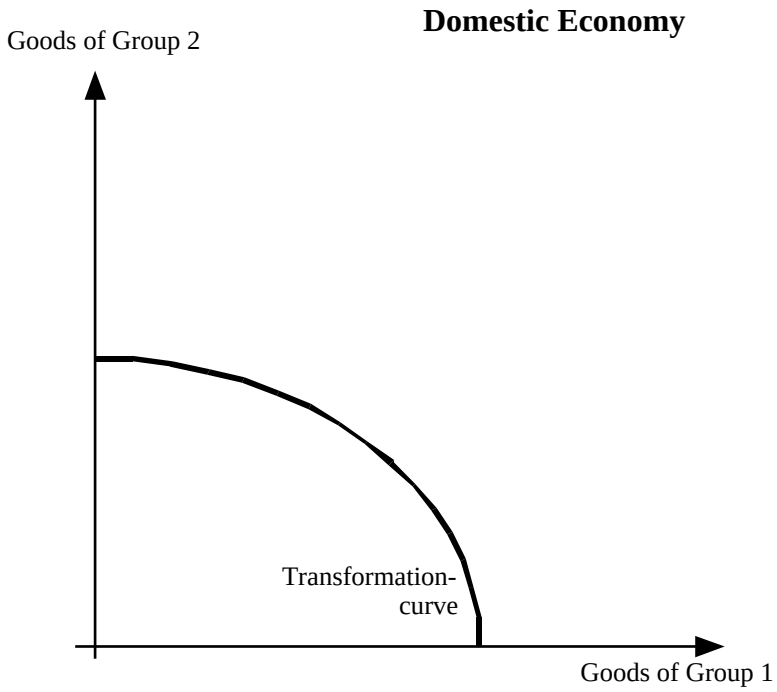

Figure 4: Transformation curve

Production is realized if the domestic budget (determined by all kinds of incomes) tangents to the transformation curve. Without international trade the production would automatically determine the consumption, i.e. the highest available preference curve also tangents this point.

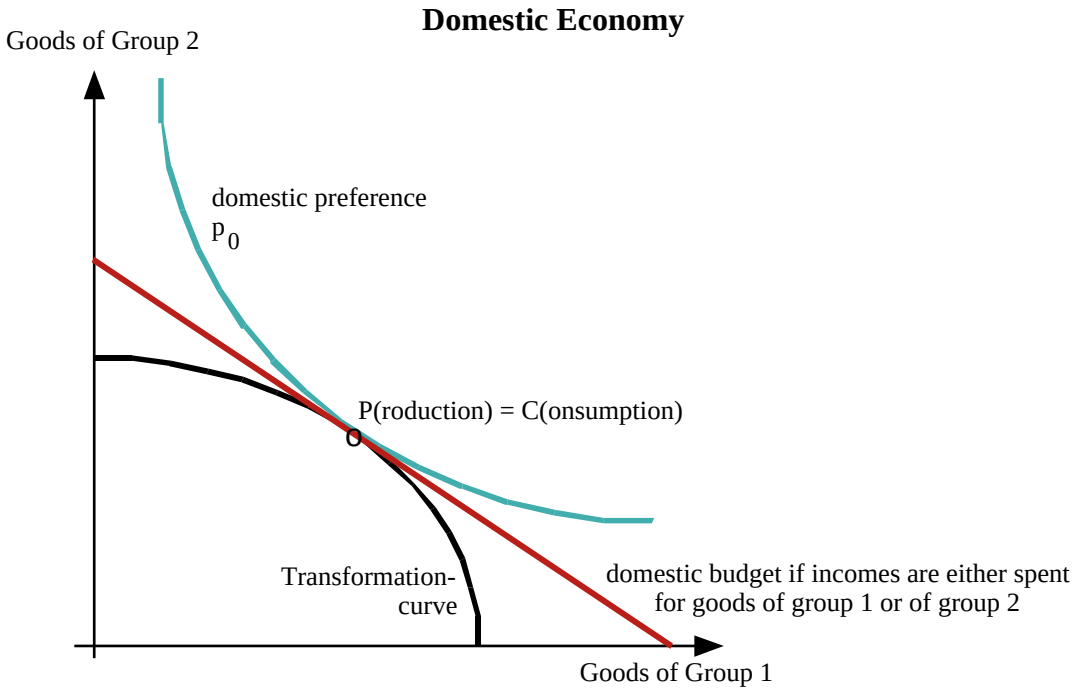

Figure 5: Production and consumption without trade

Of course external and intra-EU trade is one of the main ideas of modern economics, such that instead of domestic budgets (here relative) world prices determine the domestic consumption. It is now assumed that goods of group 1 are relatively more expensive at the world market, i.e. the 'world-price-line' is steeper than the 'domestic price line'. Since consumers are eager to maximize their benefits this yields to a separation of production P and consumption C, which implies exports and imports and which eventually leads to an increased welfare signed by a jump to a higher preference p_1.

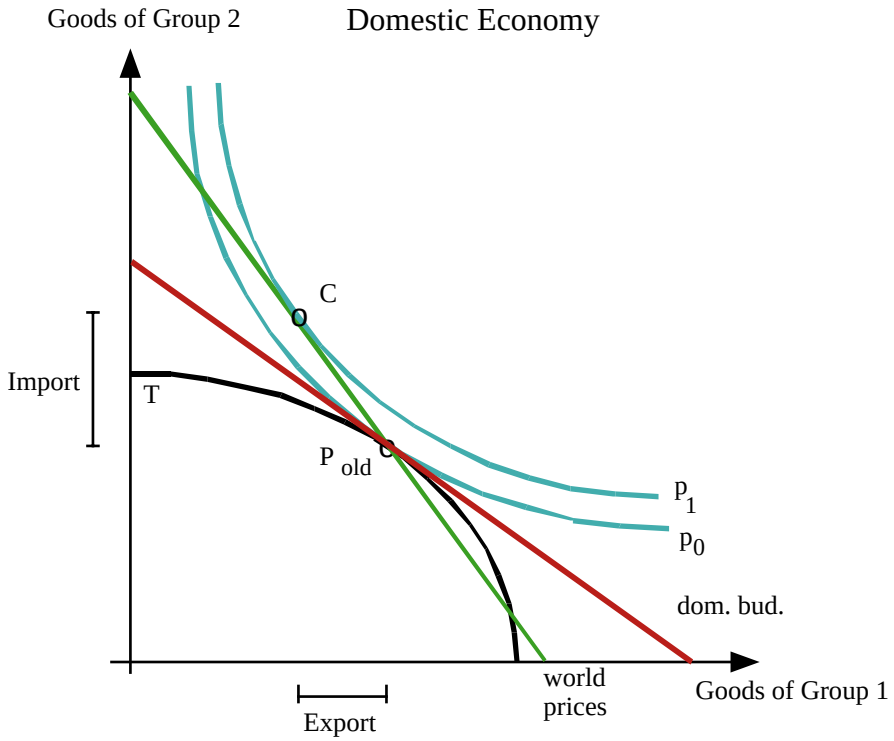

Figure 6: Production and consumption with trade and fixed production

Figure 6 shows the advantages of free trade, even if the production is considered to be fixed. However, since production factors in Figure 6 are not fully employed anymore the economy will tend to shift production P. The optimal production can be derived by a parallel shift of the 'world prices' until transformation curve and world-price line just tangent. Notice that the shifting does not imply a change of the relative prices. In fact due to the assumption of perfect competition overall supply and relative prices are considered to remain constant, despite additional production. For the sake of clarity the domestic budget and the preference p_0 are not given in Figure 7.

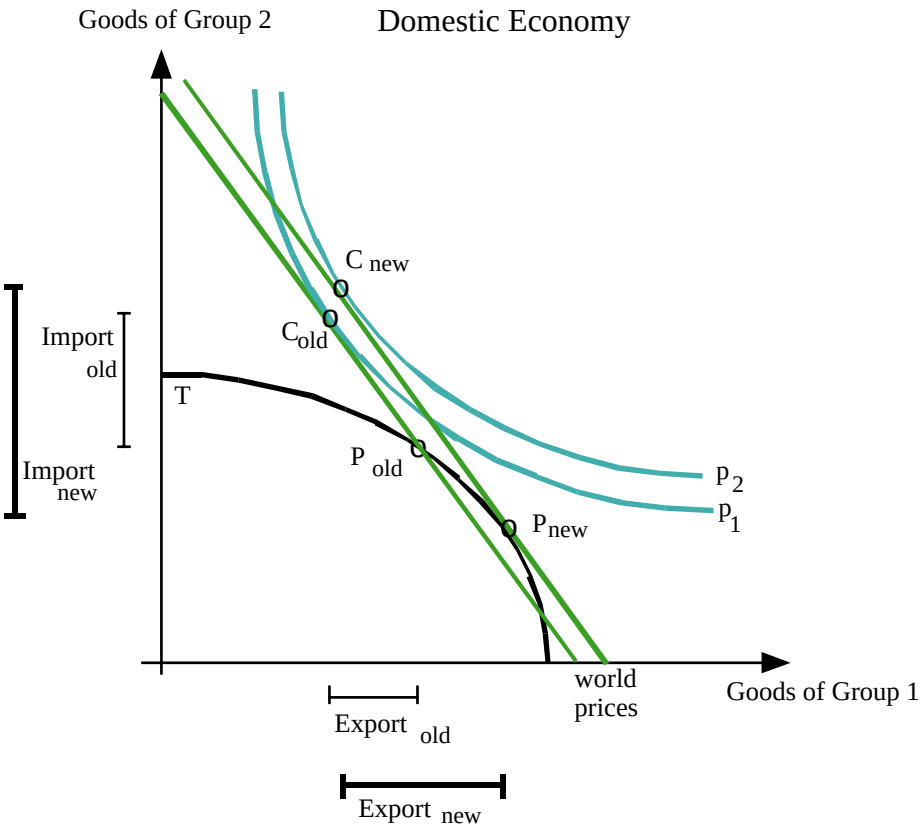

Figure 7: Production and consumption with variable production

Clearly the shifting or specializing of production leads to increasing welfare, exports and imports. Since the additional production of goods of group 1 is facing decreasing production of goods of group 2 the sign of the net employment effect can not be projected easily. It is now assumed that Figure 7 is closest to the current situation for the four macro regions of Europe. What happens if intensive investments on human capital finally pay off? The effect would be equivalent with additional capital. Since all sectors could potentially benefit by the improvements of the educational systems, the transformation curve would be shifted parallel outwards[15]. Now the world prices are shifted again, such that eventually the next preference p_3 is reached. In Figure 8 old production, consumption, export and imports are omitted. The revised parameters are marked by 'hci' (human capital improvements)

[15] Though from the microeconomical point of view the shifting would imply a quantitative rather than a qualitative improvement it is assumed, that qualitative improvements will finally result in increasing sectoral monetary output. Thus the effect would be similar to rising quantitatives. Certainly an exact parallel shift will not occur, since human capital is more important for goods of group 1. However, still all sectors will benefit by improvements and the effects with a not exactly similar shift would be similar.

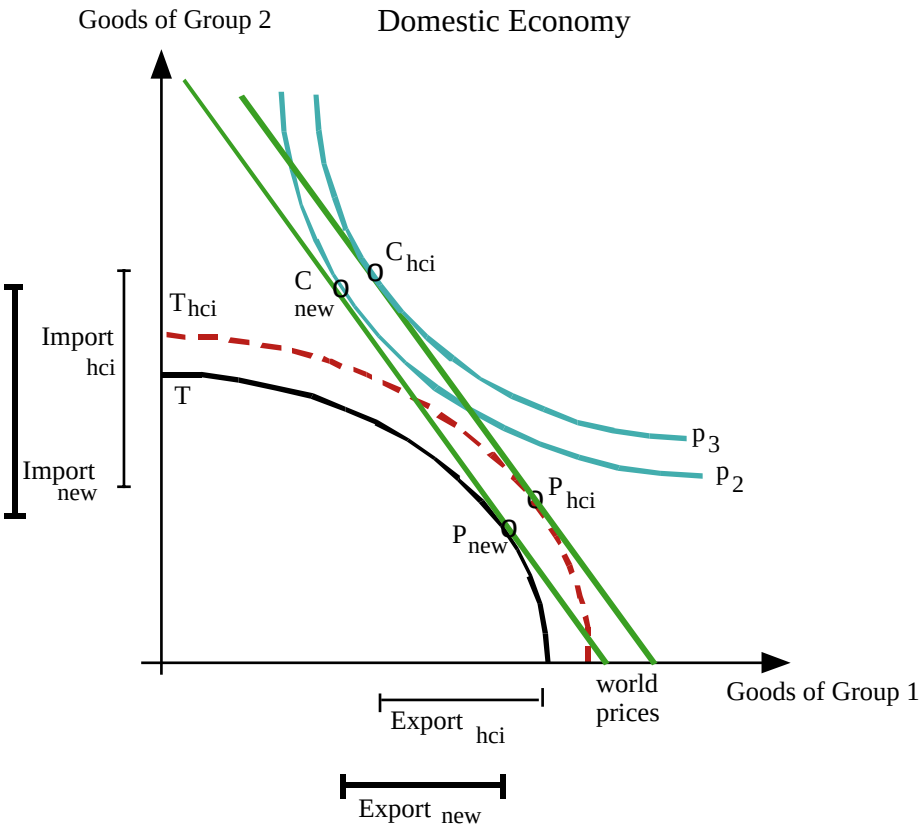

Figure 8: Production and consumption after human capital improvements

Though the newly established export and import levels hardly differ from former ones, (imports seem to decrease slightly) the policy leads to positive production effects for both groups, i.e. the above described extended potential for all sectors is implemented. Thus the policy may not favor necessarily the international accounting balance, but should nevertheless contribute to the strengthening of structural or international competitiveness. However, due to continous structural changes there is of course no guarantee that all sectors will benefit by such a policy. Furthermore the rather simple model abstracts from a variety of important aspects. But still the overall results including the net employment effects look rather favorable and despite the simplicity of the model the consequent implementation of such a policy can be recommended strongly. Considering the already defined scenarios this alternative could be interpreted within the following scenarios

**Uniform scenario*

**Baseline Scenario* and partly

**Diversified Scenario*.

3.1.3 Alternative B: Comparative advantages via process innovation of specific sectors

While the investment in human capital is supposed to affect production of all sectors in the long run, effects of specific R&D expenditure will differ significantly for the considered sectors. According to a study elaborated by the 'Institut für Systemtechnik und Innovationsforschung' and the 'Niedersächsisches Institut für Wirtschaftsforschung' about sectoral R&D expenditures sector 5 (Steel products, Machinery, Transport Equipment, Office and Data Processing) and 6 (Electrical, Optical Goods) of the aggregated I-O-table described above can be considered to be highly innovative[16]. In the following table each sector is classified into one out of three groups – highly innovative sectors (direct effects e.g. via direct investments), medium innovative sectors (sectors, which absorb significantly intermediate inputs of highly innovative sectors[17]) and low innovative sectors (without strong links to highly innovative sectors).

Table 1: Innovation intensity of sectors (data refers to German situation)

sector	Group 1 (highly innovative)	Group 2 (medium innovative)	Group 3 (low innovative)	% of export outside EU	% of absorbed group 1 inputs[18]
Agriculture, forestry and fishery			X	1	6
Energy, Water, Mining Products, Crude Oil		X		1	10
Chemical, Mineral, Plastic, Petroleum Products		X		15	11
Ferrous and non-ferrous ores and metals		X		5	12
Steel products, Machinery, Transport Equipment, Office and Data Processing	X			32	45
Electrical, Optical Goods	X			10	39
Textiles, Clothing, Paper, Wooden Goods			X	9	8
Food, Beverages, Tobacco			X	5	6
Building and Construction		X		0	23
Services for Repair, Wholesale and Retail, Transport, Communication		X		17	11
Other Market Services like Lodging, Catering, Credits, Insurances			X	2	3
Non-market Services			X	3	4

Obviously the knowledge intensive sectors already form the major part of exports, in particular with regard to the here relevant trade flows among EU and non-EU regions.

[16] Based on results elaborated by GRUPP et al., 1995, p. 29f.
[17] Based on the input coefficients of input-output tables
[18] Percentage of all intermediate inputs

However, it makes probably sense to subdivide the regions outside the EU (13 have been defined for this project) into less industrialized regions like Africa, Latin America, China and though catching up rapidly major parts of Eastern Europe and more or less equally equipped economies like Japan and the USA. Considering trade with less industrialized regions the following effects may be caused by specific R&D expenses. While Figure 4 to Figure 7 are still valid for the overall background the transformation curve in Figure 9 is shifted towards the highly and medium innovative goods of group 1 and 2 (in the model aggregated to one group) at the cost of less innovative but often labour intensive group 3.

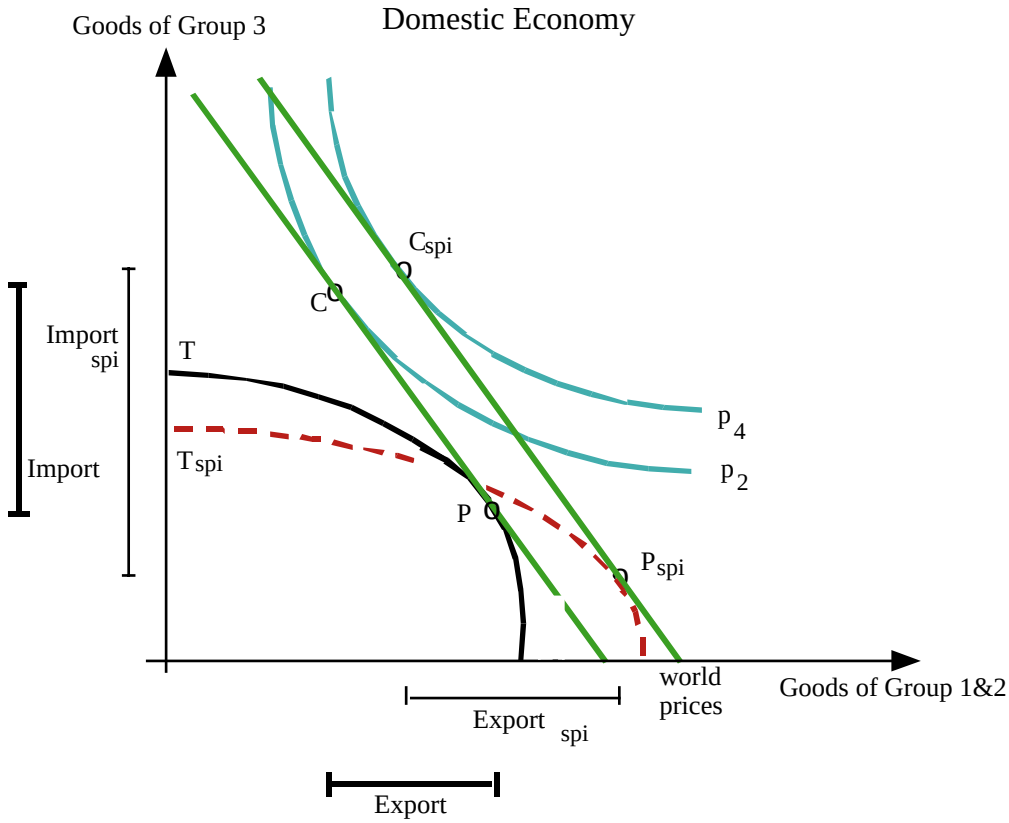

Figure 9: Concentration on comparative advantages

The parameters marked by the index 'spi' show the effects of the specific process innovation versus the situation provided in Figure 7. Though specialization and consequently international trade grow faster than in Figure 8 (human capital improvement) the implications for the overall welfare and employment are not clear. On the one hand p_3 (Figure 8) and p_4 (Figure 9) marks higher benefits compared to p_2. On the other hand neither one can be considered to be superior to the other. The example can be interpreted in line with the

** Diversified Scenario.*

Trade with the advanced industries of the USA and Japan follows similar patterns. However, trade focuses on goods of group 1 and 2. Often goods of the same group are traded (intra

sectoral trade), which makes it hard to project future flows without more intensive research. Nevertheless the

* *Concentrated scenario*

is still waiting and some interesting impulses could be given even with a simple model like this. If increases in R&D spending are concentrated on advanced technologies (electronics, telecommunications, genetic engineering, nano-technologies, aeronautics & space applications the currently leading position is not necessarily with EU (if it is the causalities look similar to Figure 9). Lets assume the comparative advantage is with the United States or Japan. Hence it is likely that these products are – up to now – imported by the EU rather than exported. Figure 10, which basically follows Figure 7 with some simplifications, shows the starting position.

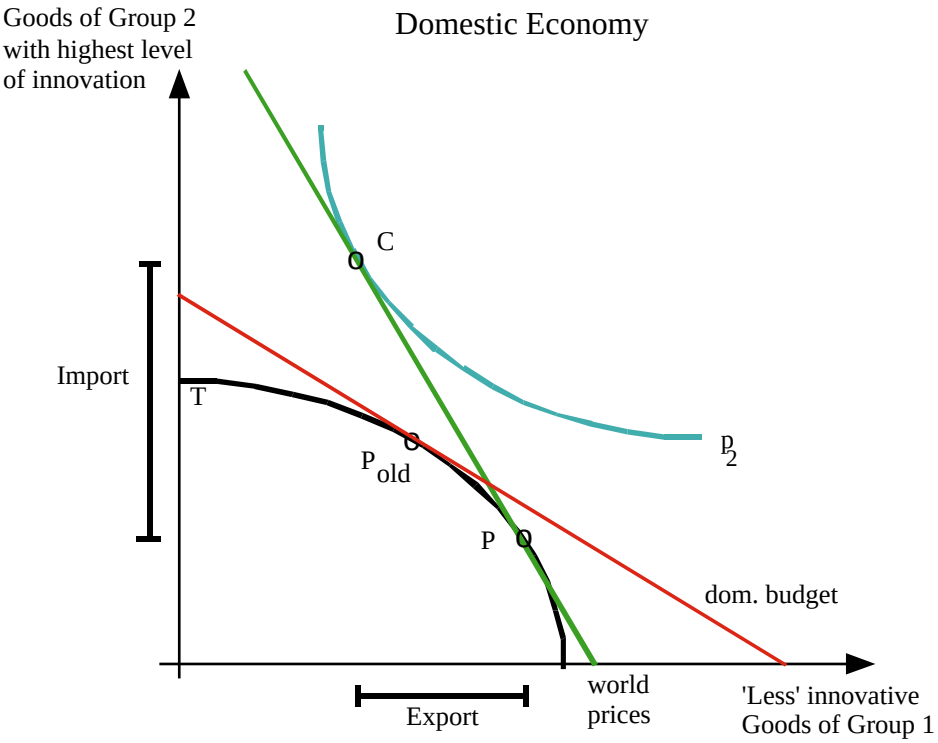

Figure 10: Trade of Group 1 goods

The concentrated efforts on the most innovative sectors lead to a shift of the transformation curve. Though all sectors will finally benefit by the R&D expenditures, the transformation curve will be extended strongest towards the most innovative sectors. Besides the domestic budget will also be turned in favor of these superior goods.

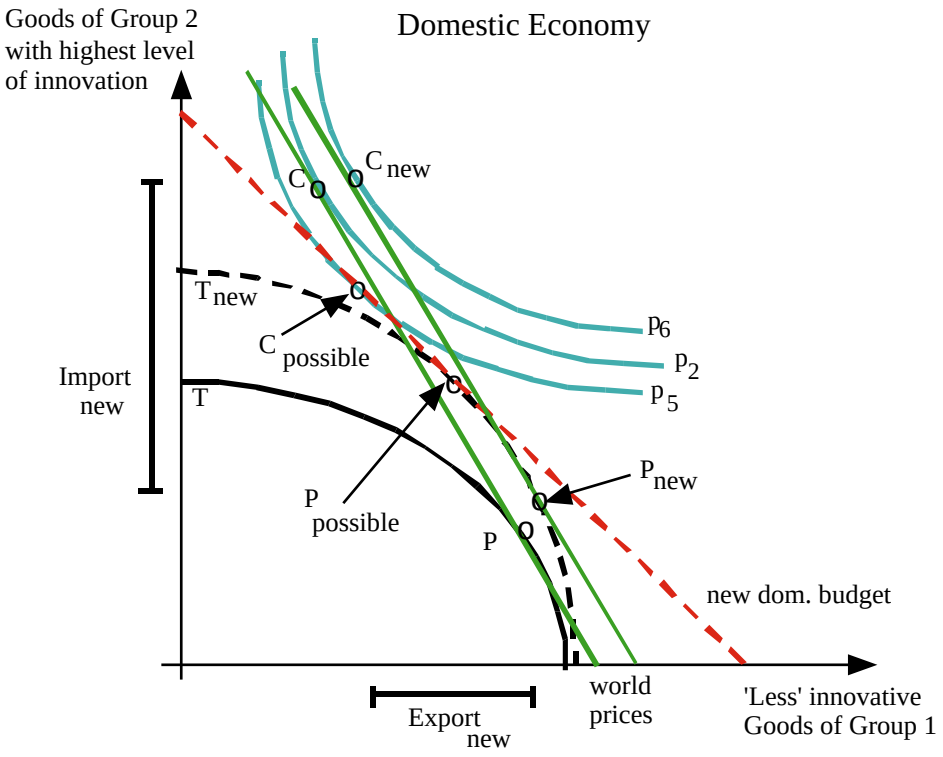

Figure 11: Concentration on most innovative products

Though the possible production $P_{possible}$ of most innovative products could clearly be extended, the in fact realized new production P_{new} is particularly shifted by the (relatively small) positive indirect effects for 'less' innovative products, which eventually allows the realization of C_{new}[19]. Despite the simplicity of this model, the results show that the *Concentrated Scenario* may after all not cause the most favorable results. It is interesting that even if the EU would produce most innovative goods cheaper in the end the situation would not change significantly.

However, this conclusion is still based on the assumption of perfect or at least sufficient competition. While the assumption may come close to reality for some sectors, e.g. microelectronics, communication or biotechnology, it clearly fails for the production of aircraft. Intensive and specific R&D expenditures may in this case indeed strengthen the position of the domestic (here European) competitor. Eventually the policy will induce positive employment effects, which makes such a policy very attractive. On the other hand it must be questioned if the approach is not at odds with the rules of fair competition and free trade. It is not our task to answer the question (which should be adressed by political decision makers) but we will explain the causalities of this rather strategic trade policy.

[19] C_{new} in particular implies higher welfare compared to $C_{possible}$, which could be achieved within EU if hypothetically trade of these goods would be substituted by intensive public R&D expenditures.

3.1.4 Strategic trade policy

In 'Is Free Trade Passé' KRUGMAN (1987) picks up an idea outlined by BRANDER and SPENCER in 1983 and 1985 respectively. It is assumed that two regions are generally capable of producing a specific highly innovative good. The perfect competition is replaced by a duopolistic market structure. To illustrate this assumption the market of wide-bodied passenger aircraft is considered. The only companies capable of developing and producing the aircraft are Boeing, located in the United States, and Airbus in Europe. Without public interventions both companies are equipped with qualitative and quantitative similar production factors. Once the company decides to build the aircraft, production factors are strictly bound to the challenging project and there is no way back without serious financial crises. Thus both companies only have binary choice: Produce (P) or Not-Produce (N). The production is expected to be profitable if either Boeing or Airbus enter the market alone – it is not profitable if both companies decide to produce. Due to the duopolistic market structure only four different strategies can occur. Both companies produce, despite being aware that the return on investment is (probably slightly) negative, both companies decide not to produce, or either one produces alone. The following payoff matrix is taken from KRUGMAN (1987, p. 136). Payoffs for Airbus are given by the upper right numbers of the cells and Boeing's by the lower left numbers respectively.

Table 2: Hypothetical payoff matrix with fair competition

		Airbus	
		Producing	Not Producing
Boeing	Producing	-5 -5	0 100
	Not Producing	100 0	0 0

The game would end in a draw, if neither one would have a kind of a headstart. But since we assumed above (fig. 8), that the United States are in general slightly better in producing the most innovative products and if we add that only Boeing has the experience of introducing the last remarkably huge passenger aircraft (Boeing 747) the game would probably go to Boeing in the end – leaving Airbus with a payoff of '0'. If now the EU would intervene let's say by very specific R&D expenditures to bring Airbus ahead the game could indeed turn. Additional investments of **10**, which the EU would certainly label as R&D expenditures for the aerospace sector and which would be blamed to be illegal subsidies by the American competitors, the payoff matrix would look as follows (see again KRUGMAN, 1987, p. 136)

Table 3: Hypothetical payoff matrix after European R&D expenditures / subsidy

		Airbus	
		Producing	Not Producing
Boeing	Producing	5 -5	0 100
	Not Producing	110 0	0 0

Since Airbus would not risk a negative payoff the decision would certainly be to produce - either way whether Boeing produces or not. Boeing, however, knows that it will not enter the market alone and will therefore prefer not to produce. Thus the European public expenditure ensure Airbus an income of 110 instead of certainly possible '5'. In turn Airbus guarantees highly qualified new workplaces within Europe. Note that both additional income and ensured jobs are now provided at the cost of Boeing's or America's income.

It is worth mentioning that, even if the strategy is considered to be fair or at least legal, the development of new wide-bodied passenger aircrafts needs immense investments and is accompanied by various uncertainties leading to high financial risks. The assumption that the production is profitable, if only one firm is entering the market can - considering the development of the Boeing 747 that almost lead to a financial disaster for Boeing – indeed be questioned. In this case the not-investing competitor could easily gain market shares and domestic workplaces would be at stake.

3.2 Implementation of export-(import) model in ASTRA-E

The foreign trade model consists of a detailed export model with two parts:

- INTRA-EU exports and
- EU to rest-of-the-world (RoW) exports.

To complete the foreign trade flows a simplified import model is implemented, which is built on sectoral historical import data, and considers future growth of imports dependent on the GDP growth of the importing European region.

3.2.1 INTRA-EU export model

INTRA-EU exports are not in the main focus of the study. So, for the sake of simplicity these export-import-flows are only modelled roughly considering aggregated goods flows (sectors 1-8) and aggregated service flows (sectors 10-12). Sector 9 "construction" is not contributing a significant share of exports such that it is not considered in the export model. The influencing factors in the INTRA-EU export model are:

- relative productivity between the four European regions,
- GDP growth of the importing country,

- world GDP growth.

It should be considered that during the calibration period (1985 – 1996/97) world GDP and GDP of the EU countries was not continously growing but was facing a recession in the years 1990 –1992/93. However the applied GEM-E3 forecasts are smooth and rather optimistic as well as the GDP calculations in ASTRA both not assuming any serious breaks in economic growth. So, calibrating exports based on a period including a recession and making forecasts not considering any significant slow-downs of economic growth or recessions would lead to an overestimation of exports. Therefore the future impacts on exports caused by world GDP growth and by GDP growth of the importing country are dampened.

3.2.2 EU to rest-of-the-world (RoW) export model

The model for exports from the four European regions to thirteen rest-of-the-world regions (RoW) is completely developed from scratch based on a mixed approach consisting of System Dynamics calibration analysis supported by initial theoretical and practical ideas about the driving forces of exports and restricted by data availability. The System Dynamics calibration analysis is similar to econometric testing in the sense that by parameter variations the best fit of the dynamic equations to statistical data is searched. The two major differences are that this is undertaken within the context of the model and the feedbacks not only on the basis of one single equation. Secondly, the statistical tests for the equation under investigation are one part of the analysis but the scope is widened to the fit of other relevant interlinked equations, such that the quality of the statistical fit of each single equation is not the only important criterion.

Again the major database was the OECD online database. The part of the database on international trade provides export-import data on a sectoral level of 63 sectors categorised by the Standard International Trade Classification Revision 2 (SITC Rev 2) that can be aggregated to agriculture, the 7 manufacturing sectors and construction for ASTRA purposes (see annex Table 28). However, as construction exports are very small or zero this sector is assumed to be zero (it is rather difficult to export a house or a road and construction consulting services would belong to sector 11). Export data is prepared for 11 of the RoW regions (FSU, RotW are missing; AFR and NAF are aggregated into one region) and for the 15 EU countries aggregated to 4 European regions. This aggregated data consists of 352 data series while the processed raw data series amount to several ten-thousands.

In terms of productivity the OECD database is not that comprehensive such that sectoral productivity figures are available only for a few countries. One basic difficulty is that labour productivity in the form needed for the IPTS project is not directly available. It has to be calculated based on employment and value added given by different data sources of which the OECD online database is the most important one. Further data sources are the World Development Indicators 2001 database from the World Bank and the Industrial Statistics Database 2001 (INDSTATR) from the United Nations Industrial Development Organization (UNIDO). Currently data is processed for NAM region (NAFTA), Japan and AUZ region (Australia and New Zealand), China and CEA region (Bulgaria, Czech Republic, Hungary, Poland, Slovakia, Slowenia, Romania). For agriculture rough productivity values for nearly all RoW-regions are available such that the calibration is completed.

Concerning the trade of services the databases are less comprehensive. The OECD database includes a part on trade of services; which has a sectoral split that can be easily aggregated to the ASTRA sectors 10 to 12. However, the time series are not complete and the exporter-importer relationships are not considered. Only Intra-EU and Extra-EU service exports can be distinguished by this datasource.

For the EU-RoW export model three impacts are considered:

- Relative changes of productivity in the exporter-importer relation;
- GDP growth of the importing country;
- World GDP growth.

Based on these influences the following equation drives sectoral exports:

$$\text{Exports}(t)_{E,R,S} = \text{Exports}(t-1)_{E,R,S} * (\text{Impact Productivity}_{E,R,S} + \text{Impact GDP Importer}_{E,R,S} + \text{Impact World GDP}_{E,R,S}) \quad \text{eq(1)}$$

E = European region
R = Rest-of-the-world region
S = Economic sector
t = current time

The structure of this approach implicitely assumes that currency exchange rates are roughly stable.

3.2.2.1 Impact of productivity in EU-RoW export model

The relevant variable to consider the influence of productivity of trade flows seems to be the change in relative productivity between the exporting and the importing region. This is calculated as difference of the sectoral productivity between the two regions. Second the change of this difference within half a year is taken as input that finally changes exports.

The change in relative productivity will not immediately be translated into higher exports. It will take some time until the reduced prices or the better quality has a positive impact on exports. The calibration results show time lags of close to 0 up to 1,5 years.

$$\text{Impact Productivity}_{E,R,S} = \text{Param Export Effect Productivity}_{E,R,S} * (\text{relative change productivity}_{E,R,S})_{t\text{-lag}, E,R,S} \quad \text{eq(2)}$$

E = European region
R = Rest-of-the-world region
S = Economic sector
t = current time
lag = length of time lag

3.2.2.2 Impact of GDP growth of importing country

In principle exports to a country depend on the development of the four broad categories of final demand in the importing country. However, as the macroeconomic system of the RoW-regions (or countries) is not explicitely modelled in ASTRA-E the development of GDP of the importing country is taken as proxy for these categories. Forecasts for GDP are harmonised with the GEM-E3 forecasts. Changes of GDP influence imports in the same direction as the change of GDP. Again, it can be argued that a change in GDP of a country does not immediately lead to a change in its imports assuming that first income is increased and then consumption of imports increases such that here also a lag is considered.

Analysis of GDP impact on imports with aggregated data revealed that a certain positive threshhold of GDP growth is required to produce import growth. This was also transferred to the sectoral level. However, for the calibrated regions this conclusion was not that evident on sectoral level. Nevertheless, the threshhold was included in the equation for the calculation of the impact of GDP on exports.

$$\text{Impact GDP Importer}_{E,R,S} = \text{Param Import Effect GDP}_{E,R,S} * ((\text{Change GDP}_{R})_{t\text{-}lag,\ E,R} - \text{Threshhold Positive GDP}_{E,R}) \quad \text{eq(3)}$$

E = European region
R = Rest-of-the-world region
S = Economic sector
t = current time
lag = length of time lag

The applied exogenous GDP growth rates for the RoW regions in Table 4 have been taken from the *Baseline Scenario* output of GEM-E3. They are input for the calculation of export flows from EU regions to RoW regions. The description of the RoW-regions is given in the annex in Table 24.

Table 4: Yearly GDP growth rates of rest-of-the-world regions [%]

Region	1986	1990	1995	2000	2005	2010	2015	2020
[NAM]	3.13	1.75	2.36	2.79	2.88	3.00	2.44	2.61
[LAM]	6.79	-2.39	3.63	2.52	3.16	3.71	3.25	3.18
[OEU]	3.33	4.64	2.99	1.98	3.56	3.85	4.12	3.84
[CEA]	3.23	-6.79	5.95	2.58	3.39	3.72	3.66	3.21
[AUZ]	2.63	-0.24	4.45	3.63	2.77	2.85	2.68	2.65
[JAP]	2.90	5.08	1.47	1.28	2.40	2.38	2.17	2.30
[EAS]	7.16	7.98	7.86	1.72	4.01	4.82	5.35	5.42
[CHI]	8.80	3.80	10.50	7.31	5.89	5.50	5.00	4.76
[IND]	4.93	5.63	7.38	4.46	4.44	4.31	4.04	3.95
[FSU]	4.20	-0.72	-5.58	-0.46	3.86	3.72	3.59	3.61
[AFR]	3.00	3.41	3.82	2.93	3.69	4.11	4.09	4.33
[NAF]	-0.47	3.77	2.62	2.57	3.61	3.95	4.56	5.03
[RotW]	1.18	1.29	7.56	1.96	3.36	3.43	3.22	3.47

3.2.2.3 Impact of world GDP growth

Looking at long historical data series of exports and world GDP growth a strong correlation can be identified. Though on world level the causal relationship between world GDP growth and exports is rather from the latter to the former than the other way round. But on country level world GDP growth can have a separate influence not captured by productivity changes and GDP growth. In general it can be assumed that positive changes of world GDP growth will increase exports. It seems that there is also a threshhold of world GDP growth, which is required for a positive influence on exports. This is also confirmed on EU-RoW export relationships by the calibration with values for the threshholds usually ranging from 0.5 to 1.5% world GDP growth. Finally the speed of changes of world GDP growth can have an influence on exports, which could be explained by psychological factors. For instance a situation of 2% world GDP growth is much different when the growth was 1.9% or 1.5% half a year ago. So, the half yearly change of the GDP growth rate is also taken into account.

$$\text{Impact World GDP}_{E,R,S} = \text{Param Export Effect World GDP}_{E,R,S} * (\text{Change of World GDP} - \text{Threshhold Positive World GDP}_{E,R} + \text{Change of Change of World GDP}_{t-0.5}) \quad \text{eq(4)}$$

E = European region
R = Rest-of-the-world region
S = Economic sector
t = current time

Figure 12 presents the data and the development of yearly world GDP growth rates until 2020. Data is used until 2000. After 2020 the results of GEM-E3 forecasts are used. They show a smoothed and rather optimistic development without considering any short-term business cycles such that the recession in 2001 is not reflected with this exogenous input to ASTRA-E.

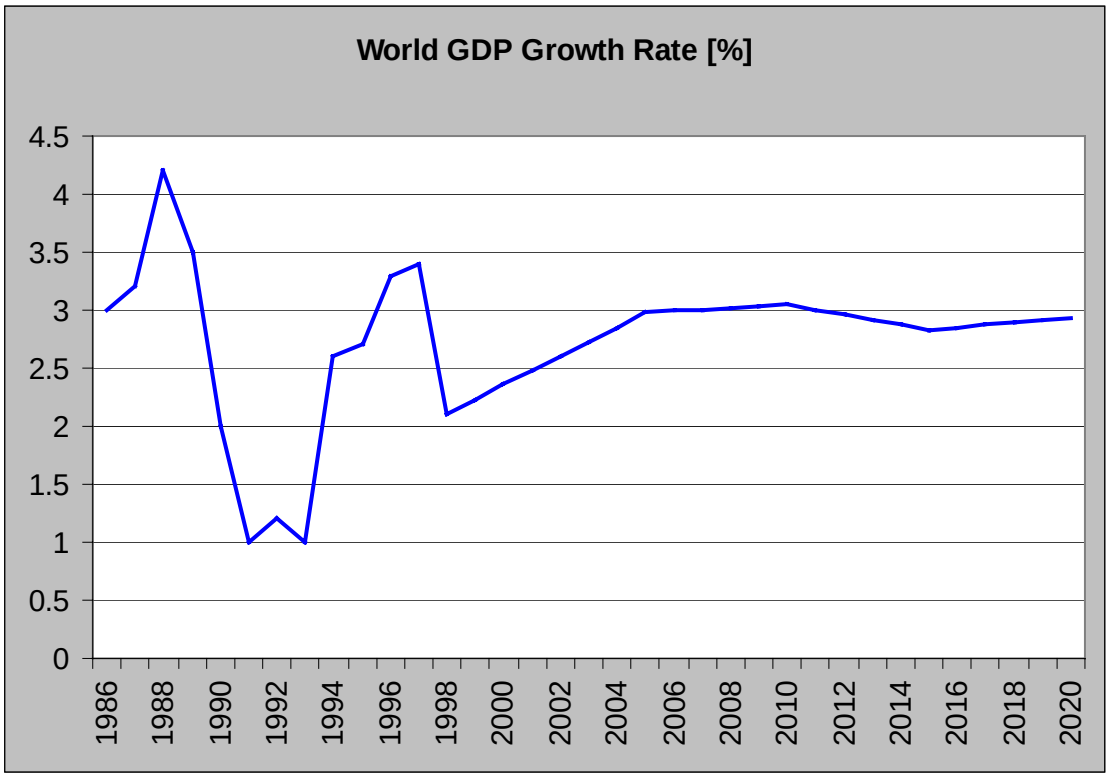

Figure 12: Data and assumed development of world GDP growth rate

3.2.3 Problem of strong growth of exports because of different historical and future patterns

Historical patterns of sectoral exports show strong variations. Yearly percent changes in the range of +/- 30% occur rather frequently. Some examples of the resulting pattern of sectoral exports are shown in the following Figure 13.

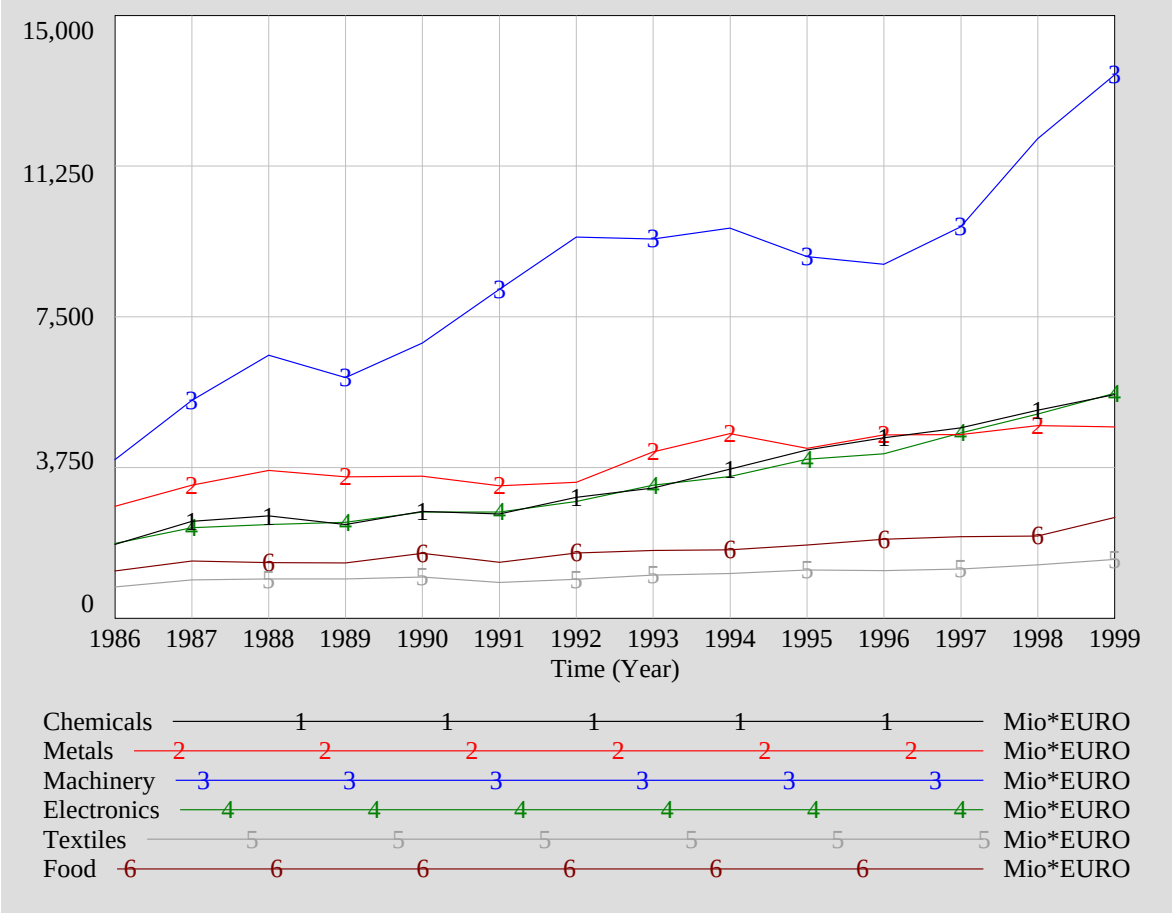

Figure 13: Patterns of sectoral exports from EUwest to NAFTA (NAM)

The pattern of the drivers of these exports, actually the three drivers considered in the model, is shown in the following Figure 14. The three drivers are relative productivity between the exporting and importing country, GDP growth of importing country and world GDP growth. Historical patterns for GDP are used until 1999 while afterwards growth rates calculated by GEM-E3 are taken. The difference in the pattern is obvious: the historic series produces oscillations with sometimes even negative values and higher peak growth rates, while the forecasts produce smooth curves with still rather high yearly growth rates. A similar picture is shown for the productivity curves. They are given in absolute values but there percent changes would show similar strong oscillations as the GDP growth for the historic series and a similar smooth development for the forecasts.

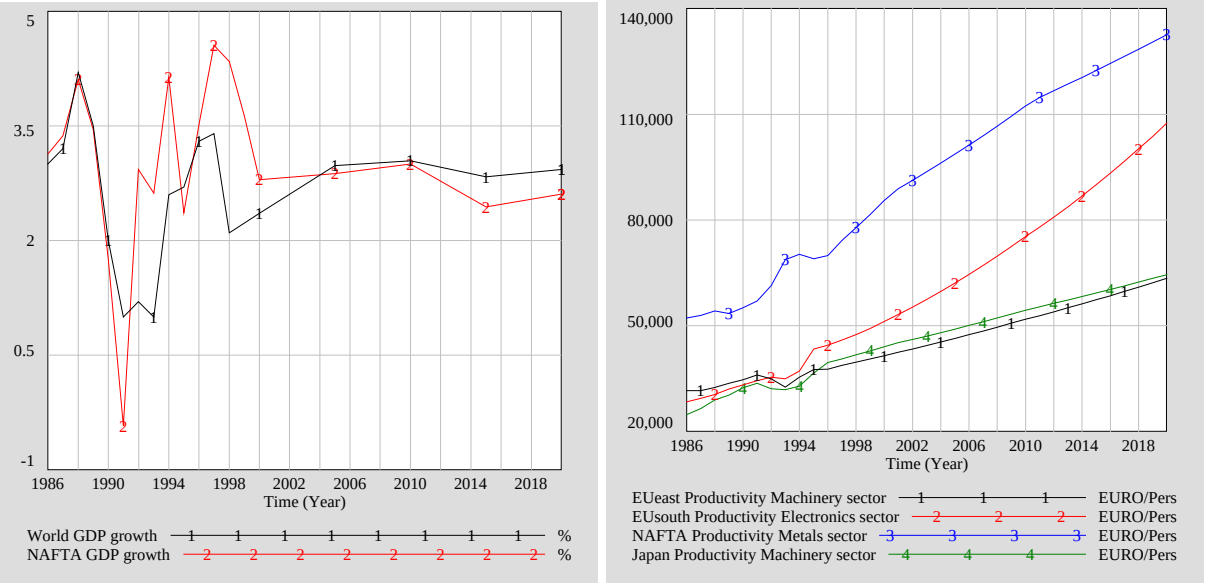

Figure 14: Patterns of drivers of exports (historical series and future assumptions based on GEM-E3 and FORMAPER input)

The aggregated driver of exports resulting from the explained three influences is presented in Figure 15. The pattern is similar to the previous figure. The historical series show strong oscillations including periods in which exports decrease, while the future development depending on the forecasts like presented in the previous figure show smooth developments that mostly will lead to strong increases in exports.

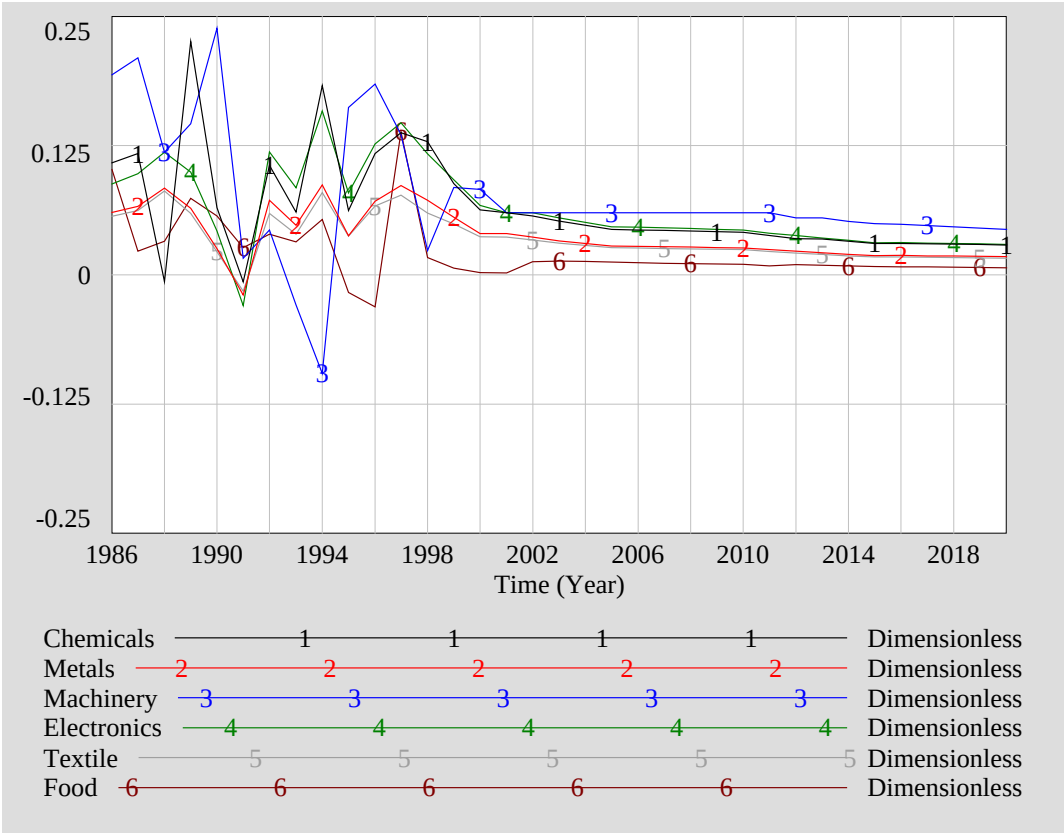

Figure 15: Total impact on exports from EUwest to NAFTA (NAM)

The problem of this discrepancy of patterns between historical series, which have to be used for calibration and the positive and smooth assumptions is that they would lead to an overestimated future growth of exports. Therefore tests were made to introduce two recession periods in the world growth until 2020 assuming a recession every ten years. In fact this would correct for a big part of the expected overestimation already. As business cycles are not the thing we are looking for a dampening influence is introduced into the model, which might also be argued that globalisation will slow down in the next 20 years, which then will reduce the driving impact of world GDP growth. Together with a limitation of maximum export growth per year the export growth follows a rather sensible path in the forecasts.

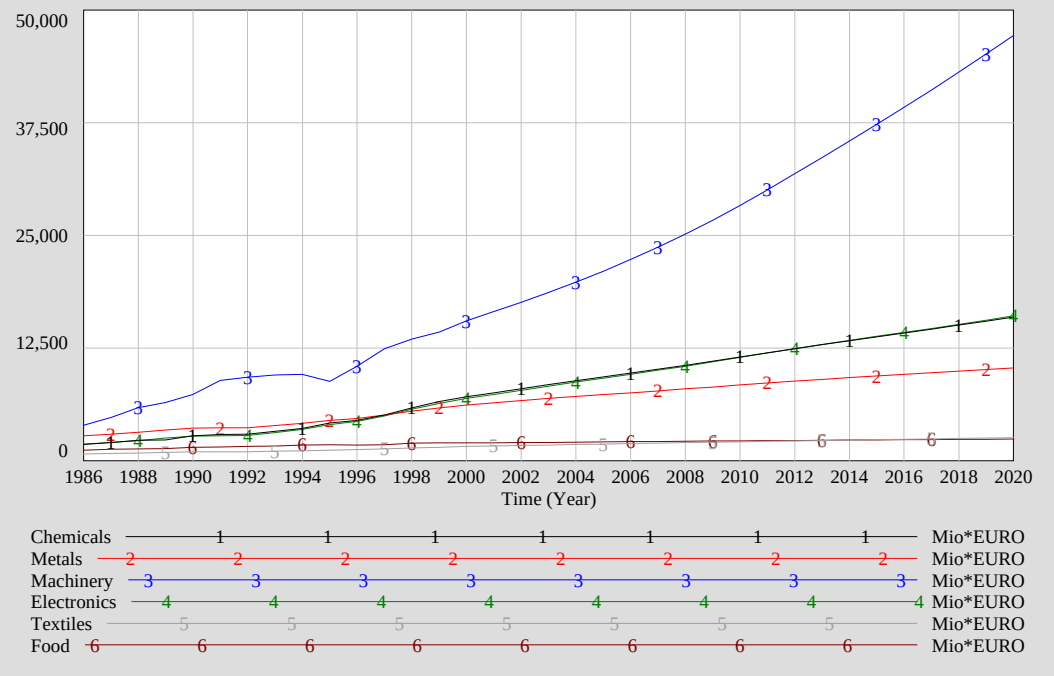

Figure 16: Estimated sectoral exports from EUwest to NAFTA

3.2.4 Analysis of modelled influences on exports changes

An interesting output of the EU-RoW-export model is the percentage split of the three considered influences on the changes of exports:

- Relative productivity between exporter and importer,
- GDP growth of importer,
- World GDP growth.

The following graphs illustrate the differences in importance of the three influences for the export changes of sectors Chemicals, Machinery and Electronics, which belong to the most important manufacturing sectors in terms of exports, to NAFTA (NAM) and Japan (JAP). In the following six figures the summed three influences on each sector amount to 100% for each point of time. Each curve represents a sector and a regional combination of trading

partners e.g from EUeast to NAFTA. The legend below the figures assigns a colours plus a number to each curve for the identification of the corresponding curve in the graph.

3.2.4.1 Analysis of Exports from EU to NAFTA in ASTRA-E

It seems that for the exports from EU to NAFTA the major driver is the GDP growth of the NAFTA region as most of the sectors depend to more than 75% on this influence (see Figure 18). Productivity plays a less important role mostly contributing less than 10% in the forecasting period (see Figure 17), while for some sectors also world growth is important (see Figure 19). For some sectors an important influence would also be the price of natural resources. However, that is not yet considered in the EU-RoW export model.

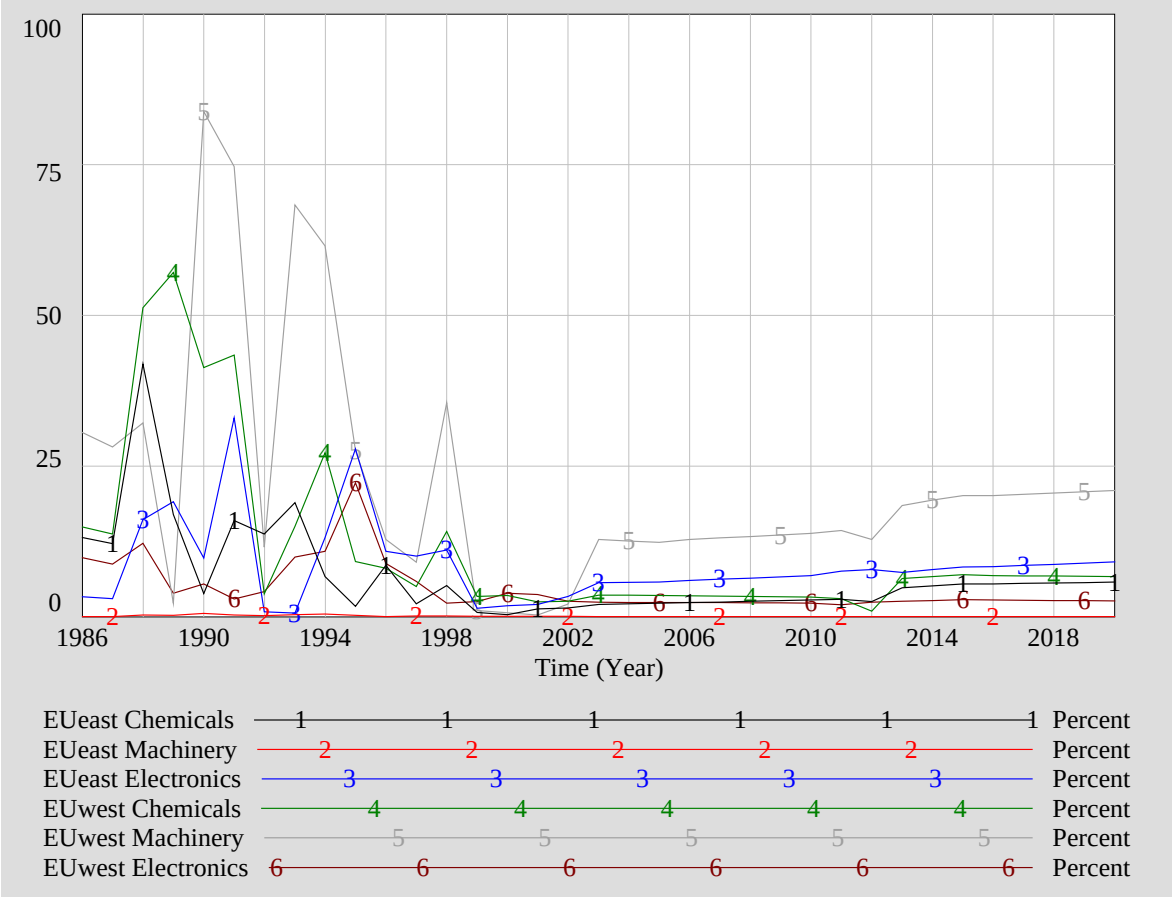

Figure 17: Sectoral influence of productivity on exports from EUeast and EUwest to NAFTA

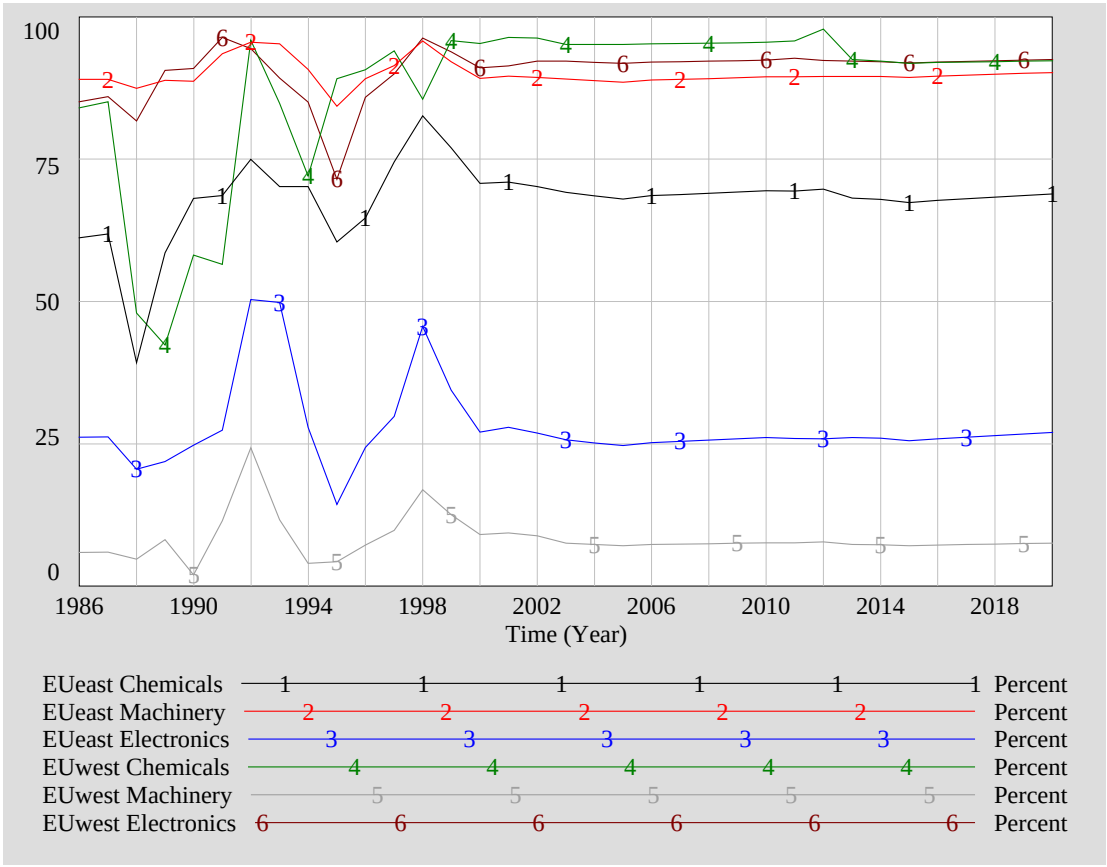

Figure 18: Sectoral influence of NAFTA GDP growth on exports from EUeast and EUwest to NAFTA

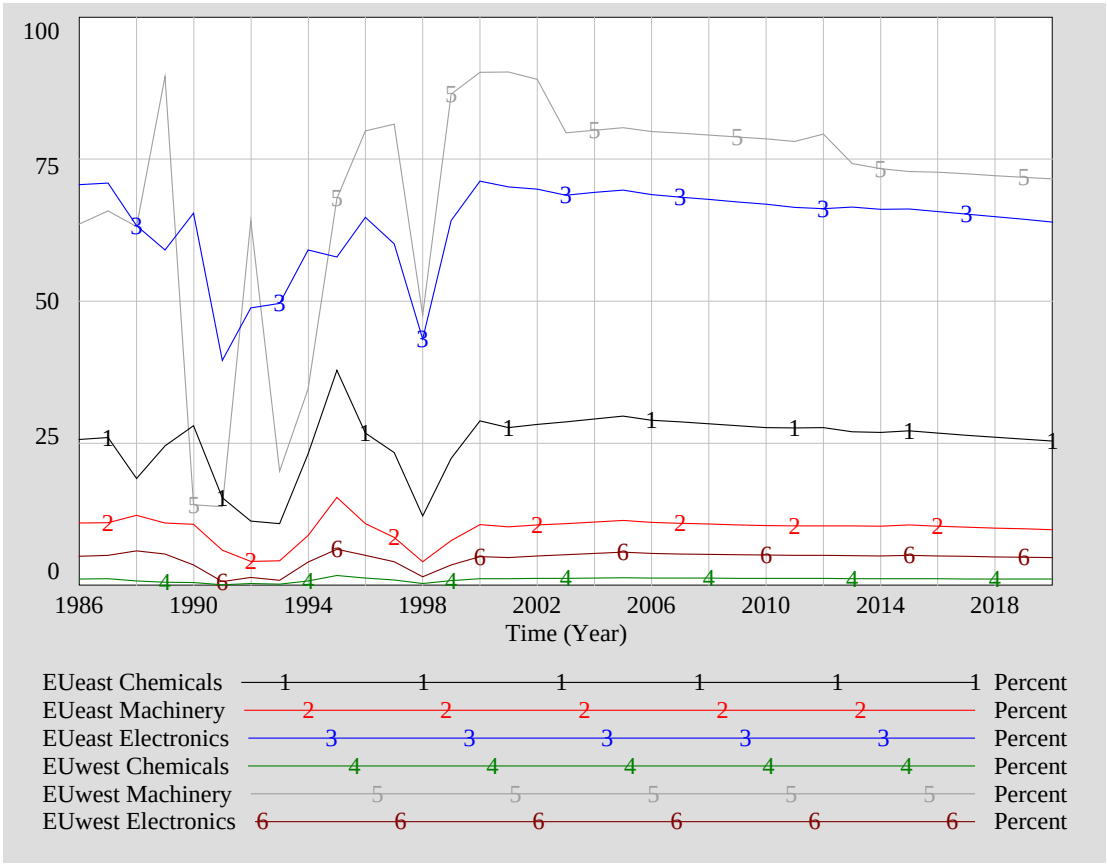

Figure 19: Sectoral influence of world GDP growth on exports from EUeast and EUwest to NAFTA

3.2.4.2 Analysis of Exports from EU to Japan in ASTRA-E

For the exports to Japan productivity plays a bigger role compared with the exports to NAFTA (see Figure 20). In general the influence of the three drivers of exports changes seem to be more balanced in the relationships to Japan.

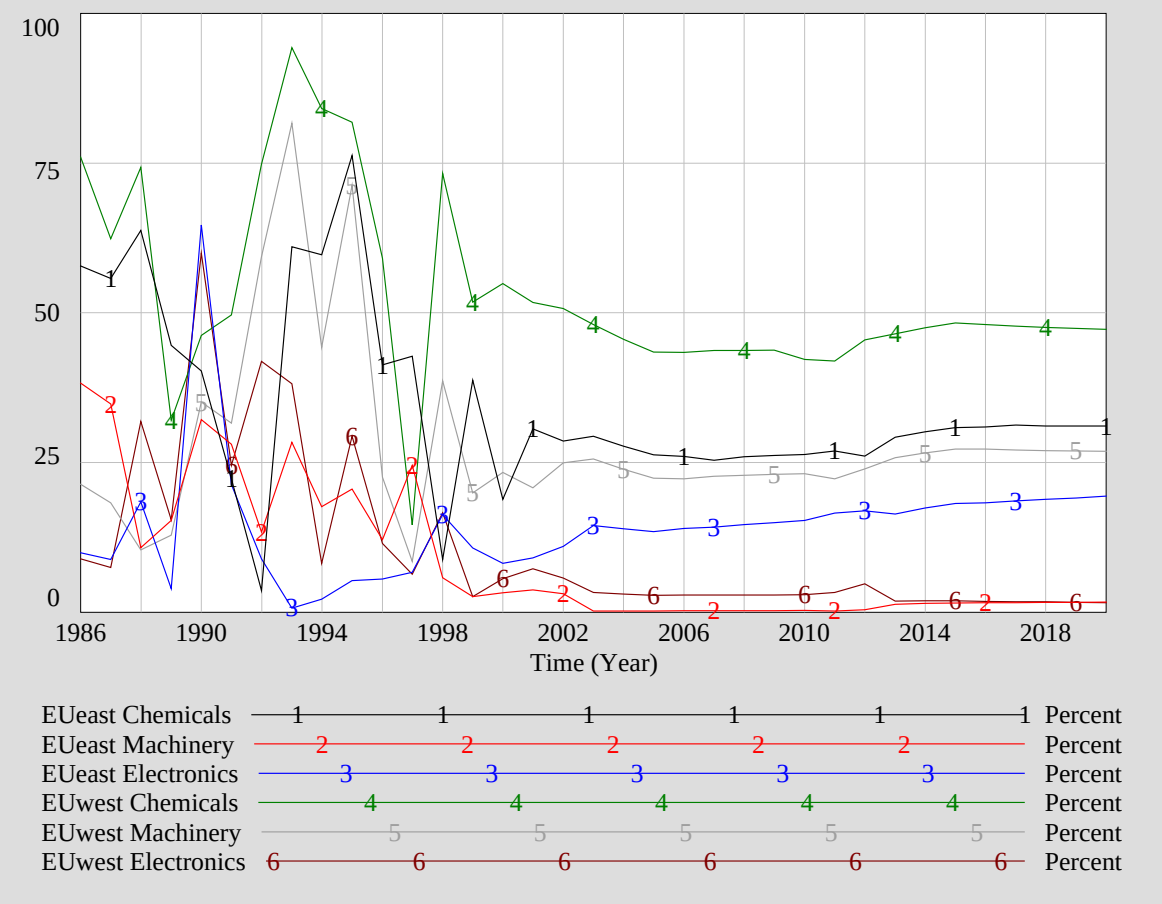

Figure 20: Sectoral influence of productivity on exports from EUeast and EUwest to Japan

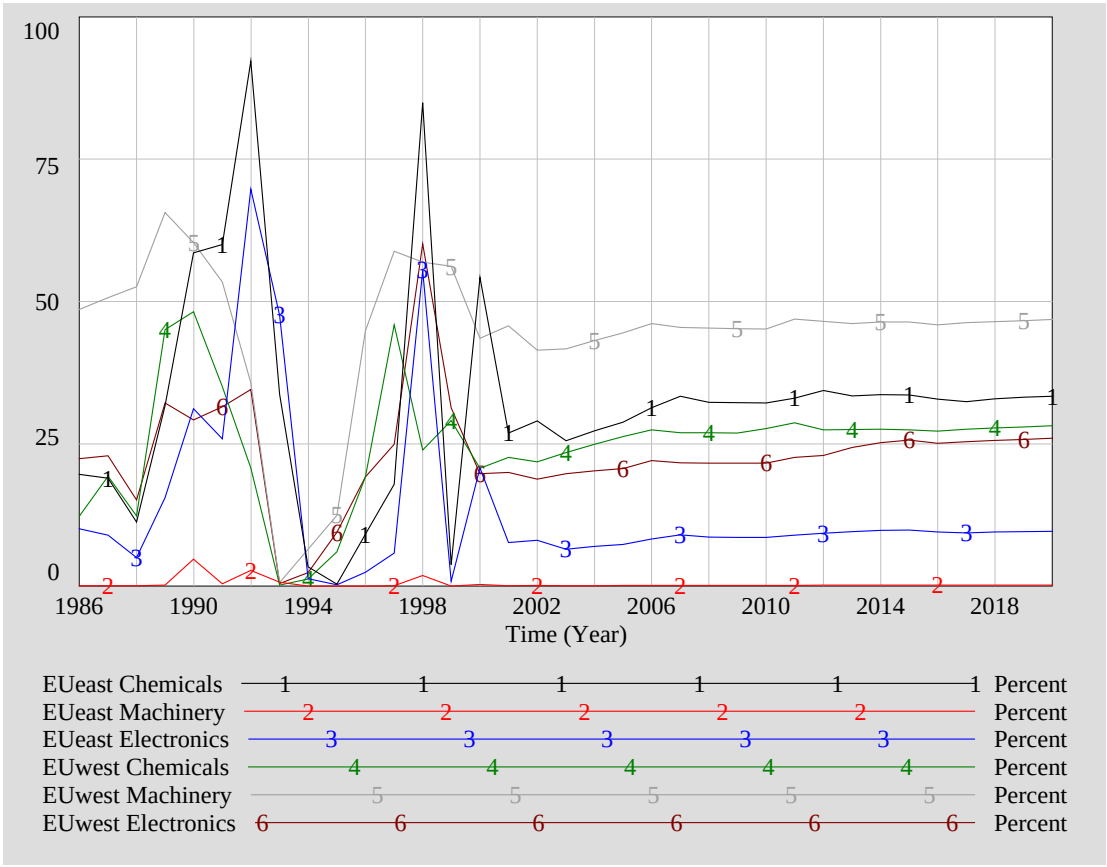

Figure 21:Sectoral influence of Japanese GDP growth on exports from EUeast and EUwest to Japan

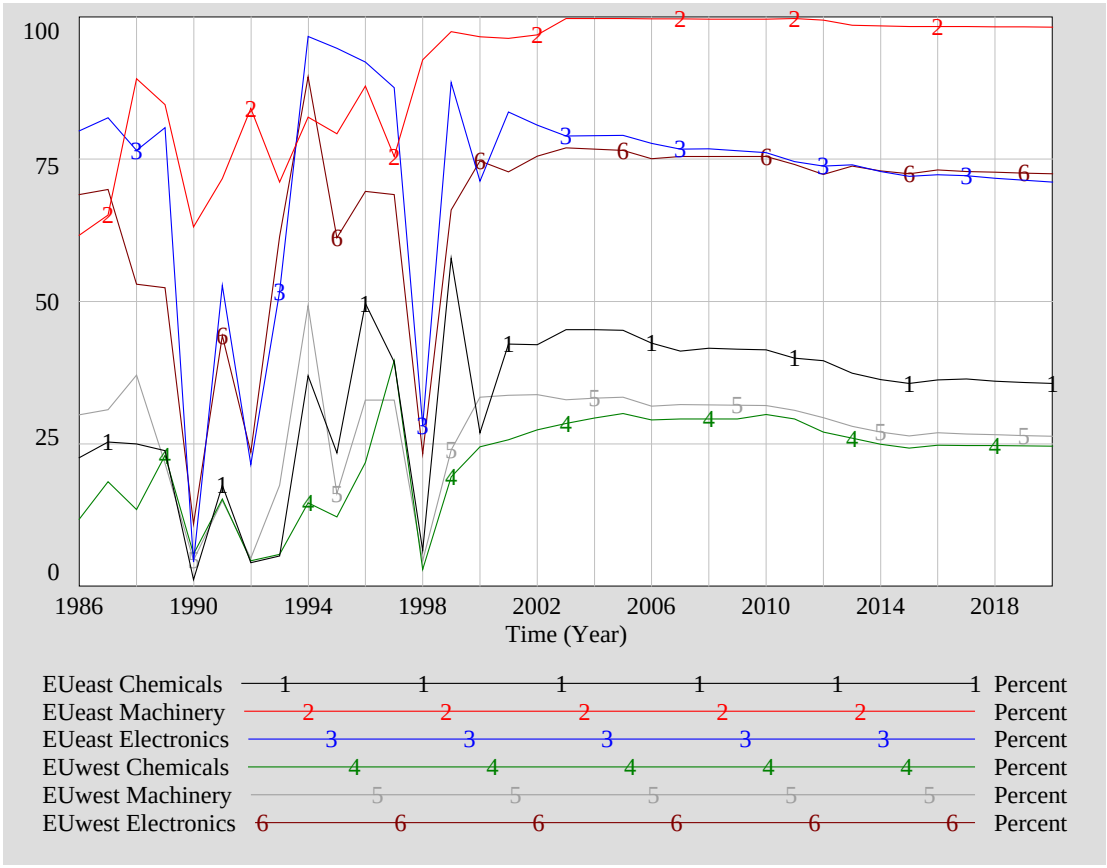

Figure 22: Sectoral influence of world GDP growth on exports from EUeast and EUwest to Japan

3.3 Labour productivity and process innovation

The labour productivity model in ASTRA was based on values for the ratio *employment per gross values added* (which is the inverse productivity) from the EUROSTAT 25 sectors input-output-table. These values were changed in a smooth manner by average yearly improvements measured as percentages. The percentages are derived from historical developments and are adjusted to calibrate employment in the model to employment statistics.

For ASTRA-E historical data of sectoral productivity was calculated based on gross value added and employment provided by several statistics. The main source is the OECD online database (http://cs4-hq.oecd.org/oecd/), which was complemented by UN Statistical Yearbooks, ILO online databases on employment (http://laborsta.ilo.org/) and EUROSTAT statistics. Most monetary statistical data has to be translated from national currency or US dollars given as current or constant prices into constant EUROs of 1995. A major difference of these statistical sources compared with the original ASTRA implementation is that instead of a smooth development productivity changes sometimes follow a rather erratic pattern with yearly changes of even more than +/- 20% (see Figure 23).

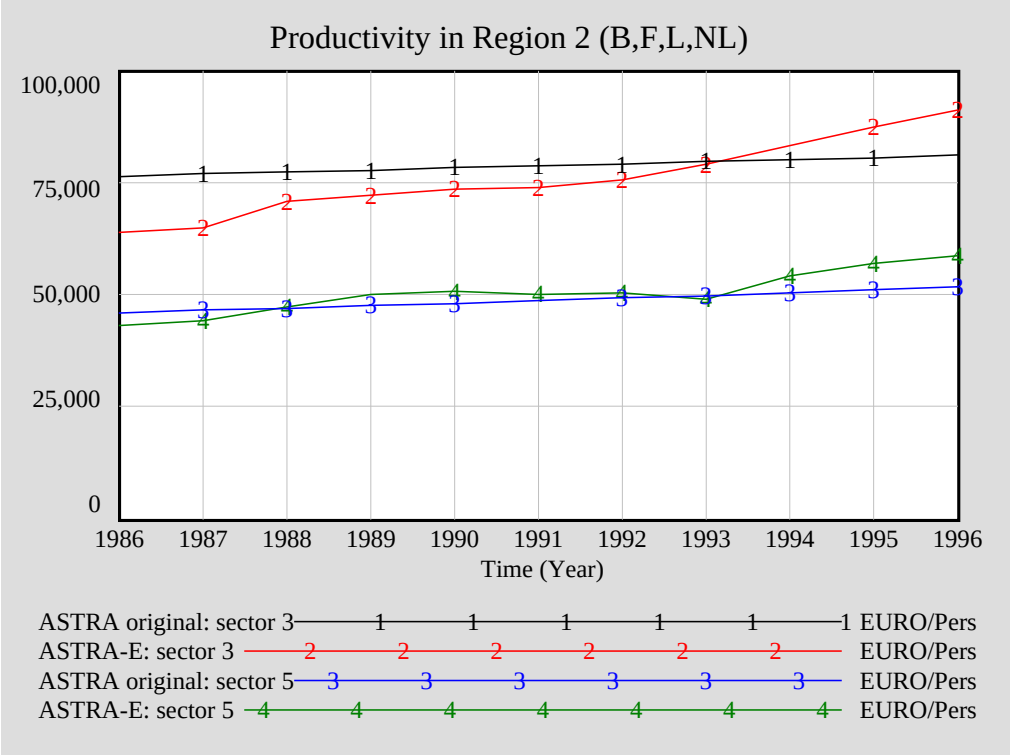

Figure 23: Comparison of sectoral productivity patterns in original ASTRA and ASTRA-E

The source data for the manufacturing sectors (sector 2 – sector 8) stems from the OECD Structural Analysis Industrial Database (OECD STAN database) on a level of 49 manufacturing sectors. The data for the service sectors is taken from the OECD national

accounts database and the OECD statistics on services. Construction is modelled with the original ASTRA approach.

Table 5: Sectoral productivity in the four European regions (calibration period) [EURO95/Pers]

[GVA / Pers]	Sector	1986	1988	1990	1992	1994	1996
Region E1	Sector1	24,455	25,247	26,065	26,897	27,730	28,555
A, D	Sector2	35,637	37,344	38,663	39,981	42,539	42,909
	Sector3	55,626	52,322	51,938	51,241	57,027	61,934
	Sector4	29,445	31,435	34,569	37,220	42,036	46,501
	Sector5	31,601	32,506	34,627	34,933	35,417	37,726
	Sector6	25,523	26,952	27,117	26,267	27,765	29,399
	Sector7	24,084	25,298	26,502	27,611	28,394	28,458
	Sector8	38,015	37,947	40,308	38,925	41,077	41,318
	Sector9	55,962	57,163	58,389	59,625	60,849	62,049
	Sector10	29,868	29,601	31,138	34,132	33,904	34,630
	Sector11	84,869	93,507	104,810	110,659	106,916	108,909
	Sector12	38,728	36,036	34,482	35,182	35,605	35,738
Region E2	Sector1	39,007	40,197	41,423	42,678	43,950	45,232
B,F,L,NL	Sector2	49,255	55,287	56,261	57,321	63,073	68,434
	Sector3	63,910	70,604	73,609	75,569	83,160	91,069
	Sector4	44,617	52,971	55,222	54,707	61,708	67,884
	Sector5	42,990	47,220	50,675	50,467	54,177	58,531
	Sector6	37,408	35,696	37,708	39,639	45,073	51,119
	Sector7	32,204	34,834	37,560	37,963	41,991	44,405
	Sector8	48,566	48,233	52,366	53,920	58,320	61,740
	Sector9	45,590	46,512	47,453	48,406	49,362	50,317
	Sector10	43,128	44,854	47,774	48,061	48,345	47,093
	Sector11	112,037	109,405	106,813	103,758	98,783	97,257
	Sector12	35,475	36,233	36,837	37,098	37,310	37,234
Region E3	Sector1	13,792	14,320	14,892	15,519	16,184	16,882
E,GR,I,P	Sector2	34,412	37,802	39,099	39,809	43,302	45,266
	Sector3	51,687	56,600	57,757	62,637	67,000	67,183
	Sector4	43,520	51,204	53,297	55,018	68,175	72,301
	Sector5	31,660	34,789	35,499	36,778	39,444	43,293
	Sector6	28,452	30,482	33,260	35,388	37,147	44,525
	Sector7	24,266	25,312	26,082	27,493	29,480	30,138
	Sector8	45,012	48,218	49,122	52,925	53,720	55,643
	Sector9	28,985	29,720	30,506	31,355	32,244	33,163
	Sector10	35,948	38,067	39,349	43,326	48,250	51,941
	Sector11	84,124	84,843	85,952	87,878	96,424	98,729
	Sector12	28,939	29,000	29,256	27,698	26,137	25,233
Region E4	Sector1	29,852	30,882	31,967	33,126	34,385	35,760
DNK,FIN,IRL	Sector2	26,126	30,162	29,131	29,067	31,408	29,501
SWE,UK	Sector3	39,503	42,435	43,269	46,765	51,674	53,296
	Sector4	25,221	31,869	31,366	33,510	36,998	38,075
	Sector5	22,788	25,171	26,743	27,418	29,871	31,208
	Sector6	19,231	21,544	23,087	22,678	22,874	22,564
	Sector7	23,041	24,888	25,759	26,510	28,693	28,478
	Sector8	32,520	34,639	35,524	38,017	40,214	42,107
	Sector9	44,817	45,842	46,909	48,035	49,244	50,547
	Sector10	25,509	28,103	27,792	27,626	30,468	32,073
	Sector11	60,308	59,168	56,993	56,659	59,813	60,203
	Sector12	25,302	24,914	25,360	25,972	26,623	27,374

The predictions from the years 2000 onwards for the background scenario and the policy scenarios are provided by FORMAPER (Prof. Pianta) and are reviewed by the project team. The assumed growth rates of labour productivity growth were derived on the basis of three main considerations. The first is the analysis of past trends in productivity. The second concerned taking into account the impact of emerging technologies like Nanotechnology or Biotechnology and relate them to economic sectors. Third, productivity is also going to be affected by gradual improvements of technologies that are already being used. These improvements can also be related to certain economic sectors. The regional, sectoral growth rates are shown in the following Table 6:

Table 6: Forecasts of yearly productivity growth rates between 2000 and 2020 (Baseline Scenario)

	[%]	E1 Germany, Austria		E2 France, Benelux		E3 South Europe		E4 UK and Nordic	
Sector		2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020
S1	Agriculture	1.5	1.4	2.0	1.8	2.0	1.8	0.6	1.3
S2	Energy	1.6	1.6	1.8	1.6	1.6	1.4	2.8	2.5
S3	Chemicals	3.2	3.0	2.2	2.0	2.0	1.9	2.1	2.1
S4	Ferrous and non ferrous	2.0	2.0	0.9	0.7	1.1	1.0	0.4	0.3
S5	Steel Transport	2.2	2.0	2.7	2.5	2.5	2.3	1.7	1.5
S6	Electronic	2.0	1.8	3.8	3.5	3.8	3.5	1.6	1.6
S7	Textile	1.6	1.4	1.7	1.5	2.3	2.1	1.4	1.2
S8	Food	0.0	1.0	1.5	1.4	1.6	1.5	1.0	1.1
S9	Construction	2.0	1.8	2.2	2.0	2.0	1.8	2.2	2.2
S10	Trade and transport	1.8	1.8	2.0	2.0	1.8	1.6	1.9	1.9
S11	Other Market services	2.0	2.0	2.0	2.0	2.0	2.0	2.2	2.2
S12	Non Market services	1.8	1.8	1.8	1.8	1.8	1.8	1.5	1.5

As data in the OECD STAN database can be used to calculate productivity up to 1996 and the FORMAPER forecasts start at 2000 to fill the gap between 1995 and 2000 the GEM-E3 productivity growth rates are used for 1995 with a transition period from 1995 to 1999 to reach the FORMAPER forecasts in 1999. That is, in the policy scenarios the productivity growth rates deviate from the *Baseline Scenario* after the year 1999.

For the 13 regions representing the rest of the world (RoW) outside the EU15 four different sets of forecasts have been developed covering the other industrialised regions, the accession countries, the East Asian countries and the other regions. The RoW productivity growth rates are shown in Table 7.

Table 7: Forecasts of yearly productivity growth rates in rest-of-the-world regions between 2000 and 2020 (all scenarios)

[%]		NAM, JAP, AUZ		CEA		EAS, CHI		Other RoW regrions	
Sector		2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020
S1	Agriculture	2.30	1.60	2.00	1.80	2.90	2.50	2.00	1.80
S2	Energy	1.98	1.88	2.95	2.78	2.75	3.05	1.75	1.93
S3	Chemicals	2.31	1.88	3.10	2.80	3.04	2.88	2.74	3.01
S4	Ferrous and non ferrous	2.60	1.60	2.00	2.00	2.80	2.60	2.60	2.60
S5	Steel Transport	2.06	1.69	2.33	2.36	2.80	2.58	2.25	2.16
S6	Electronic	3.90	3.40	2.40	2.20	3.00	3.00	2.20	2.40
S7	Textile	1.90	1.60	3.50	3.00	3.50	3.20	3.50	3.20
S8	Food	2.20	1.70	3.50	2.80	3.40	2.80	3.40	3.20
S9	Construction	2.00	1.60	2.80	2.60	2.20	2.20	2.00	1.80
S10	Trade and transport	1.60	1.40	3.00	2.50	2.00	2.40	2.00	2.10
S11	Other Market services	2.50	2.50	2.00	2.00	3.00	2.80	1.50	1.50
S12	Non Market services	1.80	1.80	1.40	1.40	1.50	1.50	1.30	1.20

3.4 Endogenising Total Factor Productivity

In ASTRA aggregated technical progress was conceptualised as an exogenous element of the Cobb-Douglas function of the supply-side model in the macroeconomics module. For ASTRA-E this is altered to endogenise technical progress, which in the updated version comes closer to the Total Factor Productivity (TFP) than to a mere consideration of technical progress.

TFP in ASTRA-E has been partially endogenised using labour productivity, value added and investments all on a sectoral level. About two third of TFP depend on the exogenous sectoral labour productivity changes weighted by the endogenous sectoral gross-value-added (GVA). The last third depends on the endogenous sectoral investments that have been weighted with a sectoral potential to provide innovation. TFP designed in this way is growing slightly slower than expected by the OECD forecast of TFP that have been taken over as part of the framework for the IPTS project. The OECD foresees roughly a 70% increase of TFP over the next 20 years, while in ASTRA-E the TFP growth in this period is about 50-55%.

3.5 Consumption patterns and demand for new products

Consumption in ASTRA was also split into the 12 sectors according to the data of the EUROSTAT 25 sectors input-output-table. Changes of the split occurred via changes in transport consumption modelled on the micro level, which concerns especially sectors 3, 5 and 10 with impacts on the other sectors, and by a continous slight shift towards the other service sectors namely sector 11.

As the IPTS project foresees an exogenous change of the consumption split because of the invention of new products a slightly changed model of the consumption split is introduced. The new split is based on a system of 8 private consumption categories that can also be found in the UN Statistical Yearbooks. Therefore a scheme is developed to transform input given by

the 8 consumption categories into the 12 ASTRA sectors (see annex Table 27). With this scheme the historic data from the UN Statistical Yearbooks and the consumption split forecasts provided by FORMAPER (Prof. Vivarelli) and reviewed by the project team are translated. The exogenous forecasts are based on a set of considerations. First, for information and communication technologies (ICT) it can be observed that the EU is lagging behind the US in terms of consumption as well as in terms of share of ICT capital on total capital stock. So, for related sectors a catching-up of the EU towards the patterns in the US is assumed. Second, within the EU it is expected that the Southern countries converge to the consumption patterns of the other EU countries. Third, the growth of consumption expenditures related to medical care and health is expected to accelerate in the future, reflecting the ageing of the EU population, a diminishing share of these expenditures covered by society, and new attractive health-care products and services. Data and future assumptions for the consumption patterns in the *Baseline Scenario* are shown in Table 8[20].

[20] The direct private consumption of sector 4 "Ferrous and non-ferrous metals" was set to 0 as this amounts only to a negligible number. This is obvious as households do not buy steel but the screws or cars made out of steel.

Table 8: Sectoral split of private consumption expenditures (Baseline Scenario)

[%]	Sector	1985	1990	1995	2000	2010	2020
Region E1	Sector1	1.83	1.72	1.44	1.45	1.22	0.89
A, D	Sector2	3.72	3.53	3.57	3.94	3.99	3.97
	Sector3	6.57	5.5	5.92	6.59	6.76	6.81
	Sector4	0	0	0	0	0	0
	Sector5	7.53	3.61	6.14	5.05	6.32	6.32
	Sector6	3.87	3.77	4.83	4.11	4.16	4.49
	Sector7	5.59	5.41	4.37	4.59	3.98	3.3
	Sector8	21.12	19.86	16.58	16.71	14.09	10.3
	Sector9	0.92	0.99	0.91	0.99	0.89	0.78
	Sector10	29.76	27.34	25.5	28.86	30.19	29.63
	Sector11	8.77	9.4	8.75	9.63	10.7	12.38
	Sector12	10.27	10.11	12.48	11.1	12.25	15.01
Region E2	Sector1	1.58	1.46	1.3	1.24	1.08	0.84
B,F,L,NL	Sector2	3.17	3.16	3.53	3.63	3.62	3.6
	Sector3	5.60	4.89	5.84	6.06	6.13	6.16
	Sector4	0	0	0	0	0	0
	Sector5	8.46	4.35	5.55	5.35	7.13	7.34
	Sector6	4.36	4.65	4.85	4.63	4.94	5.23
	Sector7	4.55	4.25	3.44	3.16	2.52	2.5
	Sector8	18.19	16.81	15.03	14.32	12.49	9.74
	Sector9	0.88	0.86	0.78	0.74	0.64	0.63
	Sector10	27.88	22.6	24.01	25.04	24.94	24.66
	Sector11	10.98	11.35	11.08	11.6	12.23	13.1
	Sector12	14.29	15.28	15.93	16.05	17.7	19.25
Region E3	Sector1	2.18	1.88	1.67	1.5	1.27	0.95
E,GR,I,P	Sector2	2.40	2.47	2.63	2.56	2.71	2.82
	Sector3	4.24	3.33	4.26	4.14	4.48	4.77
	Sector4	0	0	0	0	0	0
	Sector5	8.91	6.7	6.87	9.2	10.66	11.37
	Sector6	4.59	5.28	5.59	6.4	6.7	7.21
	Sector7	6.35	5.91	5.46	4.89	4.27	3.59
	Sector8	25.16	21.7	19.3	17.32	14.67	11.03
	Sector9	0.93	0.9	0.88	0.82	0.72	0.71
	Sector10	23.58	17.28	18.94	18.54	19.05	19.2
	Sector11	9.07	9.29	9.4	8.92	9.54	10.3
	Sector12	12.55	14.41	15.27	16.94	18.53	20.52
Region E4	Sector1	1.97	1.7	1.53	1.4	1.25	0.92
DNK,FIN,IRL	Sector2	3.47	3.28	3.52	3.65	3.66	3.6
SWE,UK	Sector3	6.13	4.88	5.69	6.02	6.16	6.14
	Sector4	0	0	0	0	0	0
	Sector5	8.92	6.76	7.19	7.59	8.63	8.89
	Sector6	4.59	5.74	5.86	5.64	5.66	6.22
	Sector7	4.36	3.77	3.53	3.8	3.18	2.5
	Sector8	22.74	19.64	17.6	16.17	14.43	10.63
	Sector9	0.70	0.67	0.64	0.64	0.53	0.52
	Sector10	29.41	21.21	22.9	24.21	24.77	24.3
	Sector11	6.71	6.7	6.84	7.43	8.62	9.91
	Sector12	10.94	13.57	13.98	13.91	15.44	18.05

4 Results of the *Baseline Scenario*

The *Baseline Scenario* serves as a reference for assessing the impact of the policies. The period from 1986 to 1998 has been used to calibrate the ASTRA-E model. For calibrated variables it is aspired to fit them into a corridor of a certain percent deviation from the real values. The width of the corridor depends on the variable and the accurateness of the calibration data. The most important calibration of GDP with +/- 4% deviation from real values seems to be satisfactory (in ASTRA original it was +/- 3.5%).[21]

In the *Baseline Scenario* average yearly GDP growth rates of the four European regions for the whole period 2000 to 2020 are: 2.15% for EUeast, 2.40% for EUwest, 2.25% for EUsouth and 2.47% for EUnorth. For the EU15 the average yearly GDP growth rate is estimated at 2.27%. The absolute values for regional GDP are given in Table 9.

*Table 9: Regional GDP until 2020 [Mio*EURO1995]*

Region	1986	1990	1995	2000	2005	2010	2015	2020
EUeast	1,755,260	1,861,940	2,034,040	2,270,340	2,527,110	2,795,510	3,088,300	3,451,670
EUwest	1,460,830	1,583,020	1,712,470	1,943,200	2,187,190	2,489,120	2,793,850	3,197,580
EUsouth	1,218,900	1,319,350	1,486,930	1,682,700	1,867,640	2,105,500	2,367,960	2,687,800
EUnorth	1,124,000	1,212,070	1,351,060	1,516,070	1,715,130	1,971,350	2,232,350	2,531,310

The optimistic GDP forecasts are also reflected in the development of regional employment given as full-time-job equivalents (Table 10). The impact of changes of habits to work in part-time-jobs would be additional to these figures.

Table 10: Regional Employment until 2020 [Persons]

Region	1986	1990	1995	2000	2005	2010	2015	2020
EUeast	37,004,200	36,968,900	36,786,500	36,132,300	36,626,500	36,724,400	36,899,800	38,069,600
EUwest	30,784,000	31,283,400	31,813,100	32,810,200	33,141,100	33,935,100	34,522,200	36,297,600
EUsouth	39,319,000	39,522,500	40,326,800	40,500,700	39,546,600	39,554,000	39,665,000	40,222,300
EUnorth	34,424,000	33,991,200	33,665,800	34,057,600	34,348,900	35,407,000	35,623,100	36,039,000

The sectoral results for GDP respecticely production value and employment in the EU15 are presented in Figure 24. Absolute values for GDP and employment changes between 2020 and 2000 are shown in blue and yellow with wide bars. Percentual changes are coulored in orange and green with narrow bars. Each with the two corresponding bars are overlapping e.g. blue and orange for GDP. All sectors increase their GDP over the 20 years time horizon but with varying speed, while employment increase is focused on 5 sectors only of which the two most important are service sectors: *trade and transport* and *market services*.

[21] The r^2-values for GDP of the four regions are: 0.97, 0.96, 0.9, 0.95.

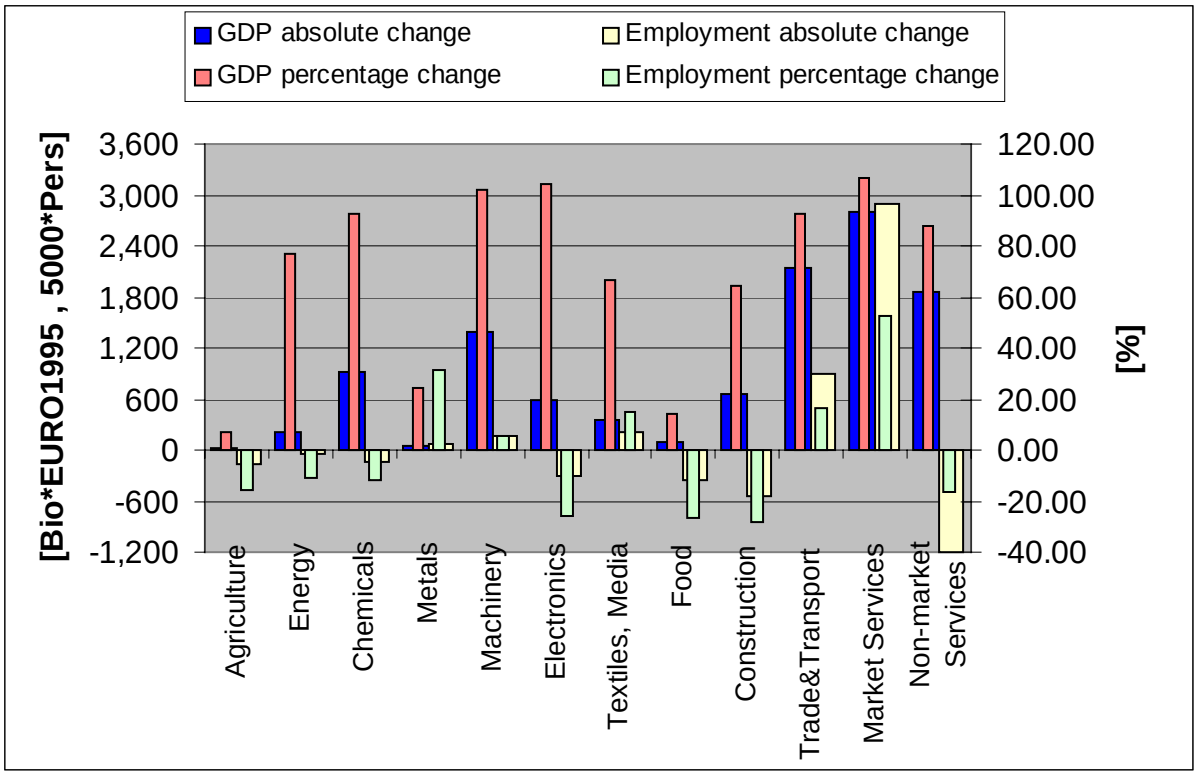

Figure 24: Sectoral changes in GDP and employment for the EU15 between 2020 and 2000[22]

It seems that nearly each sector has a singular pattern of GDP and employment changes. If we look at the GDP changes the most advantageous sectors are market-services, electronics and machinery. The major drivers for market-services are private consumption and their use as an intermediate input to other sectors. Machinery and electronics also depend to a certain extent on private consumption but are more driven by investments and exports than market services. The translation of the GDP growth into employment changes for these three sectors is much different. In fact, the electronics sector even decreases its employment, which is due to the by far highest growth rates of productivity in this sector compared with the other sectors. In contrast market-services significantly increase employment due to lower productivity growth and, which is also important, due to a higher growth in gross-value-added. This is an outcome of the input-output calculations, which shows that on average market-services need less intermediate input than other sectors but on the other hand provide a noticeable amount of intermediates to other sectors. The relationship between sectoral production value and intermediates as input or output plays also an important role for the non-market-services, which loose employment despite growing output and rather low productivity growth. The input-output calculations reveal that the non-market-services absorb a rather high amount of intermediates from other sectors, which slows down the growth of GVA and at the end of the day reduces employment in this sector. The result is consistent with the expectation that

[22] The y-axis for the absolute values are on the left side of the diagram. They are harmoised, which required for employment an adjustment of the unit of measurement to stand for 5000*Pers, which e.g. for non-market services means that about 1,200*5,000 = 6,000,000 jobs are reduced over the 20 years period.

government and authorities will reduce their employment in the next years because of budget constraints.

A peculiarity seems to be with the metals sector that increases its employment by the second highest percentage. Two reasons can be identified. First, the metals sector is by far the smallest sector in terms of absolute employment such that small absolute increases lead to higher percentages. Second, the metals sectors shows the lowest growth in productivity such that for those two reasons a small growth in production value is translated into significant percentual employment growth.

The weekest sectors considering both GDP and employment are agriculture and food with nearly output stagnation and loss of employment, which is coherent with the expectations if no change towards green agriculture and green food consumption occurs.

As labour productivity is one important factor for the above results the following Table 11 presents the applied labour productivity figures calculated based on OECD statistics (STAN, Services and National Accounts database) and on the assumed growth rates of productivity (see Table 6). For the assignment of OECD database categories to ASTRA sectors see annex Table 29, Table 30. Only productivity for the construction sector is taken from the original ASTRA data.

Table 11: Sectoral productivity of European regions [EURO1995/Pers]

Region	Sector	1986	1990	1995	2000	2005	2010	2015	2020
[E1]	S1	24456	26065	28146	30058	31940	34093	36661	39840
	S2	35637	38663	41642	47772	51784	56133	60848	65958
	S3	55626	51938	59050	69839	82172	96607	112499	131006
	S4	29446	34570	44174	52196	57745	63882	70672	78184
	S5	31602	34627	37560	41526	46411	51832	57341	63436
	S6	25524	27117	28653	32081	35491	39234	42964	47048
	S7	24085	26502	28070	30844	33435	36215	38861	41699
	S8	38015	40308	40243	43381	43381	43544	45788	48148
	S9	55963	58390	61455	64207	66858	69829	73290	77465
	S10	29868	31138	34410	37160	40693	44562	48799	53438
	S11	84869	104811	108035	117517	130008	143827	159114	176027
	S12	38728	34483	35583	38307	41949	45937	50305	55087
[E2]	S1	39007	41424	44593	47721	50869	54144	57625	61422
	S2	49255	56262	65607	76626	83911	91818	99530	107889
	S3	63911	73610	87274	99800	111541	124569	137809	152457
	S4	44617	55223	64429	73852	77267	80779	83667	86657
	S5	42991	50676	56754	65351	74936	85860	97447	110597
	S6	37408	37708	48418	58731	71284	86419	103269	123406
	S7	32205	37561	42398	48264	52584	57247	61741	66587
	S8	48566	52367	59541	67624	72933	78628	84371	90533
	S9	45590	47453	49842	52145	54413	56723	59127	61696
	S10	43129	47775	47633	50821	56223	62199	68810	76124
	S11	112037	106813	97558	104945	116099	128440	142092	157195
	S12	35476	36837	37064	39911	43706	47861	52411	57394
[E3]	S1	13793	14893	16532	18190	19817	21590	23504	25568
	S2	34412	39100	45867	50397	54629	59172	63494	68132
	S3	51688	57758	68085	73207	80988	89562	98578	108501
	S4	43521	53298	73271	79105	83603	88323	92875	97661
	S5	31660	35500	43252	48062	54548	61862	69494	78069
	S6	28453	33261	43379	51155	62088	75271	89948	107486
	S7	24267	26083	30503	33321	37433	42019	46723	51954
	S8	45012	49122	55771	61119	66253	71790	77425	83503
	S9	28986	30507	32704	34853	36900	39068	41343	43728
	S10	35949	39350	52031	55736	61035	66786	72395	78476
	S11	84125	85952	101093	106532	117856	130383	144241	159573
	S12	28939	29256	25646	27047	29619	32435	35518	38895
[E4]	S1	29852	31968	35055	39153	45139	53907	67358	87663
	S2	26126	29132	30088	33993	39179	45104	51191	58099
	S3	39504	43270	52877	58240	64760	72010	80071	89036
	S4	25221	31367	37492	40842	41669	42497	43140	43793
	S5	22789	26744	30626	33866	36897	40169	43323	46723
	S6	19232	23088	22132	24344	26389	28605	31008	33612
	S7	23041	25759	28699	30691	32932	35311	37508	39842
	S8	32521	35524	41220	45472	47816	50299	53159	56182
	S9	44818	46910	49881	53693	59028	66432	77046	91805
	S10	25510	27793	31220	34514	37989	41813	46022	50655
	S11	60309	56993	59380	65332	73018	81608	91210	101940
	S12	25302	25361	27090	29094	31378	33841	36497	39362

Resulting from the regional GDP growth and the development of productivity shown above the INTRA-EU export flows are altered. The results for INTRA-EU exports in the *Baseline Scenario* are shown in the following Table 12. The projections of continous growth indicate a further coalescence of the EU in the next decades.

*Table 12: INTRA-EU Export Flows [Mio*EURO1995]*

Exporter	Importer	1986	1990	1995	2000	2005	2010	2015	2020
EUeast	EUeast	0	0	0	0	0	0	0	0
	EUwest	116,864	127,064	121,118	148,644	181,969	219,314	251,419	285,649
	EUsouth	50,845	60,225	64,301	99,906	129,441	160,242	189,377	218,175
	EUnorth	65,766	68,505	64,911	93,551	116,814	142,367	163,995	185,603
EUwest	EUeast	86,883	105,545	116,672	143,838	171,579	199,896	222,642	245,376
	EUwest	0	0	0	0	0	0	0	0
	EUsouth	45,625	57,144	65,888	88,102	109,020	131,821	151,227	170,931
	EUnorth	50,650	59,668	62,415	76,267	88,654	101,735	111,710	121,293
EUsouth	EUeast	37,655	48,539	74,850	106,295	151,017	197,217	242,168	298,176
	EUwest	48,108	53,121	63,630	70,212	80,102	88,791	96,576	104,911
	EUsouth	0	0	0	0	0	0	0	0
	EUnorth	24,586	30,127	43,736	68,043	97,714	132,343	165,793	206,328
EUnorth	EUeast	33,682	46,109	72,817	124,266	181,511	236,765	284,125	329,294
	EUwest	51,028	61,869	74,327	93,995	114,561	133,643	147,972	161,006
	EUsouth	17,757	25,114	39,931	69,506	101,404	132,409	158,976	184,292
	EUnorth	0	0	0	0	0	0	0	0

The labour productivity figures for RoW regions in Table 13 are calculated based on OECD statistics (STAN, Services and National Accounts database), the world development indicators database from the World Bank (WDI 2001) and the UNIDO industrial statistics database (INDSTATR 2001) for the years 1986 to 1996 (1999 if data is available). Forecasts after the years 2000 follow the exogenously given growth rates defined by the IPTS project.

Table 13: Sectoral productivity of rest-of-the-world regions [EURO1995/Pers]

Region	Sector	1986	1990	1995	2000	2005	2010	2015	2020
NAFTA	**S2**	41,395	44,433	49,384	58,629	65,949	72,795	80,001	87,867
	S3	58,784	65,817	76,711	86,393	96,996	108,835	119,856	131,640
	S4	52,240	55,128	68,982	85,499	98,646	112,293	122,385	132,557
	S5	39,151	44,250	55,177	64,765	72,084	79,883	87,111	94,775
	S6	32,537	40,844	34,652	35,718	42,997	52,206	62,027	73,468
	S7	33,241	34,419	34,530	37,593	41,584	45,718	49,610	53,733
	S8	55,794	57,026	64,248	70,841	79,921	89,187	97,384	106,004
	S10	25,420	24,406	28,238	30,625	33,176	35,933	38,582	41,374
	S11	82,069	76,376	74,954	81,257	91,537	103,685	117,445	133,031
	S12	28,198	28,359	29,322	31,661	34,580	37,829	41,383	45,271
Japan	**S2**	25,417	29,885	29,639	38,215	42,986	47,448	52,145	57,272
	S3	33,365	38,140	37,718	43,295	48,609	54,542	60,065	65,971
	S4	46,536	62,691	67,441	89,364	103,105	117,370	127,918	138,549
	S5	24,812	32,412	36,623	44,067	49,047	54,354	59,272	64,487
	S6	43,596	55,602	58,563	67,009	80,666	97,942	116,368	137,832
	S7	17,054	19,283	17,725	20,364	22,525	24,765	26,873	29,107
	S8	34,277	31,751	29,592	34,561	38,990	43,511	47,510	51,715
Australia	**S2**	34,935	32,265	39,578	50,808	57,151	63,084	69,329	76,145
New Zeel	**S3**	43,517	45,036	48,791	55,007	61,758	69,296	76,313	83,815
	S4	31,588	31,197	42,079	53,340	61,541	70,056	76,352	82,698
	S5	26,769	24,737	31,815	36,501	40,626	45,021	49,095	53,415
	S6	25,829	20,156	24,528	27,810	33,478	40,647	48,294	57,202
	S7	25,364	20,273	26,487	30,581	33,828	37,191	40,357	43,711
	S8	35,586	33,134	39,147	47,660	53,769	60,003	65,518	71,317
China	**S2**	2,105	2,355	2,667	2,849	3,259	3,737	4,341	5,051
	S3	2,105	2,355	2,667	2,870	3,330	3,874	4,476	5,167
	S4	2,133	2,318	2,549	2,727	3,127	3,595	4,098	4,665
	S5	1,337	1,594	1,916	2,050	2,350	2,701	3,076	3,498
	S6	2,625	2,938	3,330	3,579	4,144	4,813	5,588	6,489
	S7	1,674	1,723	1,784	1,941	2,303	2,741	3,221	3,777
	S8	2,197	3,038	4,089	4,437	5,240	6,207	7,163	8,235

In Table 14 the export flows from the EU to selected rest-of-the-world regions are shown for the manufacturing sectors. In general the tendency is also positive. However, for some sectors stagnation can be observed e.g. from EUsouth to NAFTA for sector 2 and from EUnorth to NAFTA for sector 7.

*Table 14: Regional export flows from EU region to NAFTA, AUZ (=Australia&New Zeeland) and Japan regions and manufacturing sectors [Mio*EURO1995]*

Exporter	Importer	Sector	1986	1990	1995	2000	2005	2010	2015	2020
EUeast	**NAFTA**	**S2**	10	39	42	125	123	165	206	243
		S3	1,903	2,888	4,057	6,956	9,571	12,282	14,972	17,480
		S4	2,379	2,967	3,565	4,659	5,394	6,034	6,594	7,062
		S5	13,979	14,836	15,570	16,710	17,380	17,909	18,339	18,678
		S6	3,121	4,480	6,047	9,641	12,488	15,156	17,547	19,578
		S7	793	1,078	1,307	1,747	2,129	2,479	2,783	3,037
		S8	466	471	475	480	483	486	487	489
	AUZ	**S2**	4	4	3	5	6	7	9	10
		S3	323	323	408	552	652	726	795	854

		S4	251	251	289	348	385	411	435	455
		S5	1,001	1,001	1,538	2,690	3,642	4,450	5,267	6,029
		S6	486	486	644	1,045	1,308	1,478	1,633	1,760
		S7	147	147	206	377	537	741	957	1,168
		S8	28	28	24	29	31	35	39	43
	Japan	**S2**	3	8	11	26	37	53	74	98
		S3	903	1,538	1,977	3,386	4,430	5,795	7,209	8,583
		S4	249	520	631	1,146	1,628	2,288	2,964	3,594
		S5	1,319	4,302	5,265	11,620	16,648	23,554	33,079	43,841
		S6	525	1,215	1,668	3,409	4,816	6,813	9,049	11,113
		S7	196	402	485	871	1,237	1,730	2,229	2,691
		S8	78	147	174	290	409	551	688	811
EUwest	**NAFTA**	**S2**	138	252	284	464	448	472	486	496
		S3	1,836	2,792	4,189	7,118	9,327	11,493	13,582	15,505
		S4	2,784	3,621	4,492	6,183	7,352	8,396	9,327	10,116
		S5	3,947	7,348	8,827	15,524	21,028	28,321	36,825	45,378
		S6	1,863	2,736	4,012	6,915	9,158	11,418	13,598	15,565
		S7	773	990	1,197	1,594	1,872	2,119	2,336	2,517
		S8	1,178	1,511	1,806	2,022	2,127	2,248	2,348	2,428
	AUZ	**S2**	10	10	1	6	5	7	8	10
		S3	386	386	578	965	1,267	1,524	1,783	2,022
		S4	237	237	284	385	436	473	509	541
		S5	574	574	753	1,627	2,223	2,994	4,007	5,110
		S6	329	329	484	819	1,099	1,379	1,655	1,908
		S7	187	187	236	320	384	436	483	526
		S8	162	162	192	206	211	216	221	226
	Japan	**S2**	9	9	9	9	9	9	9	9
		S3	596	975	1,593	2,315	2,861	3,409	3,917	4,388
		S4	388	995	1,232	1,955	2,506	3,322	4,087	4,805
		S5	238	817	1,374	2,480	3,393	4,569	6,154	8,289
		S6	266	718	993	2,645	3,626	4,884	6,578	8,859
		S7	178	529	923	1,952	2,653	3,573	4,785	6,117
		S8	195	597	838	1,690	2,294	3,090	4,142	5,310
EUsouth	**NAFTA**	**S2**	326	333	329	335	329	328	326	325
		S3	1,355	1,602	1,713	1,892	2,053	2,200	2,317	2,411
		S4	2,840	3,116	3,358	3,750	3,983	4,172	4,328	4,452
		S5	3,995	4,865	5,597	6,995	7,936	8,756	9,457	10,032
		S6	2,552	2,892	3,277	3,888	4,250	4,548	4,800	5,004
		S7	4,156	4,180	4,190	4,214	4,228	4,240	4,248	4,255
		S8	743	797	825	814	794	786	781	778
	AUZ	**S2**	13	13	2	6	6	7	10	14
		S3	104	104	120	177	223	261	295	324
		S4	297	297	347	556	716	853	978	1,083
		S5	464	464	640	1,575	2,150	2,728	3,335	3,898
		S6	230	230	238	527	718	967	1,295	1,652
		S7	284	284	356	771	1,051	1,410	1,777	2,111
		S8	58	58	76	106	126	139	151	162
	Japan	**S2**	9	9	9	10	10	10	11	11
		S3	151	227	373	399	454	506	555	601
		S4	257	773	888	1,413	1,812	2,441	3,137	3,820
		S5	148	552	1,228	1,515	2,075	2,795	3,764	5,070
		S6	112	310	418	946	1,286	1,732	2,332	3,124
		S7	356	1,277	1,961	4,001	5,442	7,330	9,873	13,297

	S8	84	139	206	247	271	299	326	350
EUnorth NAFTA	**S2**	1,026	1,160	846	698	624	615	606	601
	S3	3,614	4,617	5,490	5,704	6,420	7,255	8,097	8,864
	S4	2,870	3,050	2,934	2,986	2,936	2,914	2,903	2,893
	S5	10,119	11,685	12,700	15,210	16,520	17,647	18,539	19,208
	S6	4,137	5,870	7,472	11,664	13,926	15,991	17,521	18,530
	S7	1,874	1,884	1,887	1,896	1,900	1,904	1,907	1,910
	S8	1,337	1,445	1,469	1,561	1,627	1,685	1,730	1,764
AUZ	**S2**	3	3	3	5	6	7	8	9
	S3	567	567	709	966	1,138	1,245	1,348	1,436
	S4	387	387	313	343	306	280	270	264
	S5	1,248	1,248	1,356	2,337	2,952	3,443	3,928	4,350
	S6	1,037	1,037	1,652	2,707	3,394	3,837	4,172	4,381
	S7	333	333	398	521	619	682	739	785
	S8	176	176	164	189	207	230	247	261
Japan	**S2**	22	22	22	22	22	22	22	22
	S3	509	896	1,603	1,896	2,298	2,730	3,170	3,595
	S4	288	589	882	1,045	1,241	1,497	1,716	1,915
	S5	402	1,324	2,573	2,382	3,054	3,915	5,019	6,435
	S6	360	1,155	2,164	1,986	2,329	2,343	2,077	1,768
	S7	270	458	840	1,097	1,370	1,660	1,910	2,125
	S8	300	596	802	1,232	1,579	2,024	2,515	2,974

Further results for the *Baseline Scenario* are discussed in comparison with the policy results in the previous chapter.

5 Results of the Policy Scenarios

We compared three technology policy scenarios with the *Baseline Scenario* described in the previous section. The alternative policy scenarios are similar in that they involve an equal overall increase in innovation and R&D expenditures, they differ from each other in the way the increase is distributed among the sectors of the economy. The scenarios are:

- *Uniform scenario* assuming a uniform increase of sectoral productivity supported by a sectoral balanced technology policy.
- *Diversified scenario* assuming an increase of sectoral productivity that is allocated to sectors that already demonstrate strong performance at least on a regional basis. This scenario comes close to current regional economic structures and diversification strategies.
- *Concentrated scenario* focusing the increase of sectoral productivity on the economic sectors, which show the highest growth potential. The policy is accompanied by a change in consumption patterns towards new products invented by the technology policy.

Two major levers are used to implement the scenarios in ASTRA-E: sectoral productivity growth rates after the year 1999 and changes in private consumption pattern introduced in the years 1997 to 2003. The sectoral productivity growth rates for the four European regions have been specifically adapted for each scenario according to the estimations of the project team

reconciled with Prof. Pianta (FORMAPER). Productivity change in the 13 rest-of-the-world regions remains the same as in the *Baseline Scenario*. Where necessary the rates are adjusted to the ASTRA sectoral split. The sectoral productivity changes directly have an impact on employment and INTRA-EU exports as well as exports to the RoW regions. Furthermore they are linked with total factor productivity (TFP).

For the *Concentrated Scenario* additionally changes in consumption pattern altering the sectoral distribution of private expenditures and reflecting the demand for new products are introduced according to the suggestions of Prof. Vivarelli (FORMAPER) in agreement with the project team. The changes in consumption split are phased in over a period of 6 years starting after 1997 and lasting until 2003 directly affecting the structure of consumption expenditures of private households. The interrelationships and feedback mechanisms in the ASTRA-E model then transfer the first round direct impacts of productivity changes and new demand to further elements of the model and into secondary impacts in future years.

5.1 Implementation of Common Policy Scenarios in ASTRA

The scenarios are designed such that they can be implemented in GEM-E3 and in ASTRA-E by two levers:

- Labour productivity changes caused by the additional R&D;
- Sectoral split of private household expenditures caused by induced demand for new products invented by the additional R&D.

Special care was taken to implement the same scenarios in GEM-E3 and in ASTRA-E as there is the difficulty that the regional differentiation within the EU15 and the classification of economic sectors is not exactly the same within the two models.

The following three tables present the productivity growth rates for the European regions in the three policy scenarios.

*Table 15: Yearly productivity growth rates between 2000 and 2020 in **Uniform Scenario***

	[%]	EUeast		EUwest		EUsouth		EUnorth	
Sector		2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020
S1	Agriculture	1.50	1.40	2.00	1.80	2.00	1.80	0.45	1.26
S2	Energy	1.82	1.71	1.94	1.80	1.94	1.80	2.51	2.24
S3	Chemicals	3.00	2.77	2.25	2.22	2.25	2.22	1.91	1.87
S4	Ferrous and non ferrous	2.00	2.00	1.00	0.90	1.00	0.90	0.43	0.39
S5	Steel Transport	1.70	1.61	2.48	2.39	2.48	2.39	0.76	0.60
S6	Electronic	3.00	2.70	4.00	4.00	4.00	4.00	3.96	2.76
S7	Textile	1.60	1.40	1.90	1.70	1.90	1.70	1.32	1.12
S8	Food	0.00	1.00	1.50	1.40	1.50	1.40	-0.16	0.83
S9	Construction	2.00	1.80	2.00	1.80	2.00	1.80	2.23	2.17
S10	Trade and transport	2.00	1.90	2.20	2.10	2.20	2.10	2.17	2.17
S11	Other Market services	2.20	2.20	2.20	2.20	2.20	2.20	2.40	2.40
S12	Non Market services	1.90	1.90	1.90	1.90	1.90	1.90	1.76	1.76

*Table 16: Yearly productivity growth rates between 2000 and 2020 in **Diversified Scenario***

	[%]	EUeast		EUwest		EUsouth		EUnorth	
Sector		2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020
S1	Agriculture	1.20	1.10	1.60	1.40	1.60	1.40	0.36	1.03
S2	Energy	1.62	1.49	1.72	1.58	1.72	1.58	2.78	2.57
S3	Chemicals	3.83	3.49	2.16	1.96	2.16	1.96	2.17	2.15
S4	Ferrous and non ferrous	1.80	1.60	1.80	1.60	1.80	1.60	0.23	0.23
S5	Steel Transport	1.96	1.84	3.13	2.90	3.13	2.90	0.73	0.55
S6	Electronic	2.00	1.80	3.00	2.60	3.00	2.60	4.52	3.48
S7	Textile	1.40	1.20	2.90	2.70	2.90	2.70	1.04	0.84
S8	Food	0.00	0.00	2.00	1.80	2.00	1.80	-0.16	0.62
S9	Construction	1.60	1.40	1.80	1.60	1.80	1.60	1.86	1.66
S10	Trade and transport	2.20	2.00	1.80	1.60	1.80	1.60	2.22	2.02
S11	Other Market services	2.40	2.40	2.00	2.00	2.00	2.00	3.02	2.88
S12	Non Market services	2.00	2.00	1.80	1.80	1.80	1.80	1.65	1.65

*Table 17: Yearly productivity growth rates between 2000 and 2020 in **Concentrated Scenario***

	[%]	EUeast		EUwest		EUsouth		EUnorth	
Sector		2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020	2000-2010	2010-2020
S1	Agriculture	1.50	1.40	2.00	1.80	2.00	1.80	0.45	1.26
S2	Energy	2.27	2.04	2.24	2.01	2.24	2.01	2.52	2.26
S3	Chemicals	2.70	2.64	2.12	1.99	2.12	1.99	1.84	1.82
S4	Ferrous and non ferrous	2.00	2.00	0.80	0.80	0.80	0.80	0.43	0.39
S5	Steel Transport	1.54	1.51	2.09	2.05	2.09	2.05	0.74	0.60
S6	Electronic	4.00	3.50	5.00	5.00	5.00	5.00	4.54	3.34
S7	Textile	1.60	1.40	1.50	1.30	1.50	1.30	1.32	1.12
S8	Food	0.00	1.00	1.20	1.00	1.20	1.00	-0.04	0.95
S9	Construction	2.00	1.80	2.00	1.80	2.00	1.80	2.23	2.17
S10	Trade and transport	2.40	2.40	2.30	2.30	2.30	2.30	2.47	2.47
S11	Other Market services	2.40	2.40	2.40	2.40	2.40	2.40	2.60	2.60
S12	Non Market services	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

The resulting absolute changes in productivity are illustrated in the following Figure 25 for the European region EUsouth and the sector 5 "Machinery and Transport Equipment". As sector 5 is one of the key sectors in the regional economy the productivity in the *Diversified Scenario* is increasing strongly though the difference in percentage only is 0.63% in the first decade and 0.6% in the second decade. However, in the *Concentrated Scenario* this region concentrates on electronics and to some extent also on agriculture while sector 5 is not in the focus of technology policies. So, the productivity growth is even lowest in this scenario.

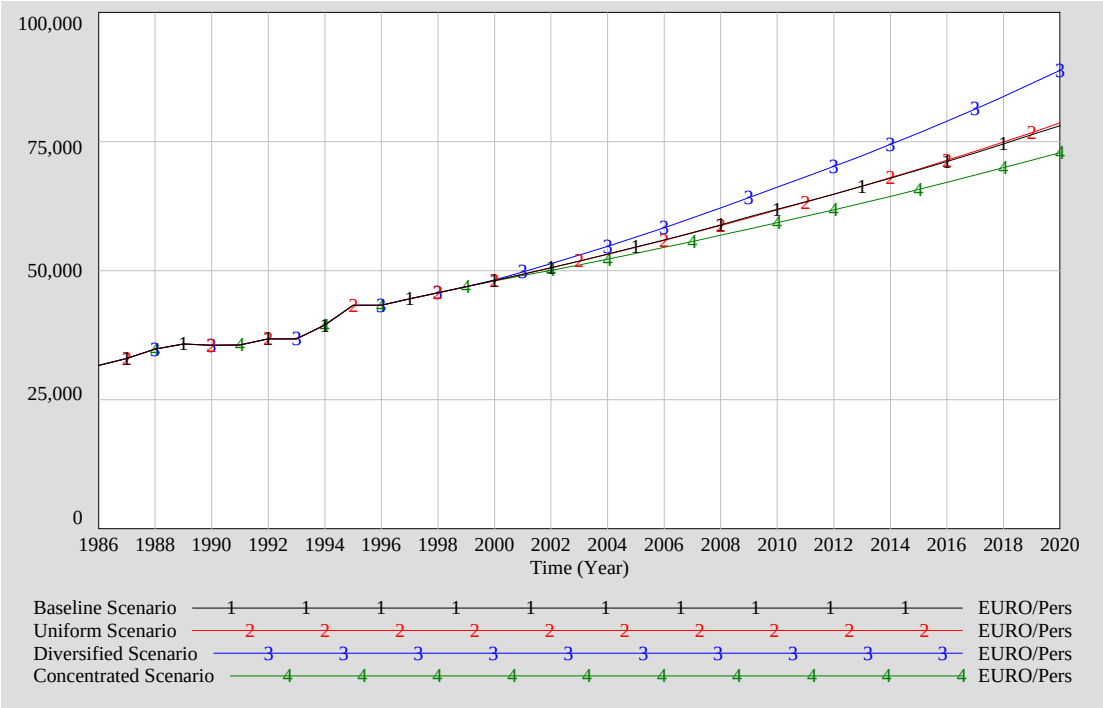

Figure 25: Productivity in the three scenarios in sector 5 "machinery" in region E3 (EUsouth)

In addition to productivity changes the demand for new or other products invented by the technology policy is introduced in the *Concentrated Scenario*. The changes are implemented in a way that some sectors loose part of their absolute shares of consumption expenditures while other sectors gain absolute percentages such that the balance of losses and gains is zero. Roughly speaking the service sectors are winners and the traditional industry sectors like food and textile are loosers. All changes are phased in over the period 1997 to 2003. The absolute sectoral changes are shown in Table 18.

Table 18: Changes in demand in Concentrated Scenario

Code	Changed Sector	*Concentrated Scenario*
S1	Agriculture, forestry and fishery;	0
S2	Energy, Water, Mining Products, Crude Oil;	***-1***
S3	Chemical, Mineral, Plastic, Petroleum Products;	0
S4	Ferrous and non-ferrous ores and metals;	0
S5	Steel products, Machinery, Transport Equipment, Office and Data Processing;	0
S6	Electrical, Optical Goods, Toys;	0
S7	Textiles, Clothing, Paper, Wooden Goods;	***-1***
S8	Food, Beverages, Tobacco;	***-1***
S9	Building and Construction;	0
S10	Services for Repair, Wholesale and Retail, Transport, Communication;	**+1**
S11	Other Market Services like Lodging, Catering, Credits, Insurances;	**+2**
S12	Non-market Services.	0

5.2 Results for the whole EU15

In this section the results of the scenarios are presented aggregated to the EU15 level. Some of the figures are given in absolute values while most of the figures show the percent changes of the policies compared with the *Baseline Scenario*. In section 5.3 it will be shown that on the level of the European regions the picture can be rather different than on the EU15 level.

Figure 26 indicates that in all scenarios total emplyoment in the EU15 given as full-time-job equivalents will increase until 2020. However, the *Concentrated Scenario* is much more optimistic than the others, which is mainly due to changes of households consumption patterns in favor of the two service sectors *trade, transport and communications* and *market-services* accepting the newly developed products and services emerging because of increased R&D. It has been tested if the same increase of consumption expenditures but in other sectors would produce similar results, which was not the case. So, the employment growth depends on the characteristics of the service sectors and it happens despite both sectors increase their productivity in the *Concentrated Scenario*. As discussed above production value of market-services incorporates a higher share of gross-value added (GVA) than other sectors, which also holds to a less extent for trade and transport. Therefore similar increases in production value lead to higher increases in GVA and subsequently to higher employment. An additional argument, which can not be verified directly in the model, is that those sectors contain more local content than for instance industry sectors, that import a greater share of their intermediates input.

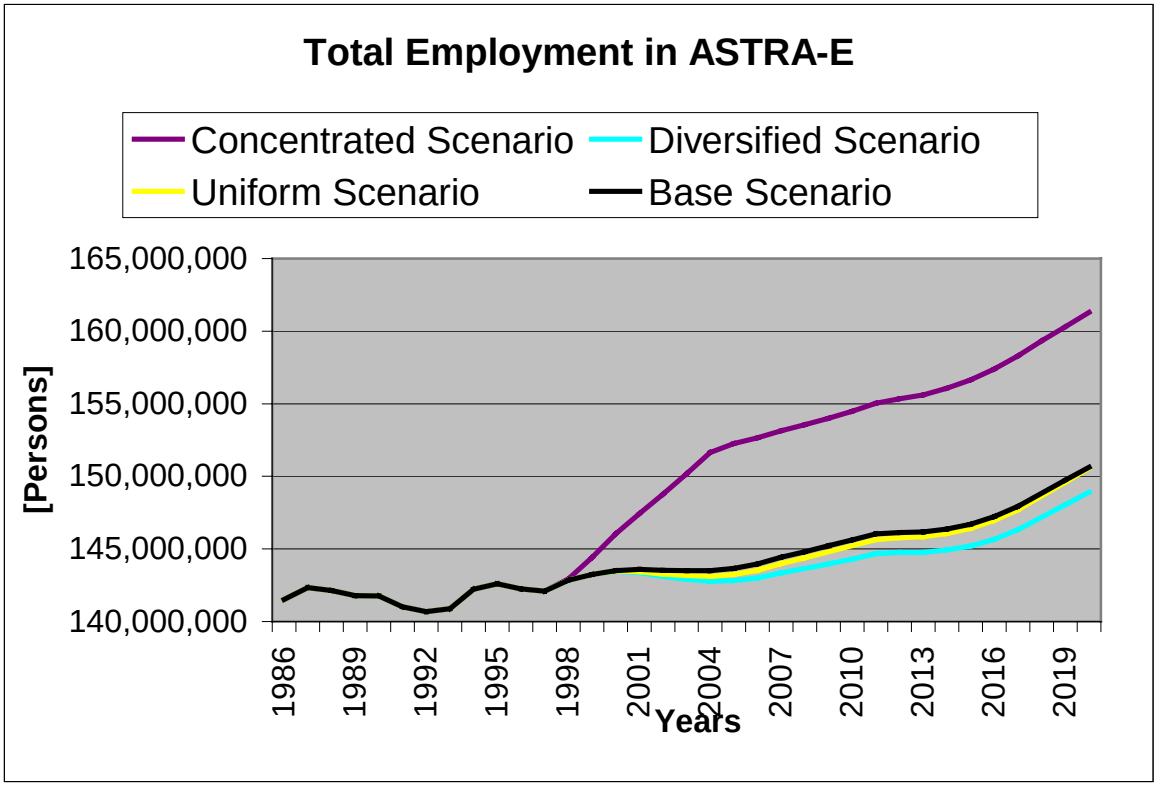

Figure 26:Development of total employment in the EU15 for the three scenarios

In Figure 27 presenting the GDP changes in relative terms to the *Baseline Scenario* it can be seen that all three scenarios would increase European GDP. However, the increase in the *Concentrated Scenario* is strongest with more than two times the growth of the second-best scenario, which would be the *Diversified Scenario*. GDP is growing as a rather direct consequence of the productivity changes augmenting TFP and exports with higher positive impacts than the direct employment reduction by the productivity increase. This is elaborated on in section 5.5.

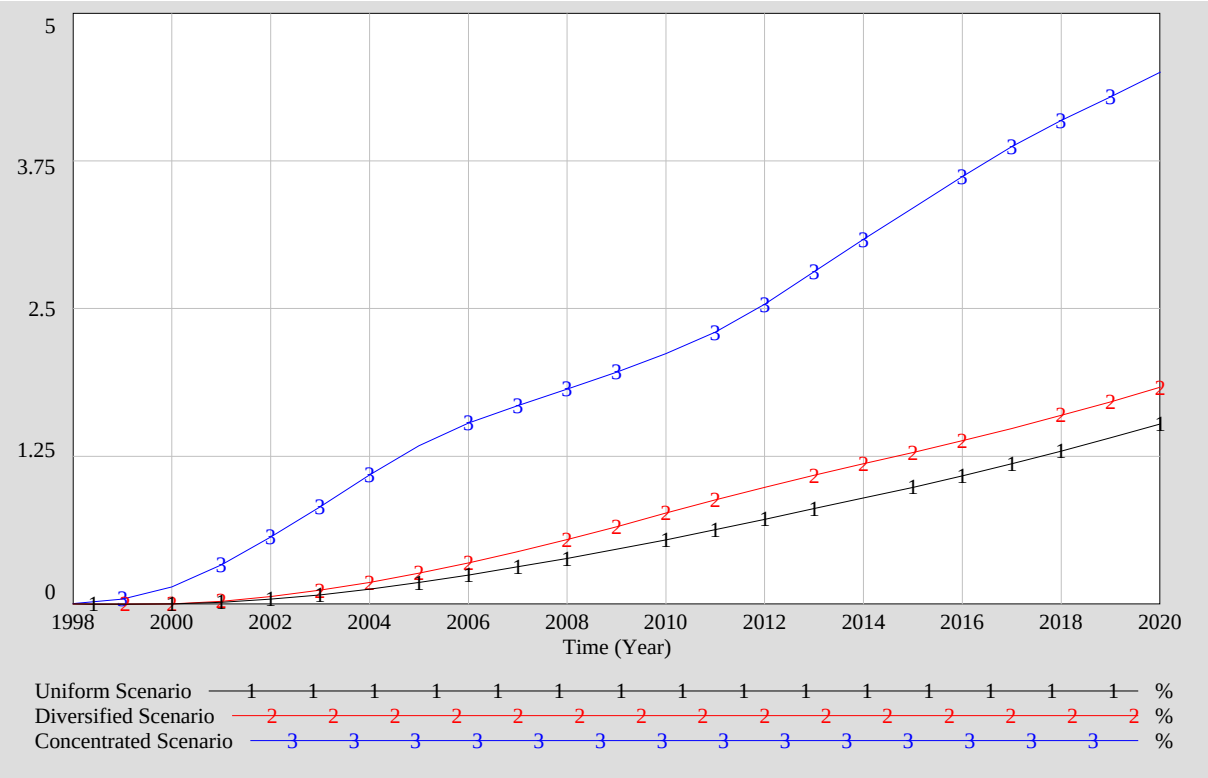

Figure 27: Percent change of EU15 GDP in the three scenarios compared with baseline scenario

In line with the changes in GDP also private household consumption is growing. This is shown in absolute terms in Figure 28 (the y-axis is not starting at 0 to increase resolution between the scenarios). Again the increase of the consumption pie is strongest in the *Concentrated Scenario*, while the other two scenarios are close together each leading to a slight increase compared with the *Baseline Scenario*.

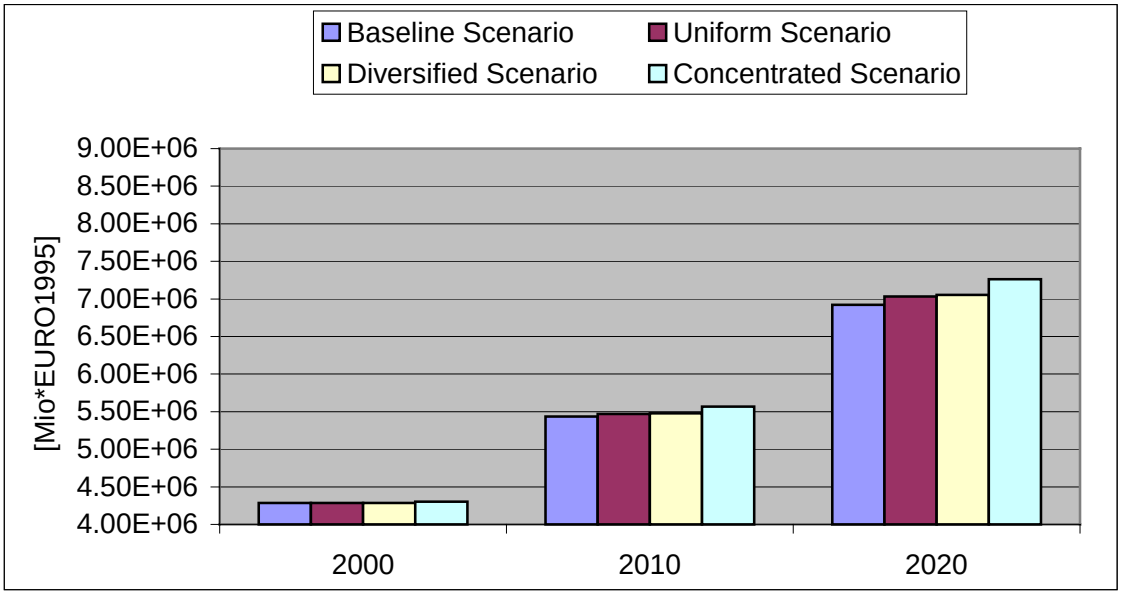

Figure 28: Absolute changes in private consumption in the scenarios

Total exports are also increasing compared with the *Baseline Scenario*. Although this change is smaller than the increase of GDP. The *Concentrated Scenario* is performing best in the first 18 years while after 2018 the *Diversified Scenario* takes over this position. Several impacts are overlaying to produce this pattern. For the *Concentrated Scenario* it seems that the changes in household consumption patterns affects INTRA-EU trade positively and therefore leads to higher export growths in the first 5 to 10 years. However, the patterns of productivity increase in the *Diversified Scenario* seems to be more advantageous to drive exports in general such that without further changes of the consumption split in the *Concentrated Scenario* after 2003 in the long run the productivity induced changes in exports outweigh the demand impacts on INTRA-EU trade.

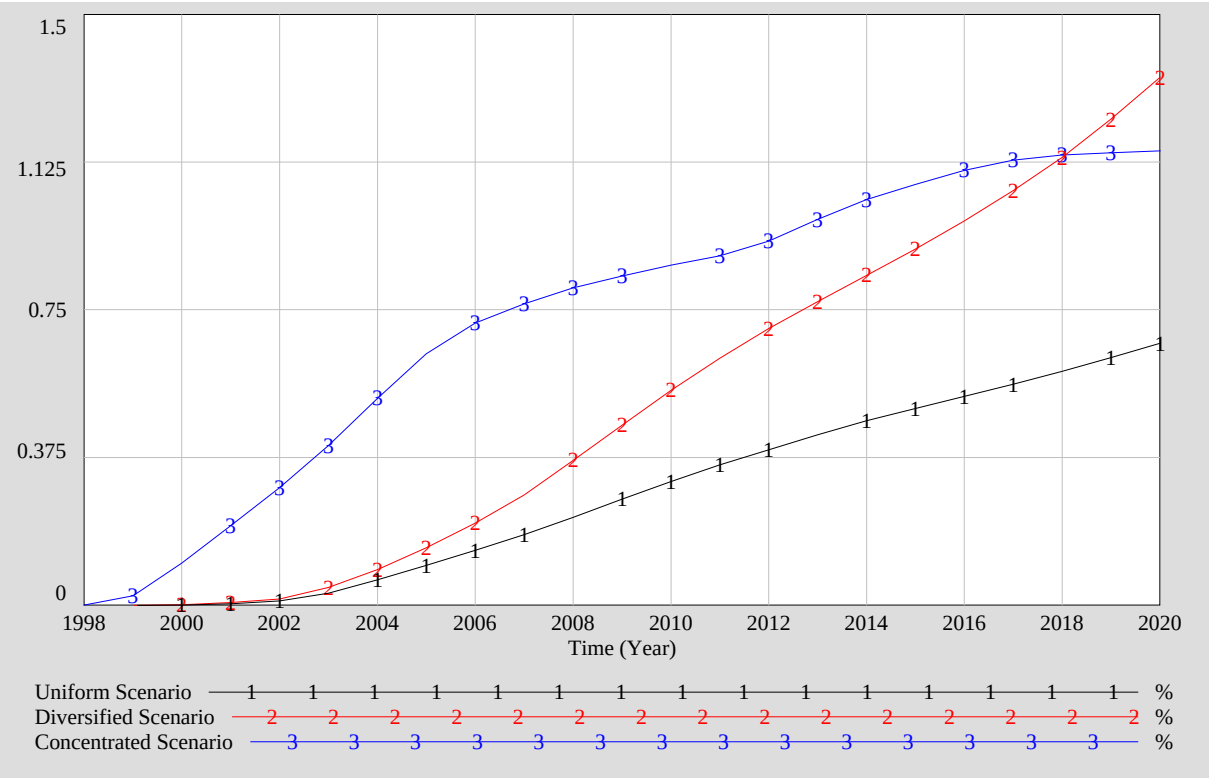

Figure 29: Percent change of total EU15 exports compared with Baseline Scenario

The picture of the percent changes is much different looking at the exports to the rest-of-the-world (RoW) regions in Figure 30. Here the *Diversified Scenario* is most advantageous. But also *Concentrated Scenario* and *Uniform Scenario* produce positive results.

It should be kept in mind that for EU to RoW exports a rough and a sophisticated model are implemented because not all calibration data could be obtained. Only the sophisticated model is able to consider the changes on exports caused by relative productivity. This model is applied for about 60% to 70% of the export flows from EU regions to the RoW regions.

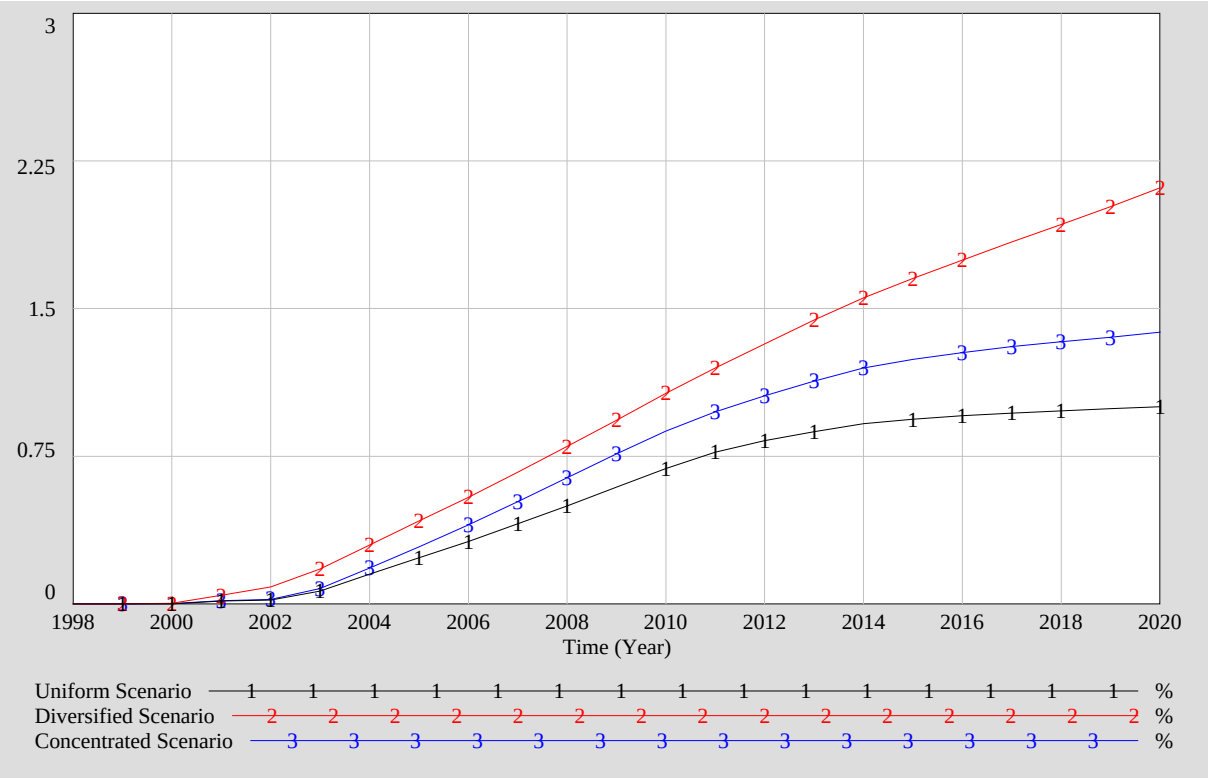

Figure 30: Percent change of EU15 exports to rest-of-the-world compared with Baseline Scenario

Up to now the comparison with the *Baseline Scenario* is positive. However, the following Figure 31 presenting the change in employment is showing a slight decrease in employment for the diversified and the *Uniform Scenario*. The *Uniform Scenario* is catching up with the *Baseline Scenario* until 2020. Obviously the labour saving effect of the productivity growth in these scenarios is higher than the impact of output and income growth caused by higher productivity plus the export growth. However, for the *Concentrated Scenario* employment is increased very significantly. This is due to the sectoral changes in consumption split in this scenario. This issue will be further elaborated on in following sections.

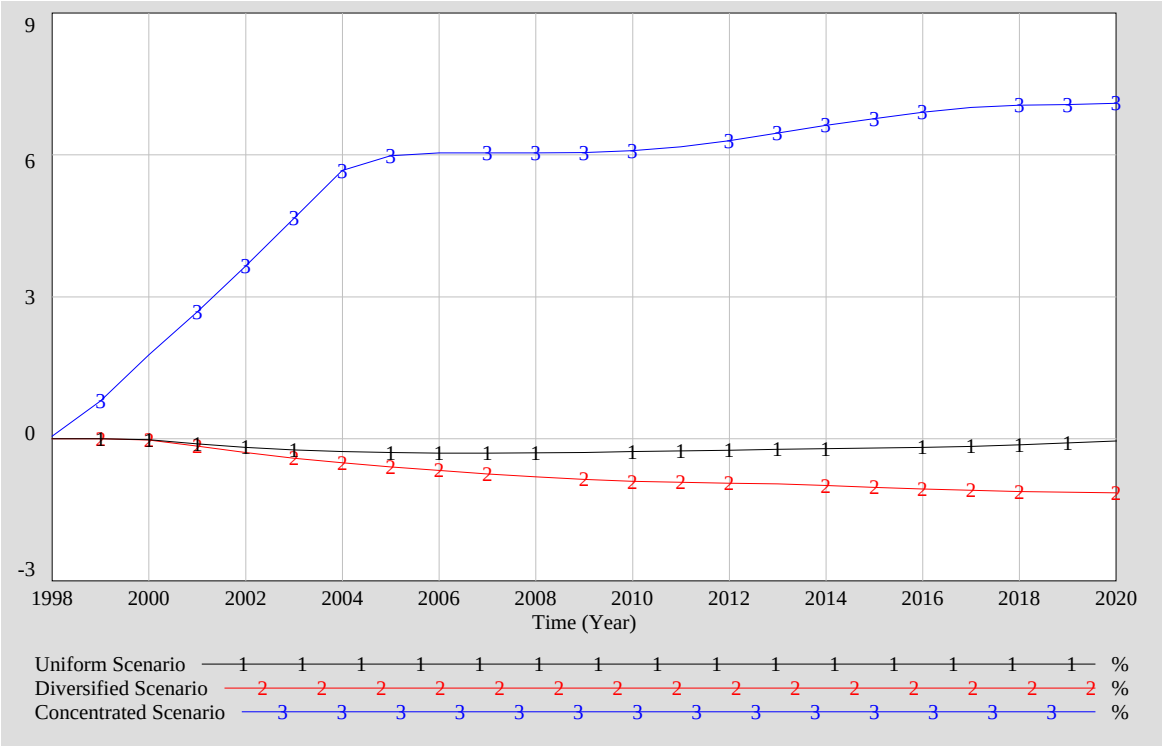

Figure 31: Percent change of EU15 employment compared to Baseline Scenario

The following three figures present the sectoral results for the changes in the EU15 between the years 2020 and 2000. Figure 32 shows the absolute changes per sector and per scenario. In absolute terms the growth is strongest in the three service sectors in all scenarios, which reflects the shift from industry to services.[23] The strongest absolute growth of the industry sector is observed for the machinery sector including transport and other machinery.

For the *Concentrated Scenario* the introduced changes of the consumption split can easily be identified by the reductions in the sectors energy, textiles and food and the increase in trade&transport&communications and other market services. For all other sectors the development is the same as for GDP with the highest growth in the *Concentrated Scenario* followed by Diversified and *Uniform Scenario*.

[23] It should also be considered that there are only 3 services sectors compared to 8 industry sectors plus agriculture.

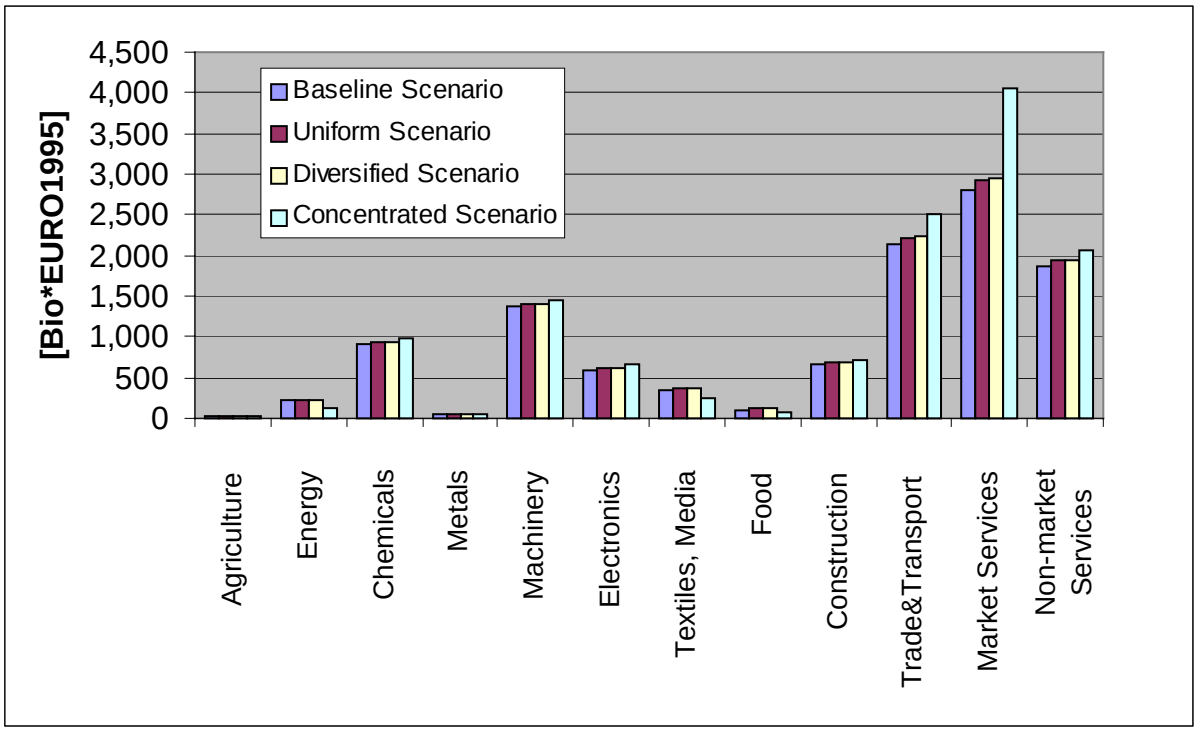

Figure 32: Sectoral changes of output for the EU15 between the years 2020 and 2000

Figure 33 presents the percent changes deleting the different size of the sectors from the analysis. Now the strongest growth can be observed for electronics, market services and machinery. Also some differences between the three policy scenarios become apparent e.g. that electrioncs is growing slightly better in the Uniform than in the *Diversified Scenario*

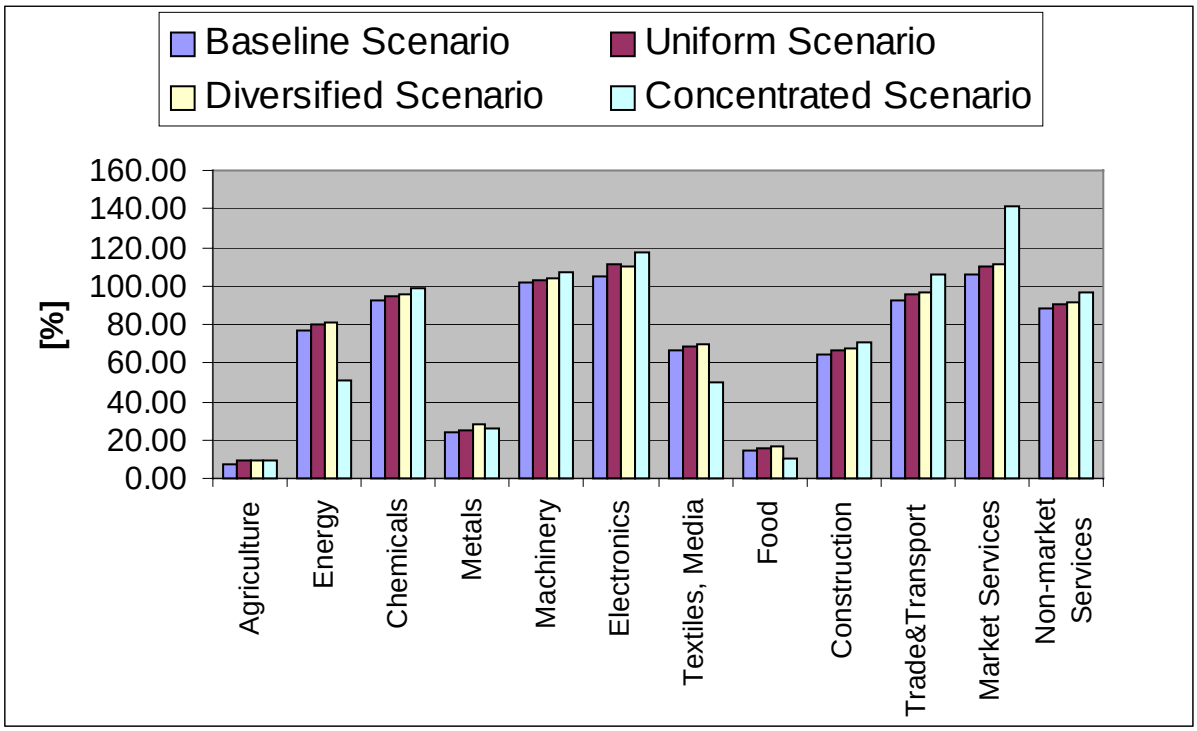

Figure 33: Sectoral percent changes of output for the EU15 between the years 2020 and 2000

The previous two figures provide the background for the result on employment changes in Figure 34. Two additional columns split the sector machinery into transport equipment and other machinery. It is interesting to notice that in electronics employment is reduced despite the highest percentage growth as seen in the previous figure. However, the productivity growth rates for electronics are highest in Concentrated and *Uniform Scenario* and belong to the highest in the *Diversified Scenario*.

Employment in market-services is one of the few sectors in which employment in the scenarios develops into different directions. While in the *Concentrated Scenario* employment increases compared with the *Baseline Scenario* the two other scenarios lead to reduced employment. This is comprehensible since in all scenarios productivity in this sector is significantly increased (in fact the productivity change belongs always to the 3 to 5 highest changes). However, in the *Concentrated Scenario* the shift in private consumption leads to much higher demand and production value for market services than in the other scenarios overcompensating the reduction of employment by the strong productivity increase.

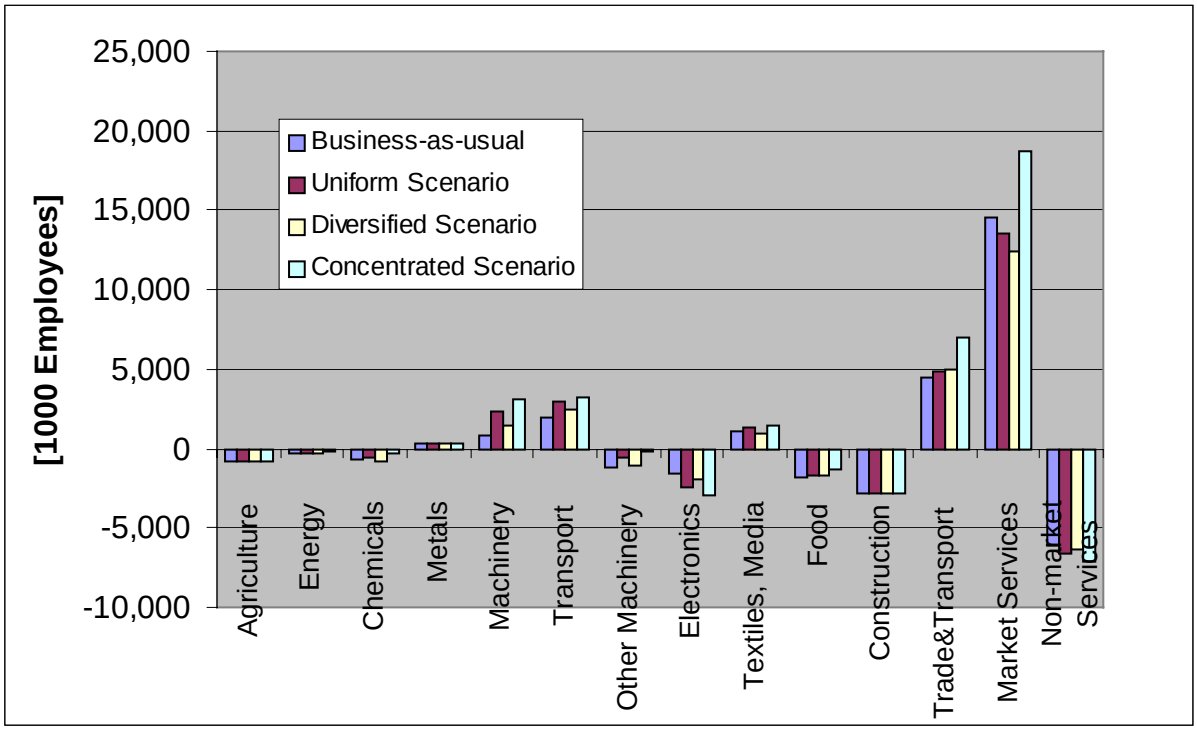

Figure 34: Sectoral changes of employment for the EU15 between 2020 and 2000

5.3 Results for the four European regions

The four ASTRA regions are:

- E1 = EUeast: Austria, Germany (A-D);
- E2 = EUwest: Belgium, France, Luxembourg, Netherlands (B-F-L-NL);

- E3 = EUsouth: Spain, Greece, Italy, Portugal (E-GR-I-P);
- E4 = EUnorth: Danmark, Finland, Ireland, Sweden, United Kingdom (DNK-FIN-IRL-S-UK).

The general comment is that regional differences do matter for the policy results and the ranking of policies in the different scenarios. This concerns sectoral relative productivity inbetween the four regions but also between the EU and the RoW regions.

Table 19: Regional changes of GDP and employment compared with the year 2000 (Percentages)

Changes to 2000 [%]		GDP		Employment	
Scenario	**Region**	**2010**	**2020**	**2010**	**2020**
Baseline	EUeast	23.14	52.05	1.64	5.36
	EUwest	28.08	64.53	3.43	10.63
	EUsouth	25.15	59.78	-2.34	-0.69
	EUnorth	30.02	66.96	3.96	5.82
Uniform	EUeast	23.78	53.88	1.54	5.59
	EUwest	28.89	67.37	2.97	9.89
	EUsouth	25.93	63.10	-2.31	-0.14
	EUnorth	30.51	68.76	3.39	5.52
Diversified	EUeast	24.36	55.27	1.02	5.08
	EUwest	28.30	64.86	2.91	9.51
	EUsouth	26.00	63.10	-2.72	-0.91
	EUnorth	31.71	72.33	1.83	2.51
Concentrated	EUeast	26.05	59.31	6.88	12.06
	EUwest	30.32	71.24	7.26	15.40
	EUsouth	27.03	65.80	0.88	4.14
	EUnorth	32.86	74.80	8.97	11.43

Table 20: Regional changes of GDP and employment compared with Baseline Scenario (Percentages)

Changes to Baseline [%]		GDP		Employment	
Scenario	**Region**	**2010**	**2020**	**2010**	**2020**
Uniform	EUeast	0.52	1.22	-0.13	0.19
	EUwest	0.62	1.71	-0.46	-0.68
	EUsouth	0.65	2.11	0.02	0.55
	EUnorth	0.37	1.07	-0.58	-0.31
Diversified	EUeast	1.00	2.13	-0.64	-0.29
	EUwest	0.16	0.19	-0.51	-1.02
	EUsouth	0.70	2.11	-0.40	-0.23
	EUnorth	1.30	3.21	-2.11	-3.18
Concentrated	EUeast	2.56	4.98	7.35	8.57
	EUwest	1.86	4.18	5.28	5.90
	EUsouth	1.59	3.87	4.47	6.05
	EUnorth	2.39	4.91	7.38	7.88

The following figures present the timepaths of the developments of GDP and employment for the European regions. First an overview on the development of GDP in the *Baseline Scenario* is presented in Figure 35.

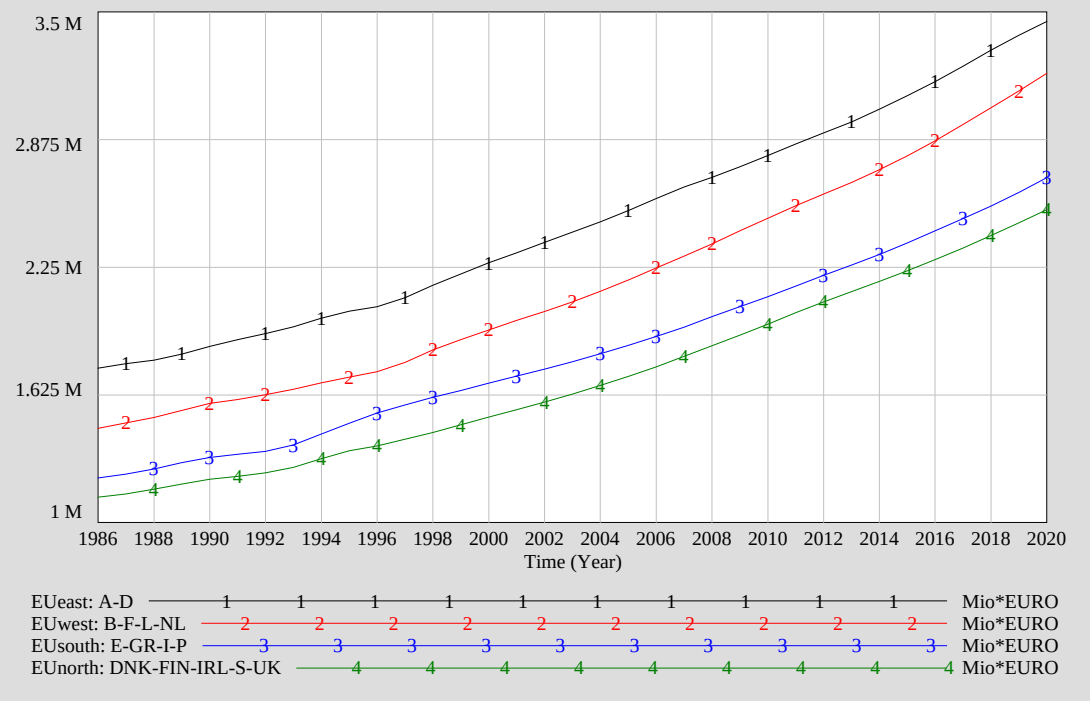

Figure 35: GDP in the four European regions in the Baseline Scenario

The following four figures present the percent changes of GDP in the four European regions compared with the *Baseline Scenario*. For all regions the *Concentrated Scenario* is the most advantageous. The second best scenario for regions EUeast and EUnorth would be the *Diversified Scenario* while for EUwest it would be the *Uniform Scenario*. In fact the *Diversified Scenario* for EUwest would be one of the worst cases with no change of GDP campared with the *Baseline Scenario*. For EUsouth Uniform and *Diversified Scenario* lead to the same development.

It seems that the most important reason for those differences is whether the productivity increase in the scenarios affect sectors with high shares of GVA or high shares of sectoral production value or not. Such sectors would be the service sectors and to much less extent the machinery sector, chemical sector and electronics sector. In the *Concentrated Scenario* all regions focus on the service sectors and there mainly on *trade, transport & comm*unication and *other market services* and on *electronics*. This leads to higher TFP growth as e.g. 1% increase of productivity in a sector contributing 20% of total GVA produces a greater increase of TFP than a 1% increase in a sector contributing only 4% of total GVA. Increased TFP kicks-off the chain increased output, increased income, increased consumption and hence increased investments both leading to growing final demand. Exports are in the *Concentrated Scenario* only minor contributing to the output changes, which is also a general conclusion for all scenarios. In the case of the *Concentrated Scenario* it should also be reminded that service exports to the RoW are only for NAFTA region modelled sensitive to productivity changes, which reduces the potential impact of changes in service exports that can be measured by the model. So, as productivity is mainly increased in service sectors exports in the *Concentrated Scenario* are only slightly changing.

In the *Diversified Scenario* for EUeast and EUnorth productivity increase is focused also on the service sectors and on chemicals for EUeast and electronics for EUnorth. Hence, similar effects as in the *Concentrated Scenario* are kicked-off in these two regions. For EUsouth the Diversified and the *Uniform Scenario* lead to the same change in output. This is interesting as the productivity changes in the two scenarios are nearly antipodal focusing in the *Diversified Scenario* on metals, machinery, textile and food while the *Uniform Scenario* concentrates on chemicals, electronics, trade&transport&communication and market services. In this case two different sets of causes lead to the same growth results. The *Diversified Scenario* increases INTRA-EU exports of EUsouth significantly and also augments its exports to RoW. Exports are also part of final demand effecting output and in addition lead to higher investments in EUsouth. But TFP is only increasing half as fast as in the *Uniform Scenario* (compared with the *Baseline Scenario* +1,5% versus +2,7% in 2020). However, in the *Uniform Scenario* Exports of EUsouth do increase compared to *Baseline Scenario* only by +0,8% versus +5% in the *Diversified Scenario*.

The *Diversified Scenario* in EUwest seems to be the wrong choice of sector to focus on for this region (e.g. productivity increases in metals, machinery, textile and food and productivity decreases in electronics and trade&transport&communication). Neither TFP nor exports are increased compared to the *Baseline Scenario*. It was checked if the same sectoral change would produce similar outcomes for the other regions. The result is that EUeast and EUnorth

would perform much better with this structure of changes than EUwest, while EUsouth would be faced with similar poor results. That means that the prevailing specific sectoral structure of EUwest seems to be the major cause for the results of the *Diversified Scenario*.

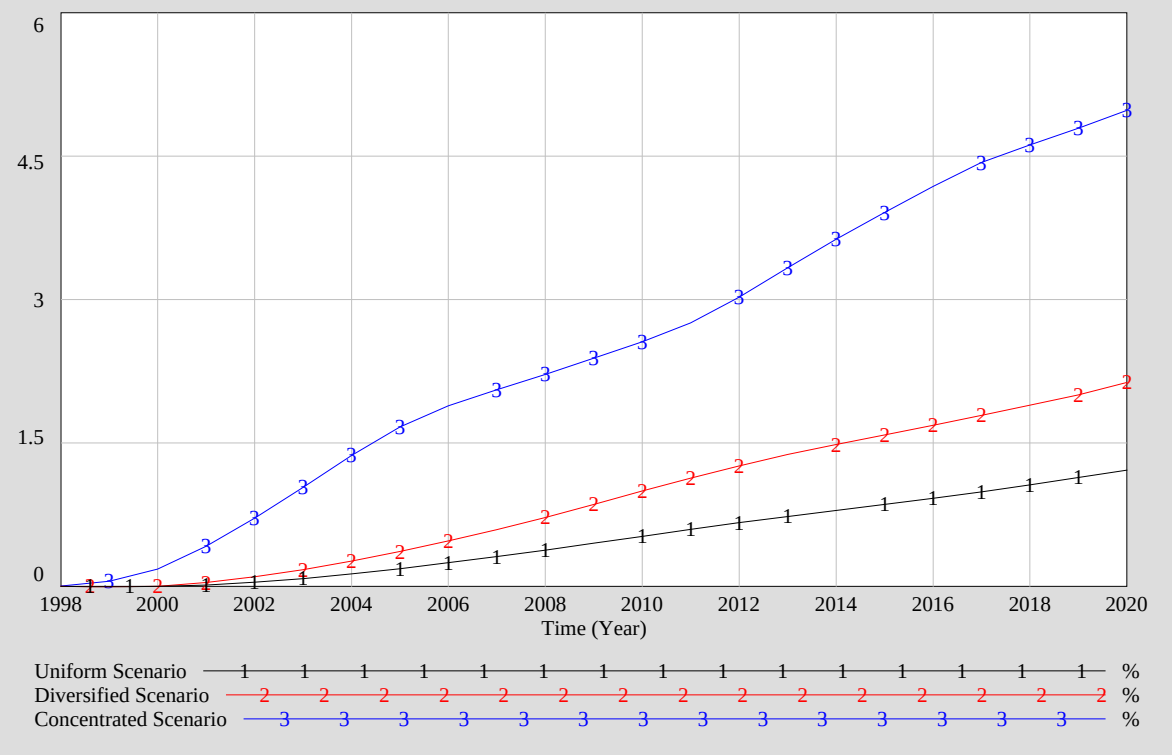

*Figure 36: Percent changes of GDP in region **EUeast** for the three scenarios as percentage to Baseline Scenario*

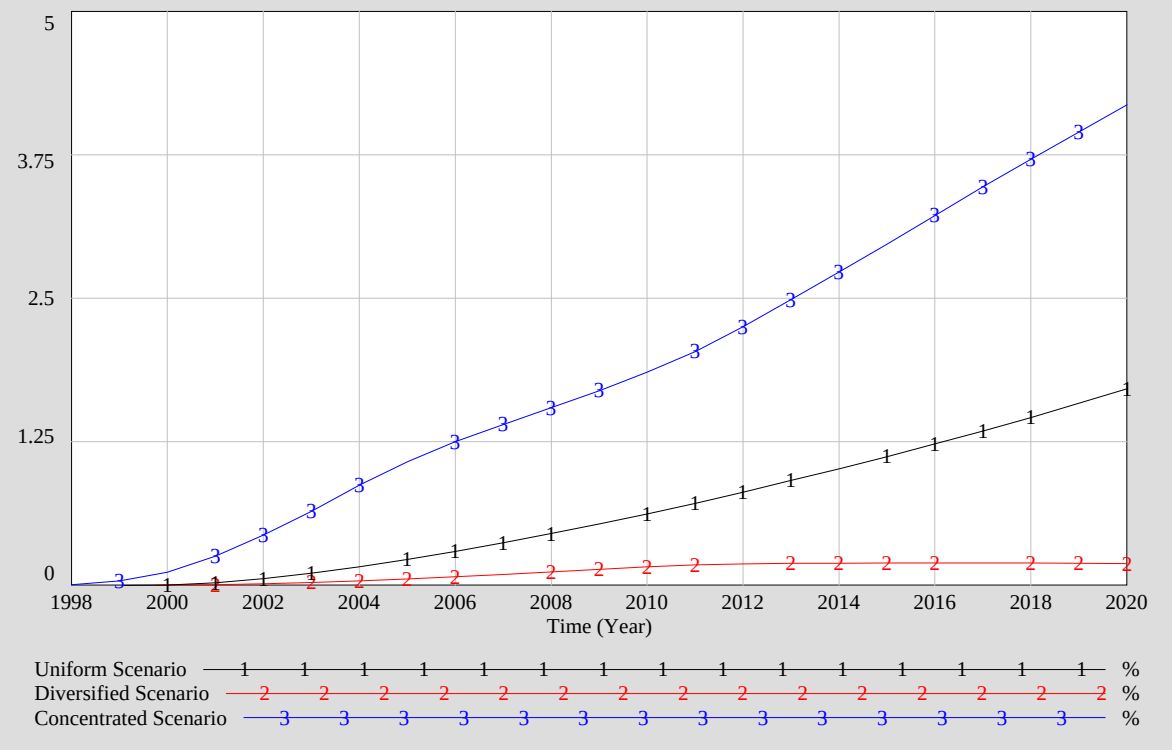

*Figure 37: Percent changes of GDP in region **EUwest** for the three scenarios as percentage to Baseline Scenario*

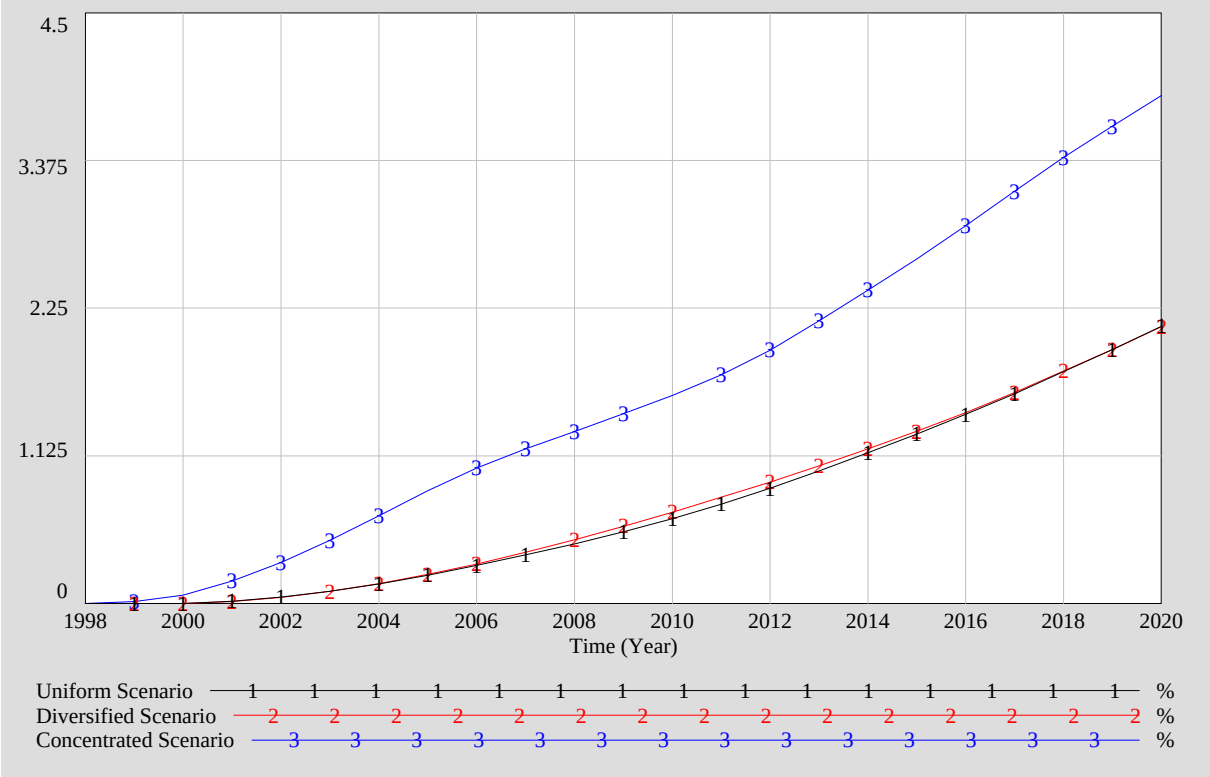

*Figure 38: Percent changes of GDP in region **EUsouth** for the three scenarios as percentage to Baseline Scenario*

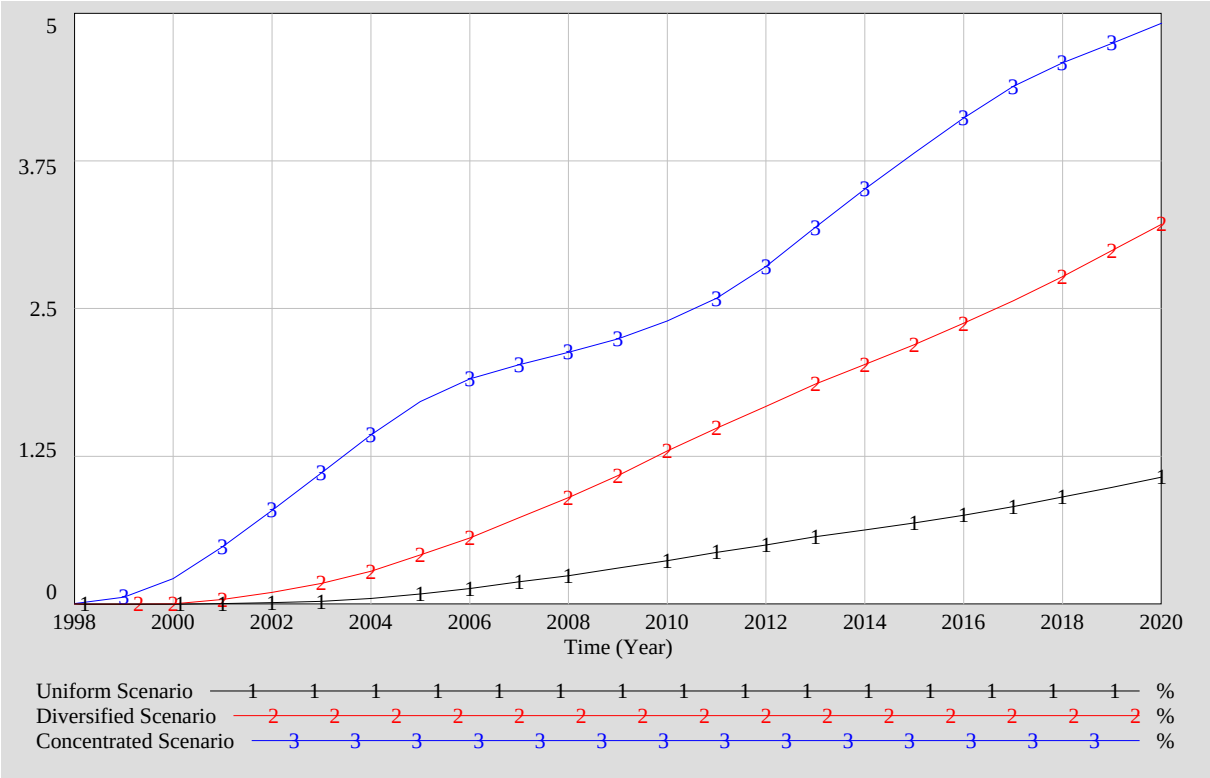

*Figure 39: Percent changes of GDP in region **EUnorth** for the three scenarios as percentage to Baseline Scenario*

The changes of employment presented in the following eight figures show for all regions a very similar pattern of the scenarios as for the aggregated EU15 (see Figure 31). The *Concentrated Scenario* is most favourable for employment. A peculiarity seems to be the strong decrease of employment in region EUnorth by the *Diversified Scenario*. As exports are also growing in EUnorth in this scenario it seems that productivity gains in this scenario are very focused on sectors, which contribute very significant shares to employment in EUnorth. This is for instance the case for sector 11 "the other market-services" contributing one fifth to one fourth of total employment. However, for this sector the yearly productivity growth is 0,82% in the first decade and 0,68% higher in the second decade compared with the *Baseline Scenario* such that in 2020 the absolute reduction of employees in sector 11 between the two scenarios amounts to 2,3 millions despite a higher GVA in the *Diversified Scenario* (+29 Bio EURO1995) and continously growing GVA in both scenarios.

The development of sectoral employment shows some commonness and some variations between the regions. In all regions the sector other market-services significantly increases employment until 2020. EUeast shows the most similar patterns of change of employment compared to the EU15 (e.g. increasing employment in four sectors machinery, textile&media, trade&transport&communication and market-services). EUwest gains employment only in the two sectors trade&transport&communication and market-services, while its losses of employment in non-market-services are negligible. All other regions reduce employment significantly in this sector. The pecularity of EUsouth is that it increases employment slightly more in trade&transport&communication than in market-services. Also the region is facing

the highest loss of employment in agriculture, which is obvious because of the rather high employment in agriculture in this region compared with the other regions. For EUnorth it should be noted that this is the only region where trade&transport&comunication is slightly loosing employment instead of increasing it, which is due to high productivity growth rates in this sector respectively in the subsectors distinguishing the different transport modes and the remaining subsectors of this sector. Also the relative level of employment in this sector was initially already higher than in the other regions.

The magnitude of employment increase in the service sectors might surprise. But looking at national studies e.g. for Germany, which is part of EUeast, the forecasts reach similar levels. For Germany the IAB/PROGNOS study estimates 2 millon new jobs in services until 2010[24], which is in line with the roughly 4 million new jobs in services in EUeast estimated by ASTRA-E until 2020 (aggregating sectors 10-12 in Figure 41).

[24] Quoted in the newsletter "IAB-Materialien 3/1999" of the Institut für Arbeitsmarkt- und Berufsforschung der Bundesanstalt für Arbeit (IAB).

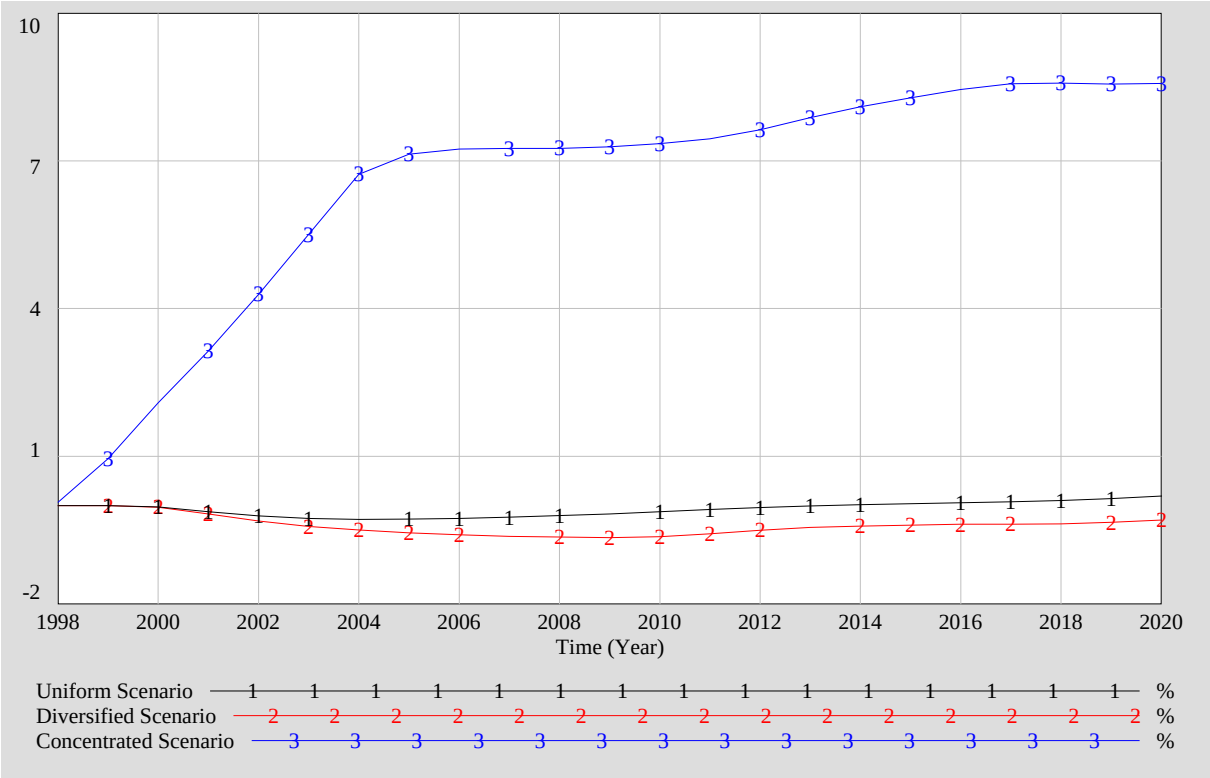

*Figure 40: Employment changes in region **EUeast** for the three scenarios as percentage to Baseline Scenario*

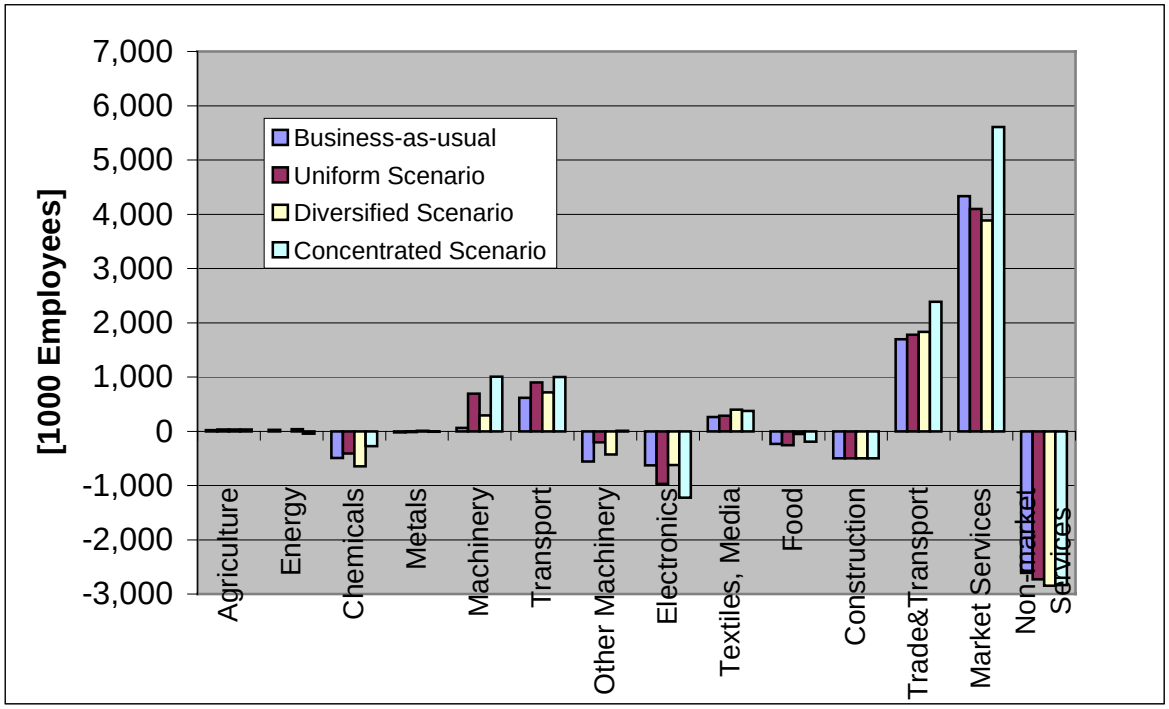

*Figure 41: Absolute sectoral changes of employment in **EUeast** region in the scenarios*

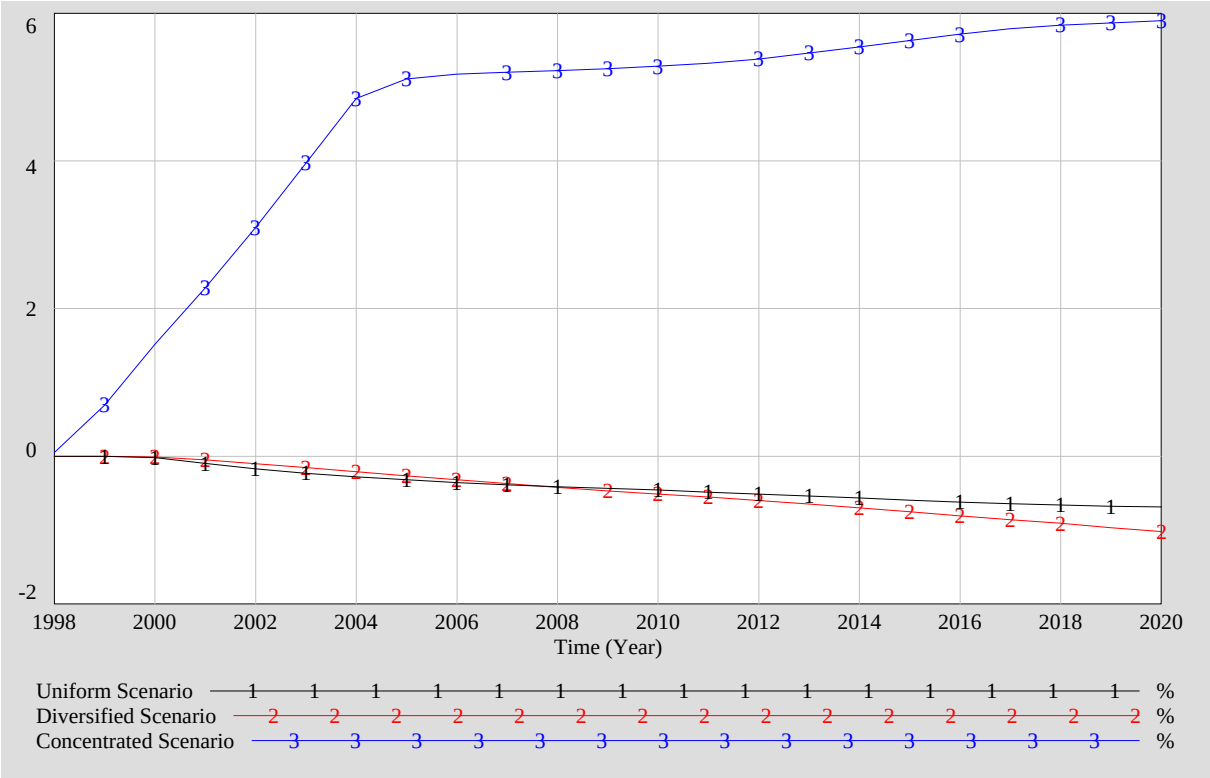

*Figure 42: Employment changes in region **EUwest** for the three scenarios as percentage to Baseline Scenario*

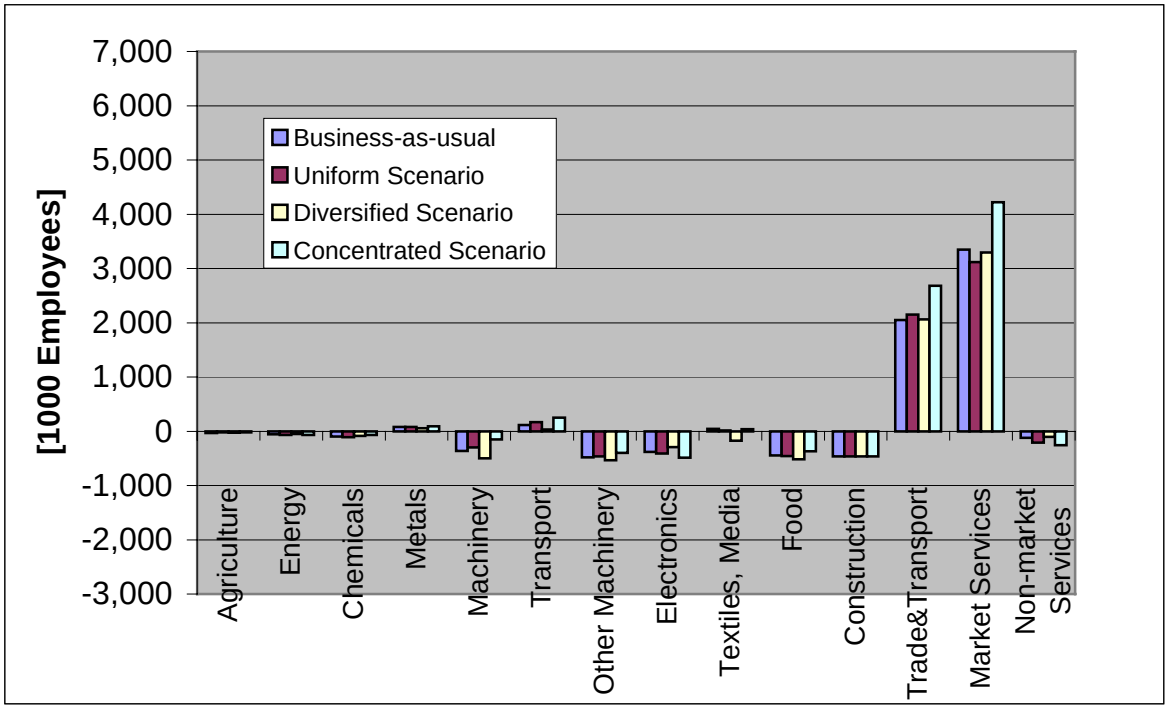

*Figure 43: Absolute sectoral changes of employment in **EUwest** region in the scenarios*

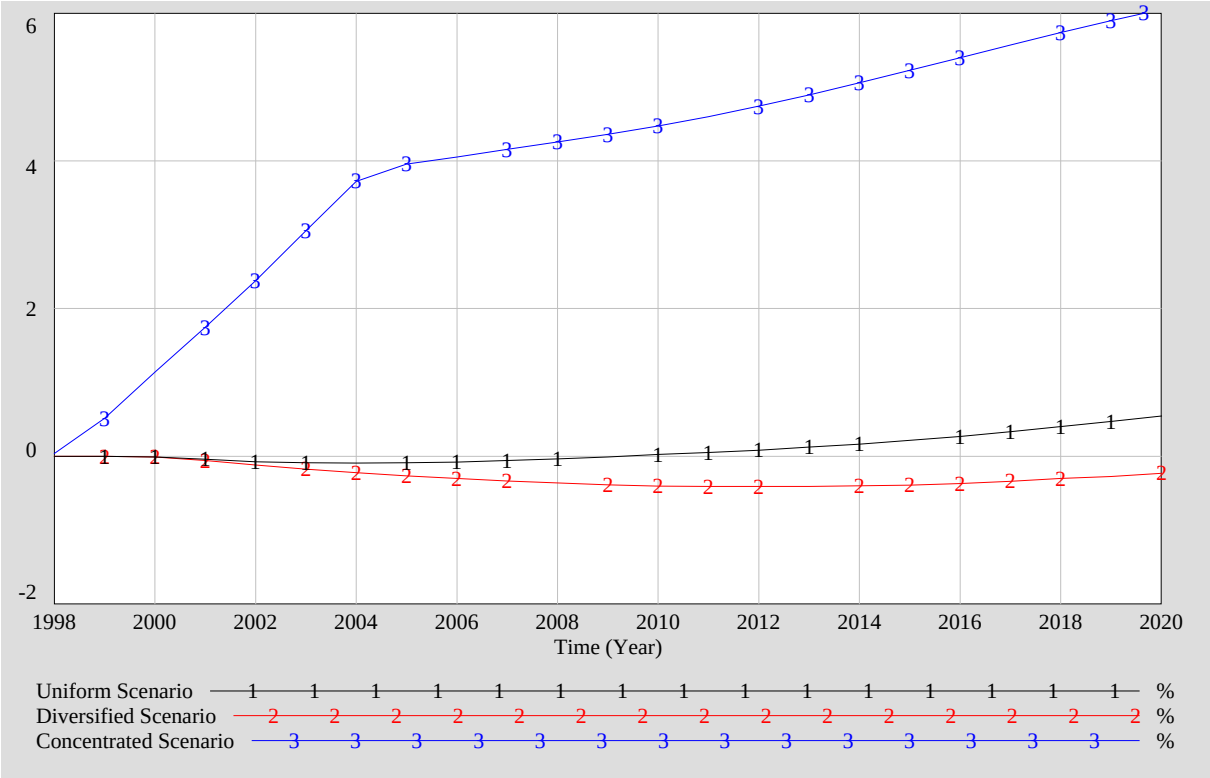

*Figure 44: Employment changes in region **EUsouth** for the three scenarios as percentage to Baseline Scenario*

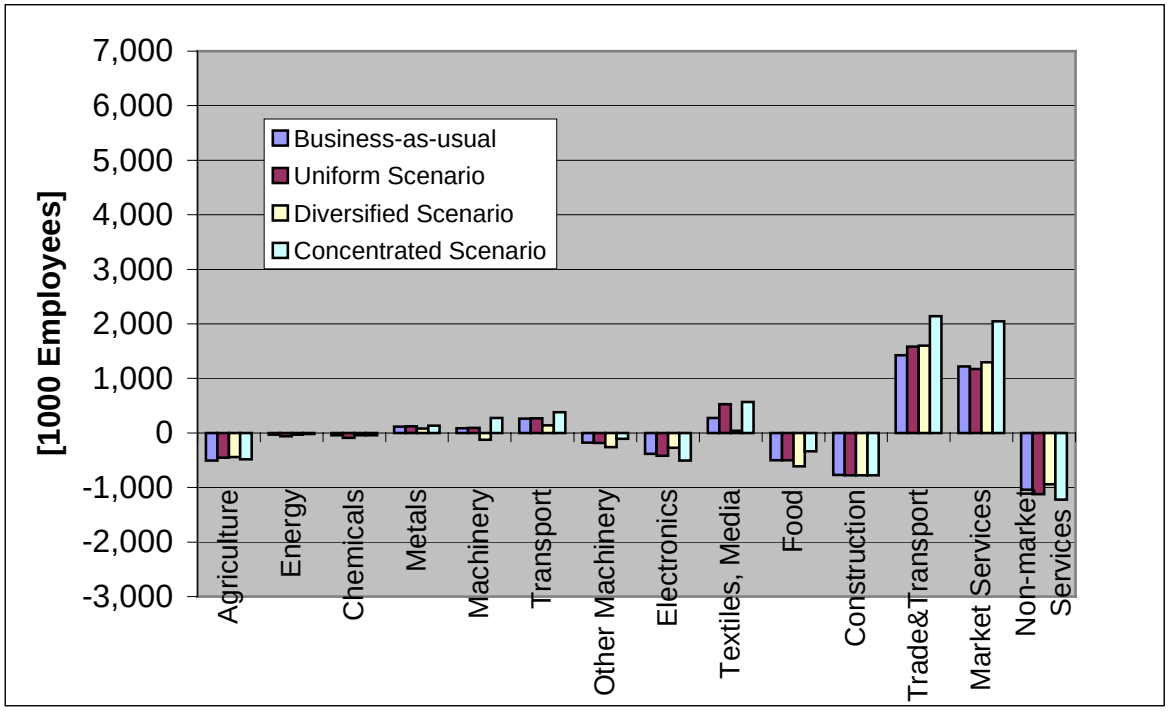

*Figure 45: Absolute sectoral changes of employment in **EUsouth** region in the scenarios*

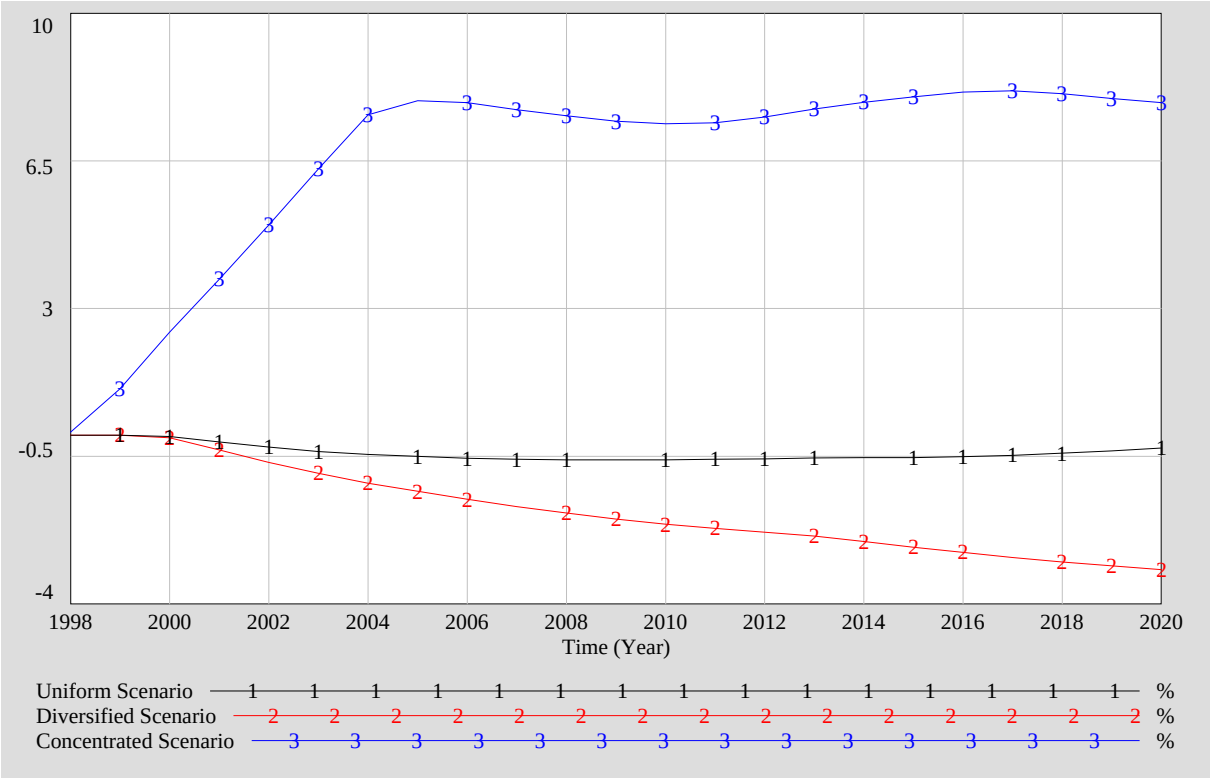

*Figure 46: Employment changes in region **EUnorth** for the three scenarios as percentage to Baseline Scenario*

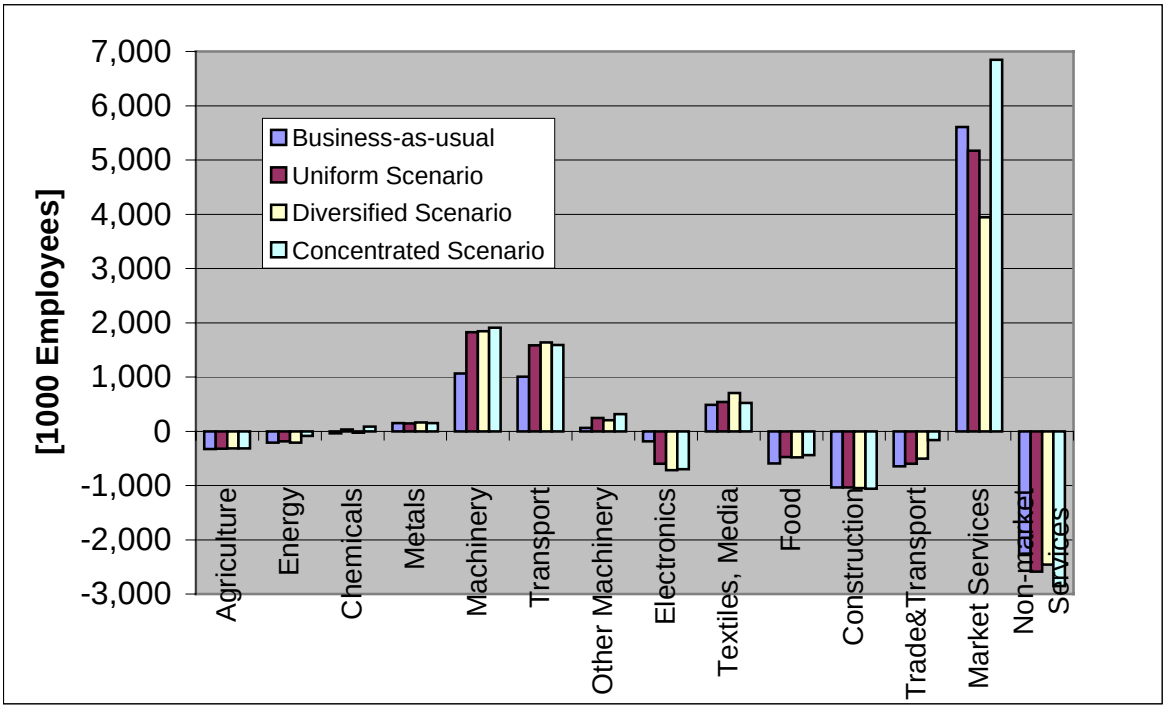

*Figure 47: Absolute sectoral changes of employment in **EUnorth** region in the scenarios*

Table 21 gives an overview on the effects on total exports and exports to the RoW in the three scenarios. Total exports are increased for all regions and all scenarios except for region EUeast in the *Diversified Scenario*. The reason seems to be that from all manufacturing sectors only chemicals increase their productivity in EUeast while all other sectors have a reduced productivity, which is different in the other regions such that EUeast experiences losses in INTRA-EU exports. The high increase of exports to RoW from EUnorth in the Diversified and the *Concentrated Scenario* is a direct consequence of the strong productivity increase in electronics in the region in those scenarios.

EUwest and EUsouth reach their best results with the *Diversified Scenario*, which is to a great extent due to the INTRA-EU exports. In this scenario these two regions increase productivity in important manufacturing sectors, while EUeast and EUnorth focus more on the service sectors. Hence, the former two regions are successful in increasing their exports in the manufacturing sectors compared with the *Baseline Scenario* (see also discussion above).

Table 21: Regional changes of INTRA-EU exports and exports to RoW compared with the Baseline Scenario (Percentages)

Changes to Baseline [%]		**Total Exports**		**Exports to RoW only**	
Scenario	**Region**	**2010**	**2020**	**2010**	**2020**
Uniform	EUeast	0.40	0.64	0.41	0.85
	EUwest	0.33	0.81	0.08	0.04
	EUsouth	0.14	0.82	0.18	0.57
	EUnorth	0.34	0.41	2.24	3.08
Diversified	EUeast	-0.66	-1.43	0.66	1.21
	EUwest	0.93	2.13	0.33	1.22
	EUsouth	1.90	4.96	0.46	1.00
	EUnorth	0.57	1.02	3.05	5.55
Concentrated	EUeast	1.50	2.25	0.86	1.95
	EUwest	0.21	0.22	-0.13	-1.01
	EUsouth	0.96	0.74	0.10	0.32
	EUnorth	0.64	1.01	2.75	4.89

The following figures list the changes in total exports for the four regions in the different scenarios. In some cases the change of productivity growth rates after the year 2010 becomes obvious e.g. for EUnorth in the *Uniform Scenario*.

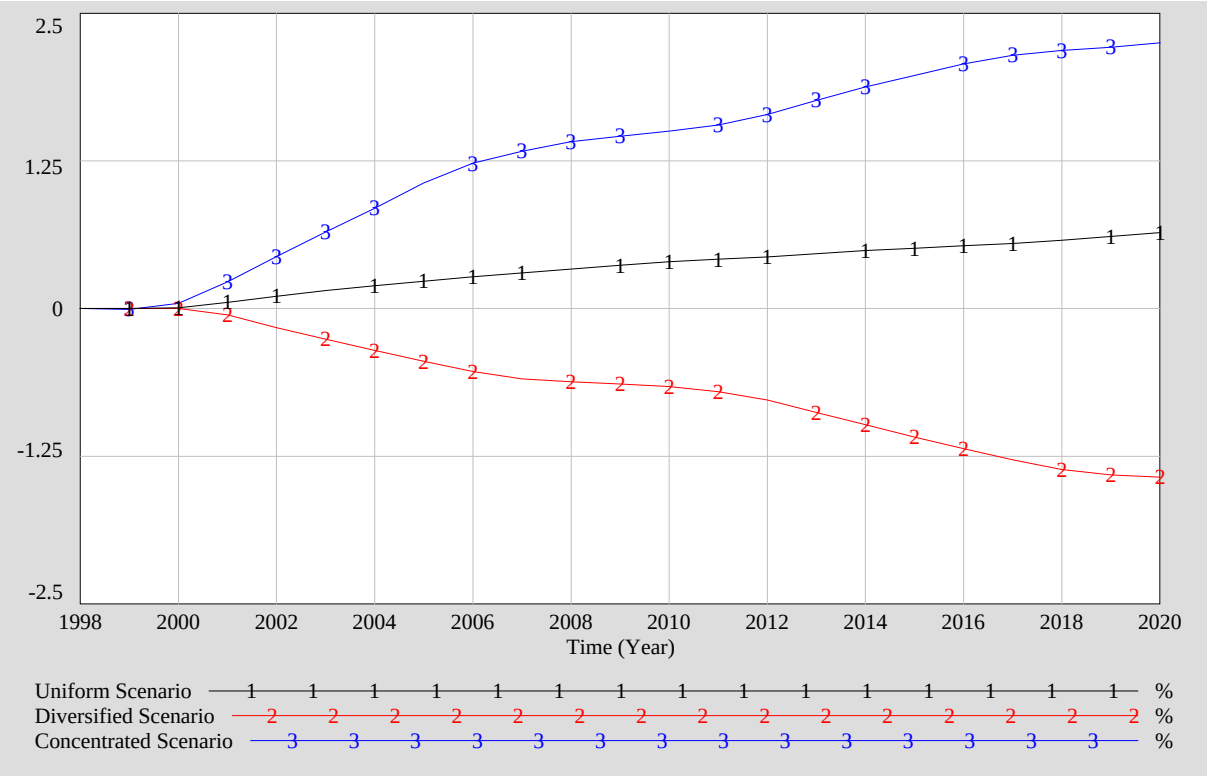

*Figure 48: Percent change of total exports in region **EUeast** compared to Baseline Scenario*

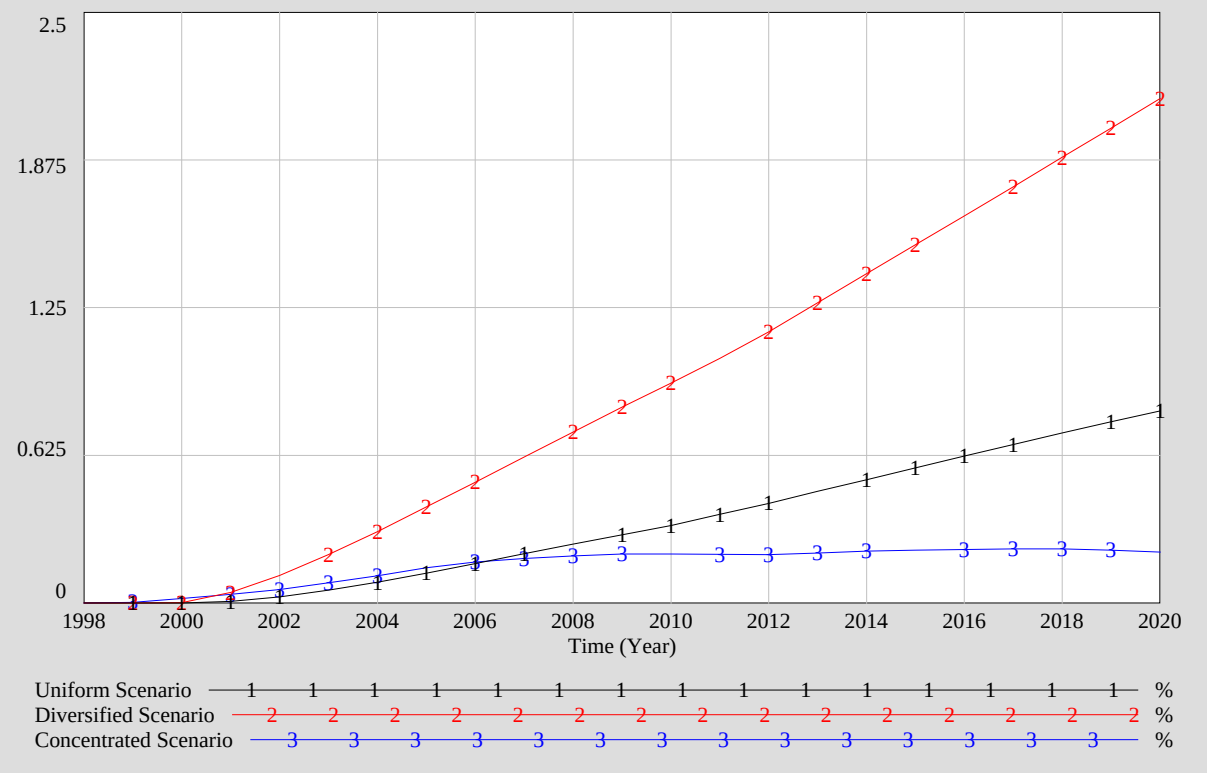

*Figure 49: Percent change of total exports in region **EUwest** compared to Baseline Scenario*

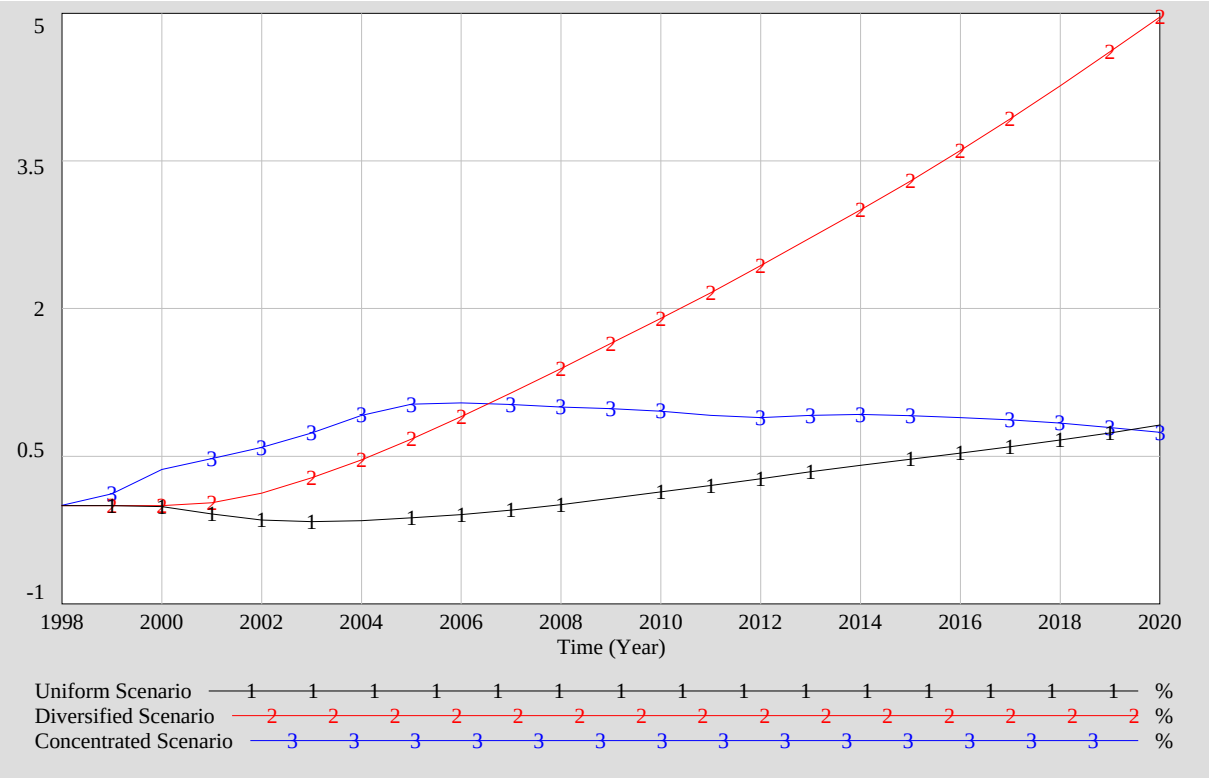

*Figure 50: Percent change of total exports in region **EUsouth** compared to Baseline Scenario*

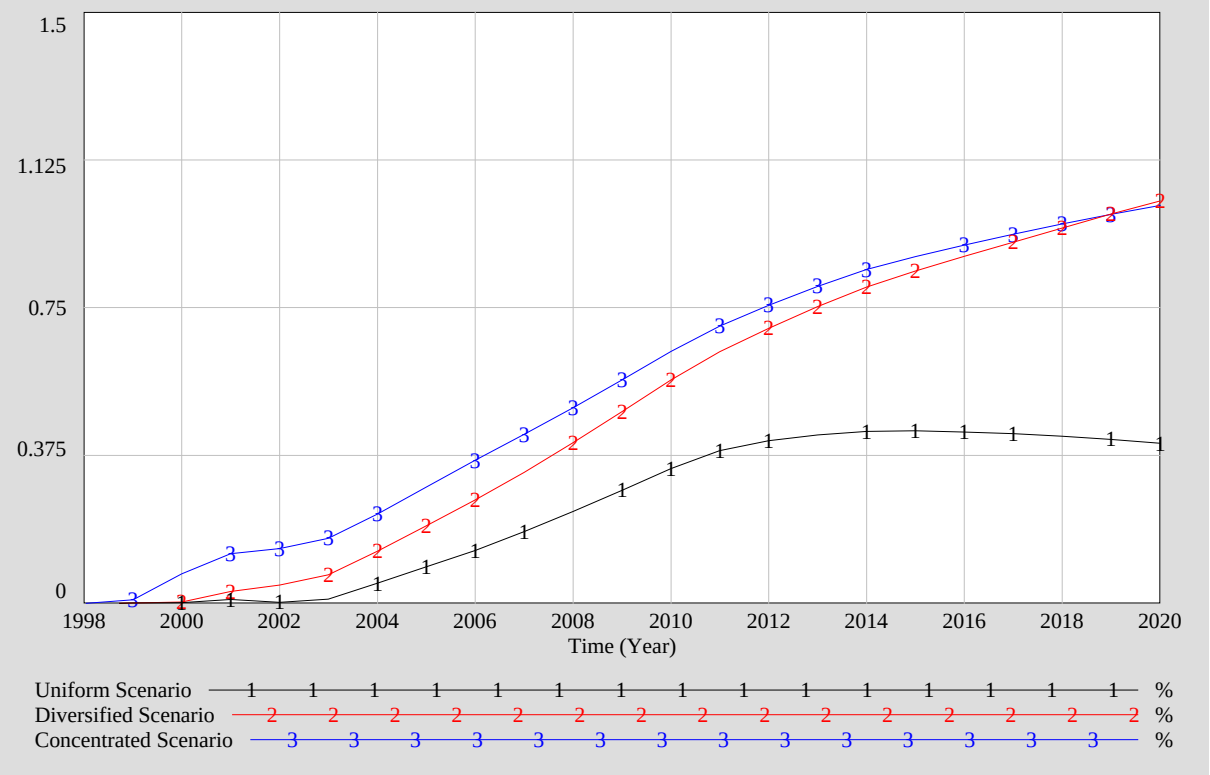

*Figure 51: Percent change of total exports in region **EUnorth** compared to Baseline Scenario*

The changes of European exports to rest-of-the-world are presented in the following three figures. In general the *Diversified Scenario* is the most promising policy leading to a 2% increase of exports to all considered RoW regions. To NAFTA region the *Diversified Scenario* increases exports by 3,5% and to Japan by 3%. In the NAFTA and Japan figures it can also be noticed that productivity growth rates before and after 2010 are different. For all shown regions the Concentrated and *Uniform Scenario* also provide positive support for strengthening exports to RoW.

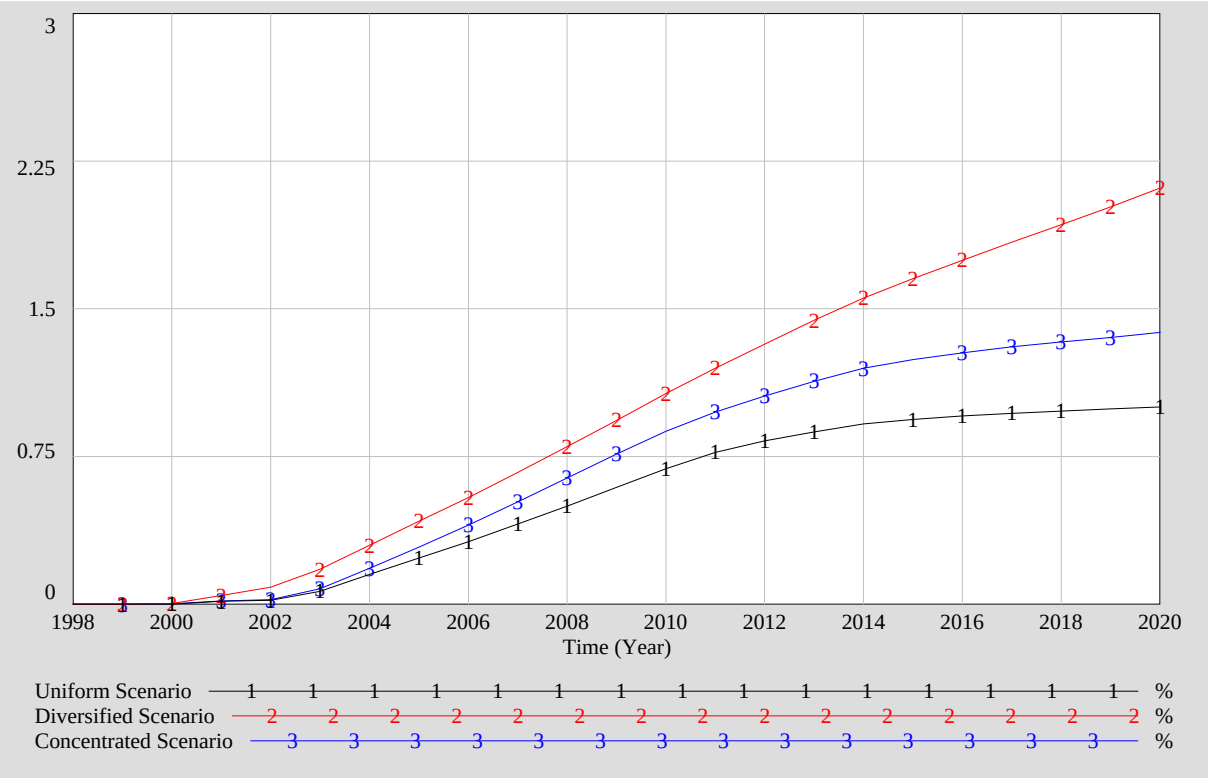

Figure 52: Percent change of total EU exports to rest-of-the-world

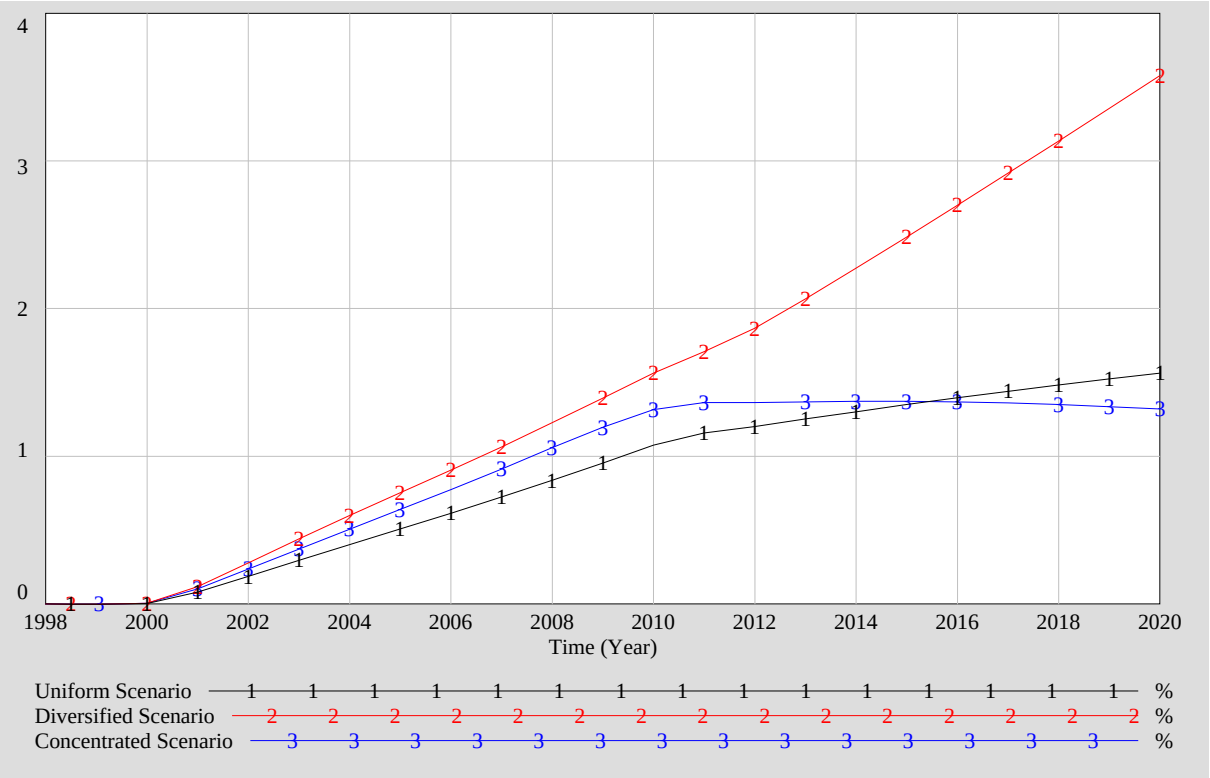

Figure 53: Percent change of EU exports to NAFTA region (NAM) in the policy scenarios

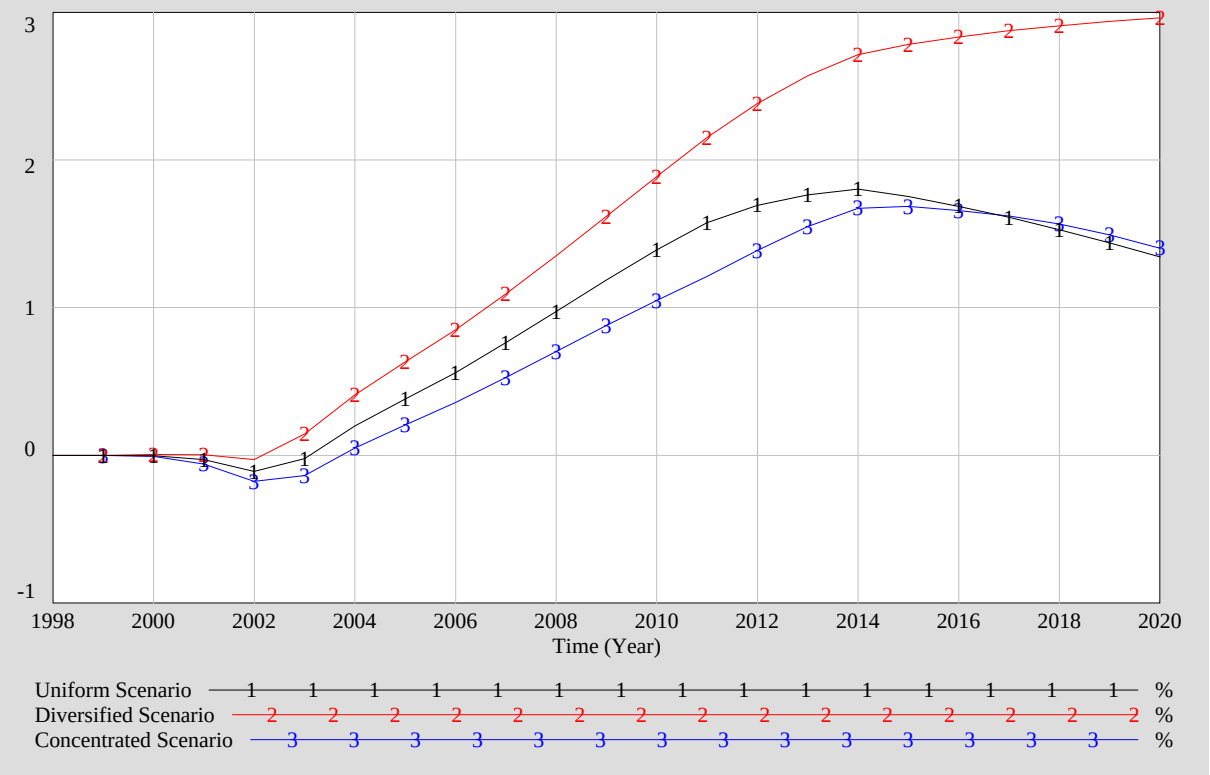

Figure 54: Percent change of EU exports to Japan in the policy scenarios

5.4 Results for the three scenarios

This section provides an overview on the three scenarios showing the comparison between the regions and the EU15. It starts with the presentation of the *Uniform Scenario*. The best performance of GDP with the *Uniform Scenario* can be observed for region EUsouth while it is worst for region EUnorth (Figure 55). In terms of employment EUsouth is experiencing a slight increase applying the *Uniform Scenario* while in EUwest the decrease is strongest (Figure 56).

The main reasons have been discussed above. One point should be added here. For EUwest, despite a rather positive performance for GDP employment development is the least promising, which is caused by employment loss in market-services and non-market-services sectors. However, productivity increase in EUwest in these sectors is similar to other regions. But in EUwest other sectors do not compensate the employment losses.

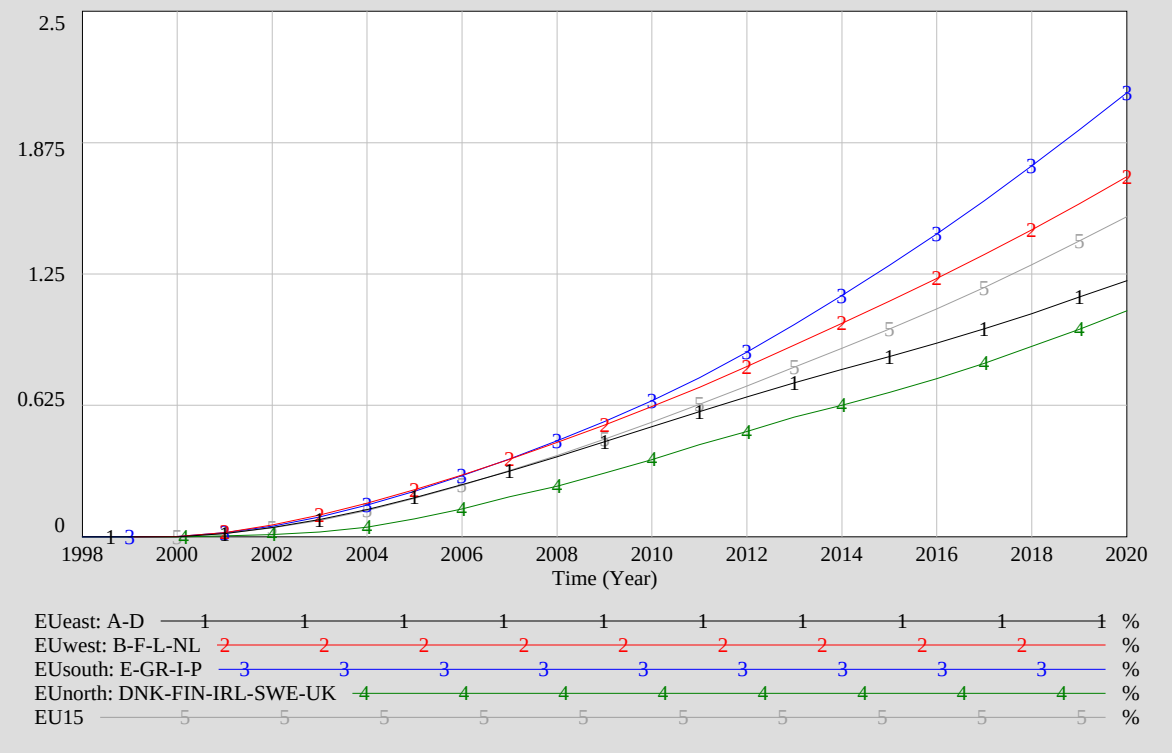

Figure 55: Changes of GDP in Uniform Scenario as percentage to Baseline Scenario

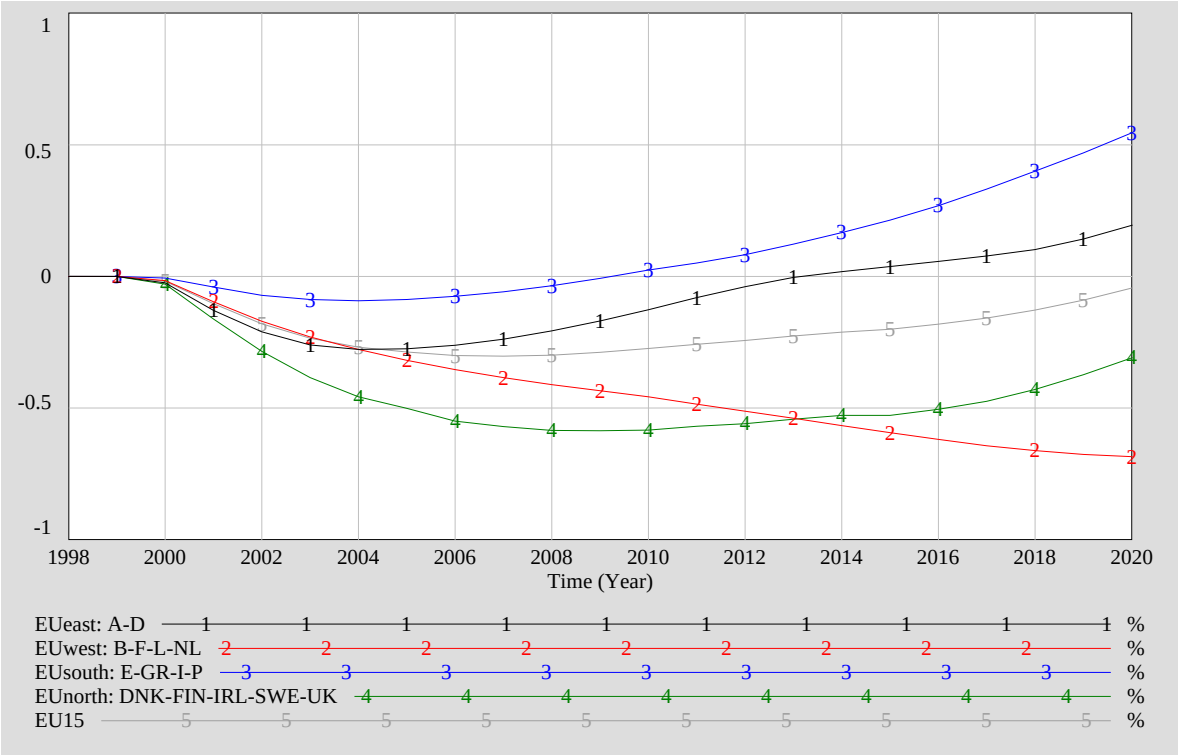

Figure 56: Changes of employment in Uniform Scenario as percentage to Baseline Scenario

The *Diversified Scenario* produces the best results in terms of GDP for region EUnorth while there is nearly no change for EUwest (Figure 57). Employment nearly is not changed in regions EUeast and EUsouth by the *Diversified Scenario*, but surprisingly it is reduced strongly in EUnorth (Figure 58). As explained above this is mainly due to the focus of productivity increase on the market-services sector having a great impact on TFP and output but also contributing a high proportion of employment such that changes of productivity can cause a significant discharge of labour.

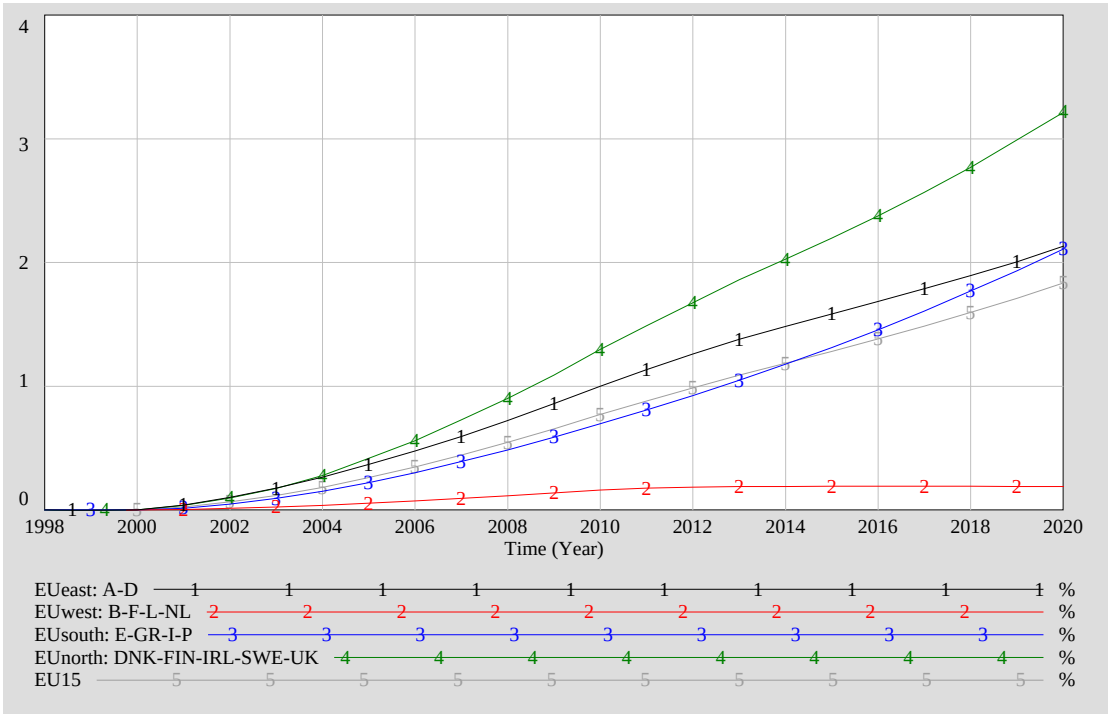

Figure 57: Changes of GDP in Diversified Scenario as percentage to Baseline Scenario

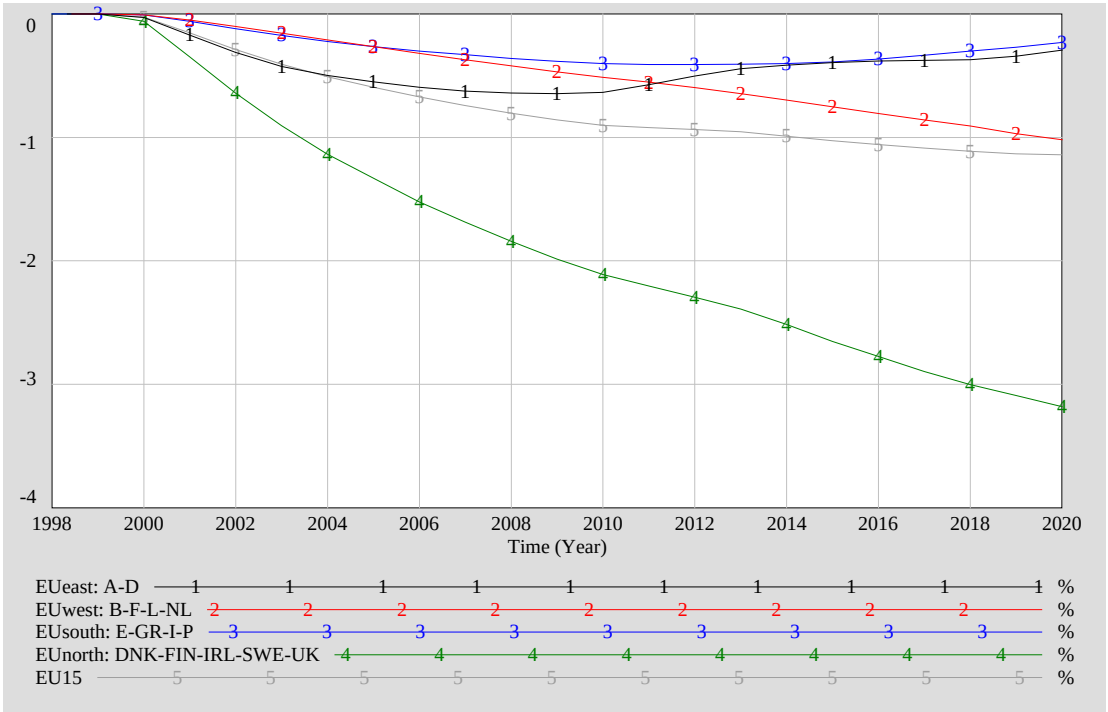

Figure 58: Changes of employment in Diversified Scenario as percentage to Baseline Scenario

The performance of the *Concentrated Scenario* in terms of GDP and employment is similar. Both are significantly increased by the policy. The ranking of the regions here is generally EUnorth and EUeast followed by EUwest and EUsouth. However, the shape of the employment change curve is to be discussed. As long as the consumption split changes are phased in (from 1997 until 2003) employment is strongly increasing. Then beyond 2004 employment growth is similar to the *Baseline Scenario*. It is obvious that the increase between 1997 and 2004 is due to the changes in consumption patterns.

At first sight it is surprising that employment is increasing that strong as consumption is shifted towards on average similar productive or even more productive sectors. However, it seems that two counteractive influences are also present: first TFP is calculated as weighted average based on productivity and the share on GVA. Since now sectors with high productivity increase their share on GVA TFP is increasing and so does GDP. Second, aggregated GVA is also increasing such that also the structure of intermediates and final products seems to lead to increased GVA by this policy. This is also supported by the fact that the consumption expenditures for new products are shifted to service sectors. As services are more regional based and incorporate less imports local GVA is expected to be higher. However, it should be kept in mind that the *Concentrated Scenario* is built-up onto two levers of which the probability to occur is substantially lower for the new demand than that of the labour saving and output change by productivity growth.

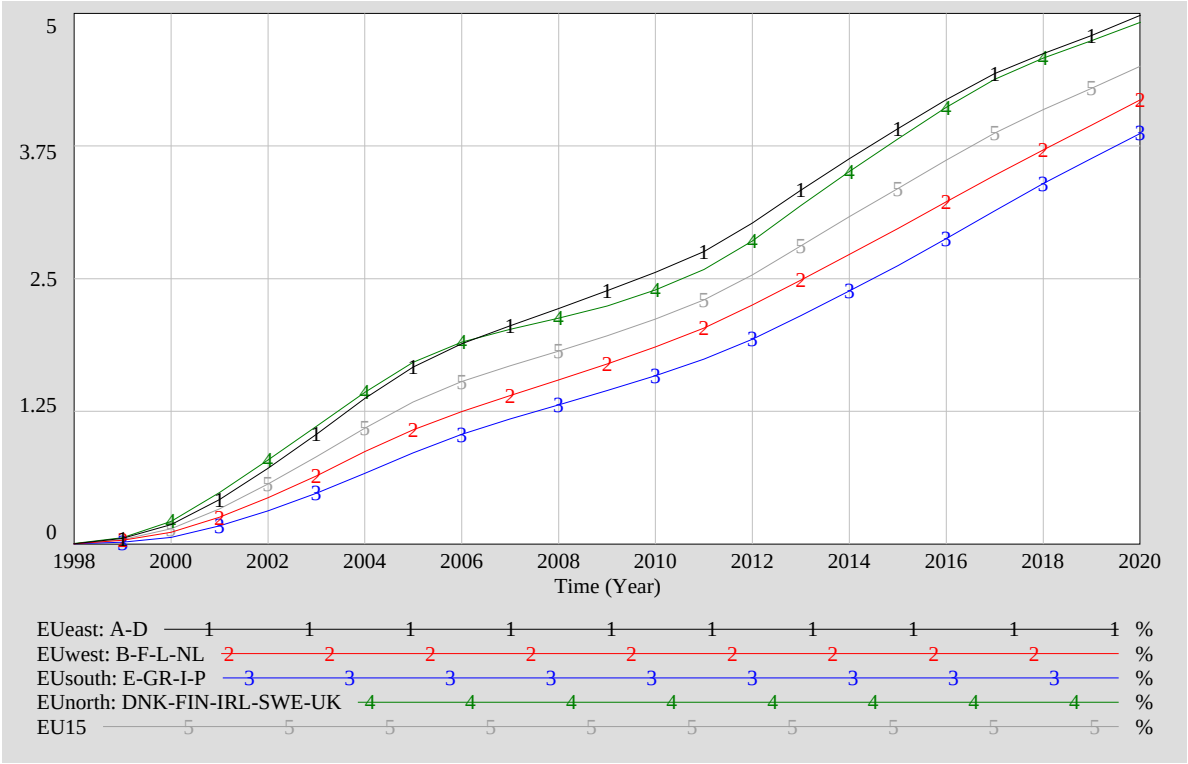

Figure 59: Changes of GDP in Concentrated Scenario as percentage to Baseline Scenario

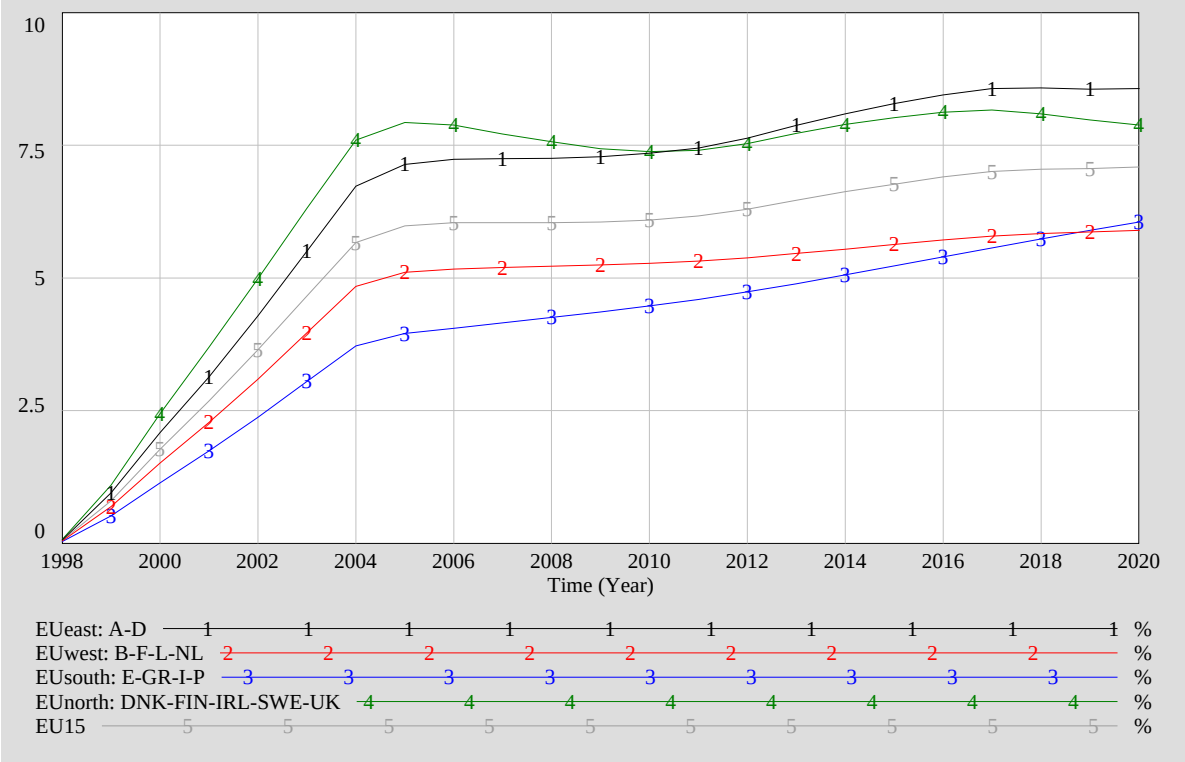

Figure 60: Changes of employment in Concentrated Scenario as percentage to Baseline Scenario

5.5 Distinction of "the 3 impacts" on scenario outcomes

As explained at various stages of the IPTS project there are three somewhat counteractive direct impacts on employment that can be caused by technology policy. Those are named the "3 impacts" in the following. The "3 impacts" are:

- Productivity gains of process innovations that cause labour savings and output growth (productivity);
- Increase of exports by improved competitiveness (exports);
- Demand for new products reflected by changes in consumption split (consumption shift respectively new demand).

Those direct impacts are causing secondary impacts. These would be changes in e.g. GDP, consumption or investments. A scheme to identify the contribution of each impact to the changes of the relevant indicators for secondary impacts is developed for ASTRA-E. To measure only productivity changes those are introduced while exports are taken exogenously from the *Baseline Scenario* and no changes in consumption split are applied. Second, the impact of productivity plus exports can be measured by applying the productivity changes and using the endogenously calculated exports for a simulation but keeping the consumption split fixed. Applying the full scenario gives the figure for the aggregated changes, which can be compared with the results for productivity and exports changes only to derive the impacts of the new demand. This scheme might overestimate the impact of the latter stages as it adds synergetic effects only to them.

The following figures present a detailed analysis of the "3 impacts" in the *Concentrated Scenario*. The changes are presented in bar charts as percent changes compared to the *Baseline Scenario* for the years 2005, 2010, 2015 and 2020. In terms of GDP growth in the EU15 Figure 61 presents that productivity and new demand (= consumption shift) have a similar positive impact in the *Concentrated Scenario*. In the first decade the impact of new demand is higher while over the long run productivity plays the more important role. For employment the impact of productivity is negative and the influence of new demand is positive and strongly overcompensating the loss of employment by process innovation as shown in Figure 62. Exports play a small but positive role for GDP growth as well as for employment change looking at the EU15 total. Subsequent figures show that this can be different for the individual regions of the EU.

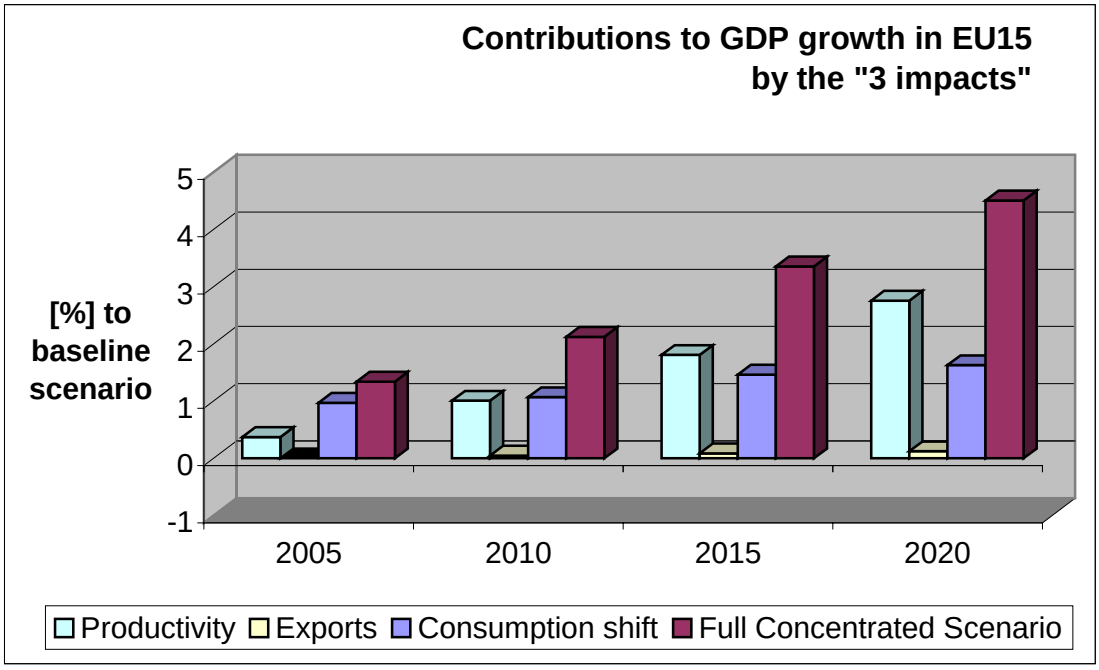

Figure 61: influence of "3 impacts" on GDP in EU15 for the Concentrated Scenario

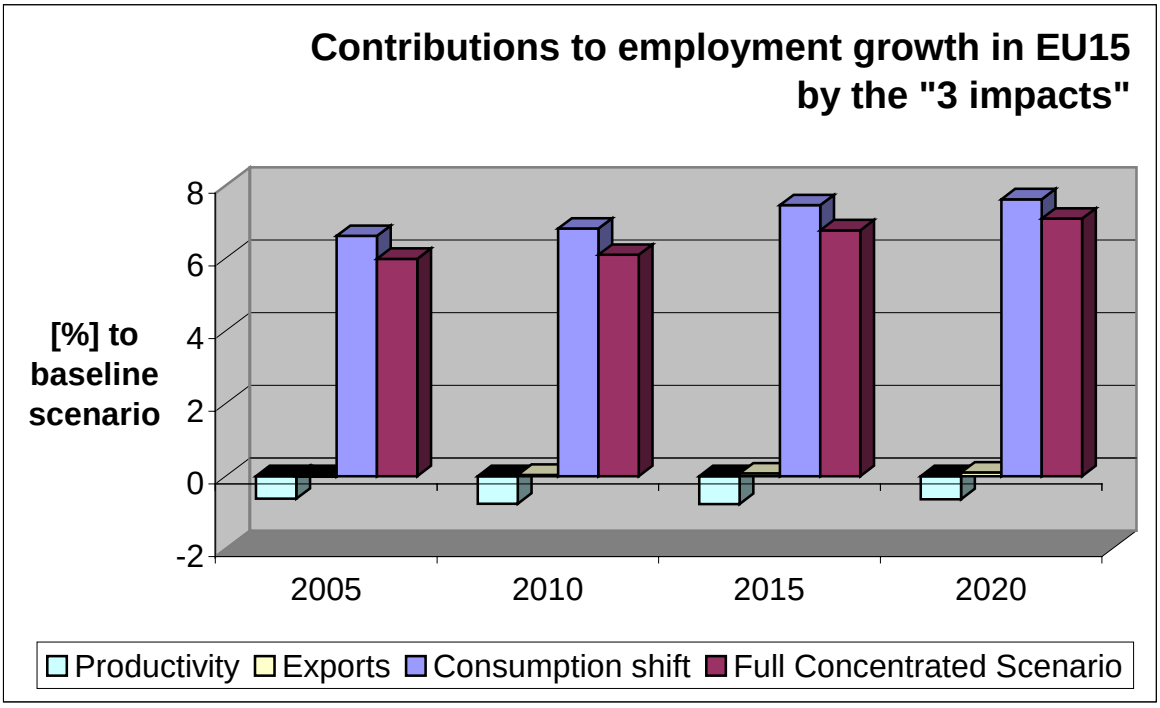

Figure 62: influence of "3 impacts" on employment in EU15 for the Concentrated Scenario

For region EUeast the pattern for GDP growth is different. As Figure 63 shows export plays also an important role for GDP growth in this region. The growing importance of productivity and in this case also exports for GDP over time can also be identified. In terms of employment again new demand seems to be the key to foster employment. However, for EUeast increase in total exports would already compensate for the loss of employment by the change of productivity (Figure 64).

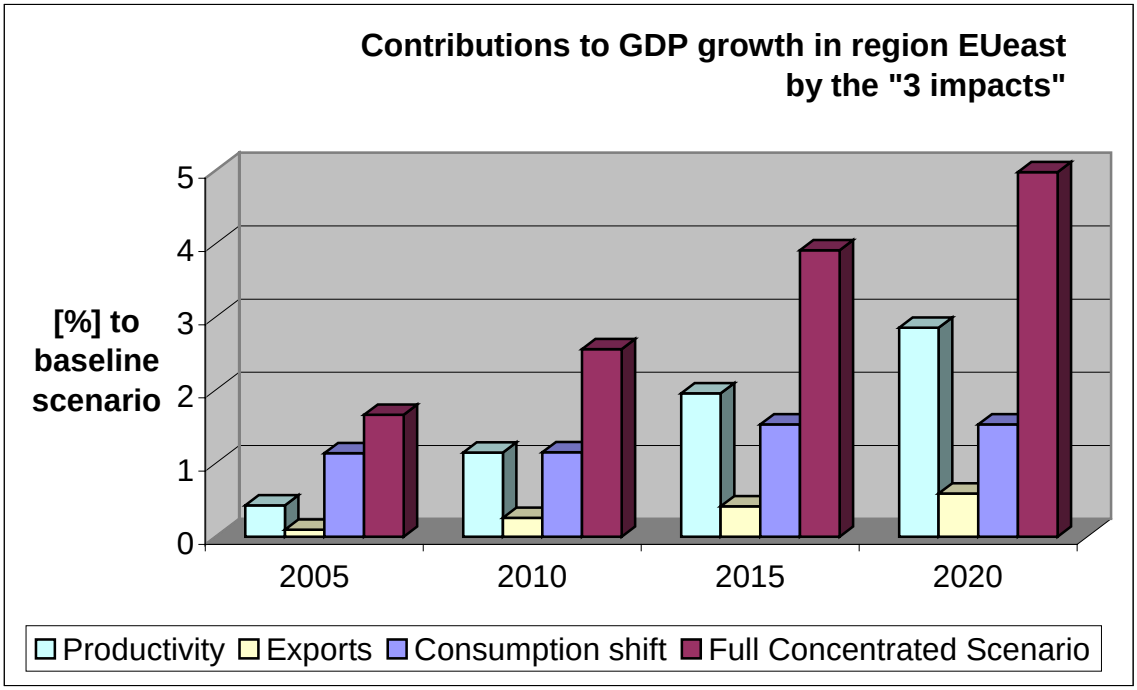

Figure 63: influence of "3 impacts" on GDP in region EUeast for the Concentrated Scenario

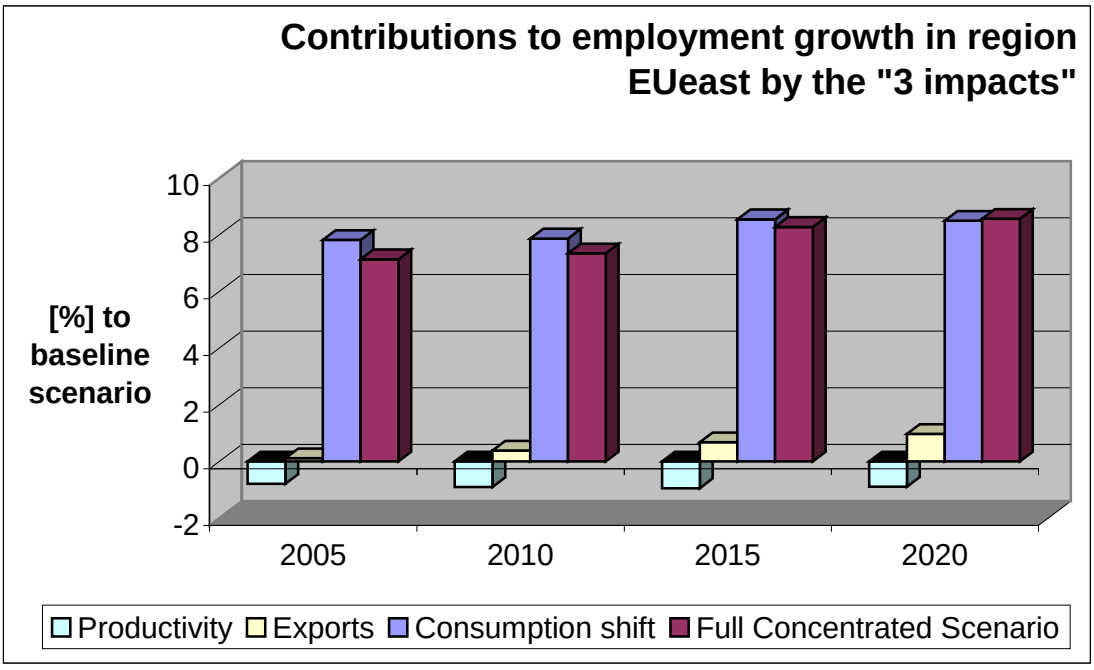

Figure 64: influence of "3 impacts" on employment in region EUeast for the Concentrated Scenario

The development of region EUwest is rather close to the average development in the EU15 with positive influence of both productivity and new demand on GDP (Figure 65) and negative influence of productivity on employment that is overcompensated by positive influence of new demand on employment (Figure 66). Exports in both cases play a very minor role.

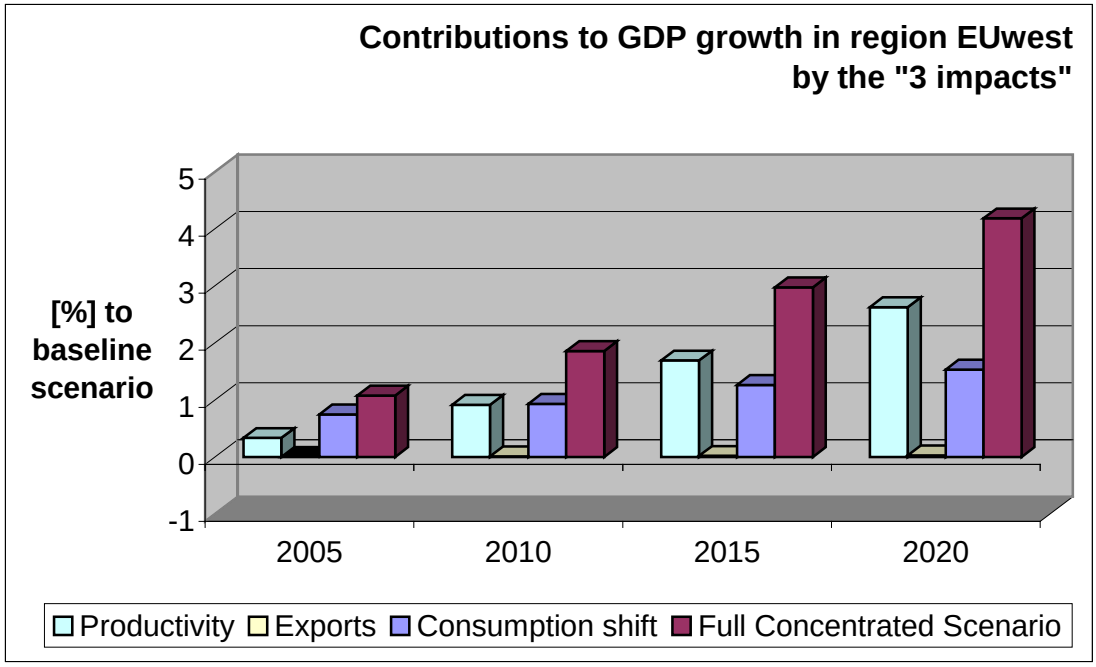

Figure 65: influence of "3 impacts" on GDP in region EUwest for the Concentrated Scenario

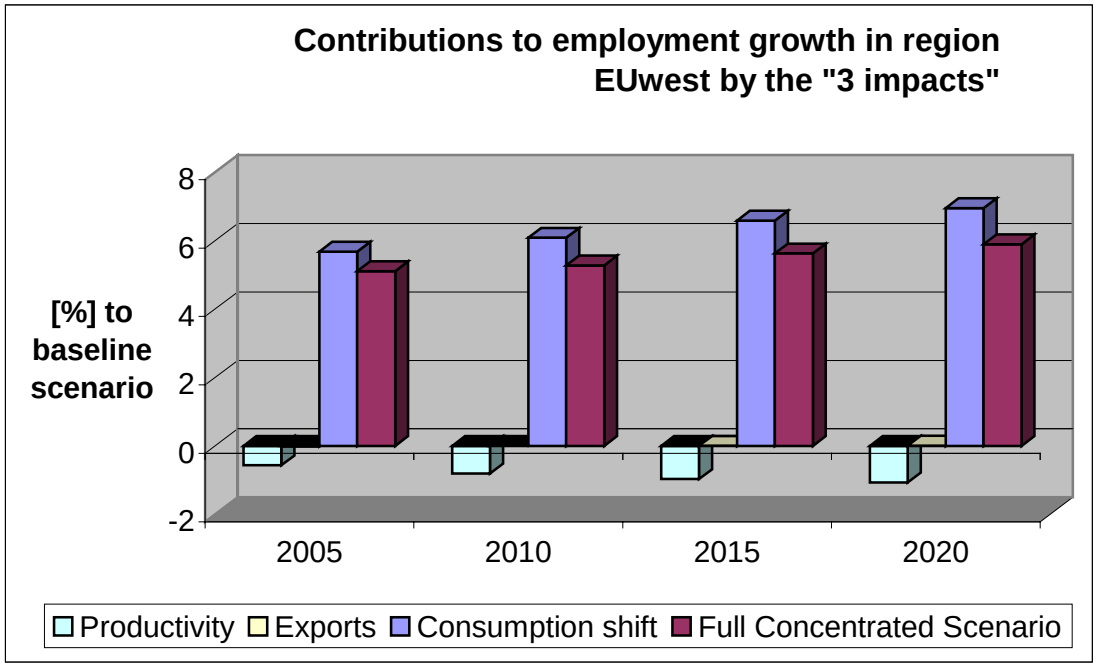

Figure 66: influence of "3 impacts" on employment in region EUwest for the Concentrated Scenario

Region EUsouth shows a different pattern than the previous two regions. Though this region is slightly gaining exports INTRA-EU as well as to rest-of-the-world exports weaken GDP and employment growth. Also over the whole two decades the impact of new demand is strongest contributing to GDP growth (Figure 67) and employment growth (Figure 68). The negative impact of exports seems to be the result of slowed down productivity increases in

specific sectors like textiles that provide a high level of employment in dependency of exports. For these sectors exports and hence employment are reduced significantly, which can not be compensated by the sectors that increase exports.

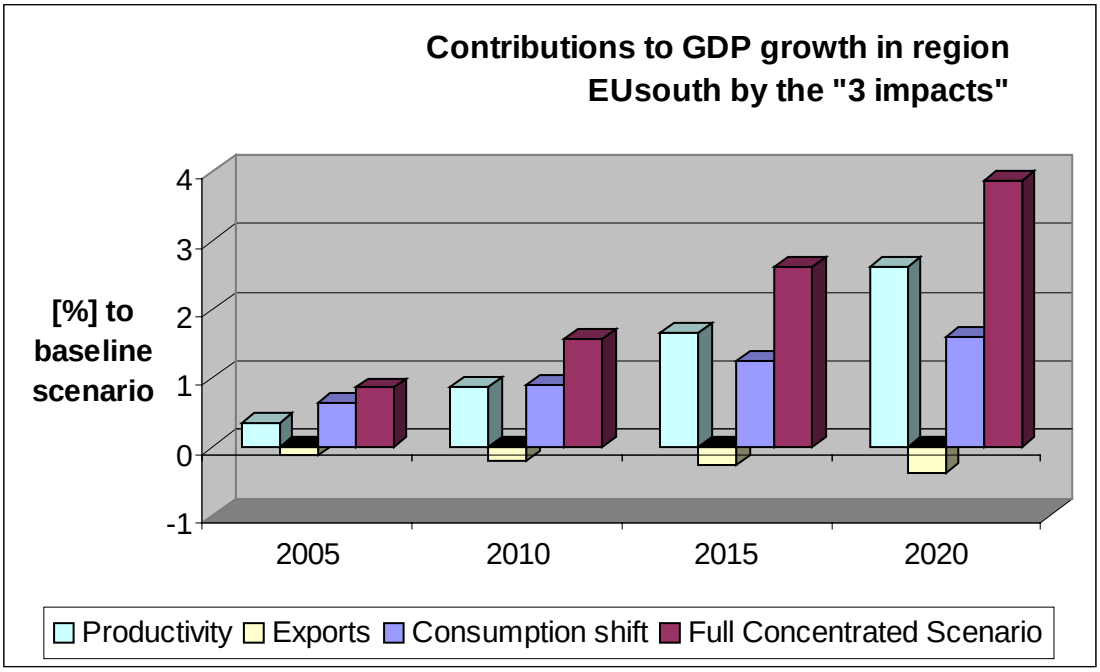

Figure 67: influence of "3 impacts" on GDP in region EUsouth for the Concentrated Scenario

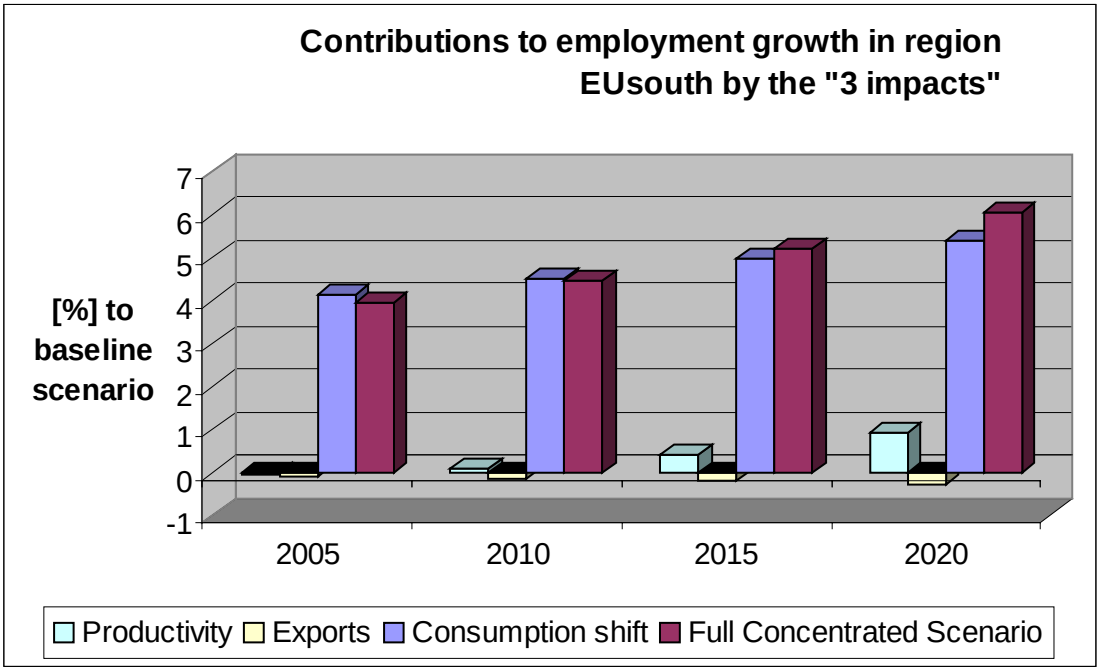

Figure 68: influence of "3 impacts" on employment in region EUsouth for the Concentrated Scenario

Region EUnorth is rather similar to EU15 average looking at GDP growth (Figure 69). That means, in the medium-term consumption-shift is most important but in the long-term rpoductivity is more important for output growth. exports contribute slightly to GDP growth. The impacts of productivity and new demand on employment is also divergent with greater amplitudes than for EU15 average as for instance new demand would cause nearly 10% more employment than in the *Baseline Scenario* in EUnorth (Figure 70).

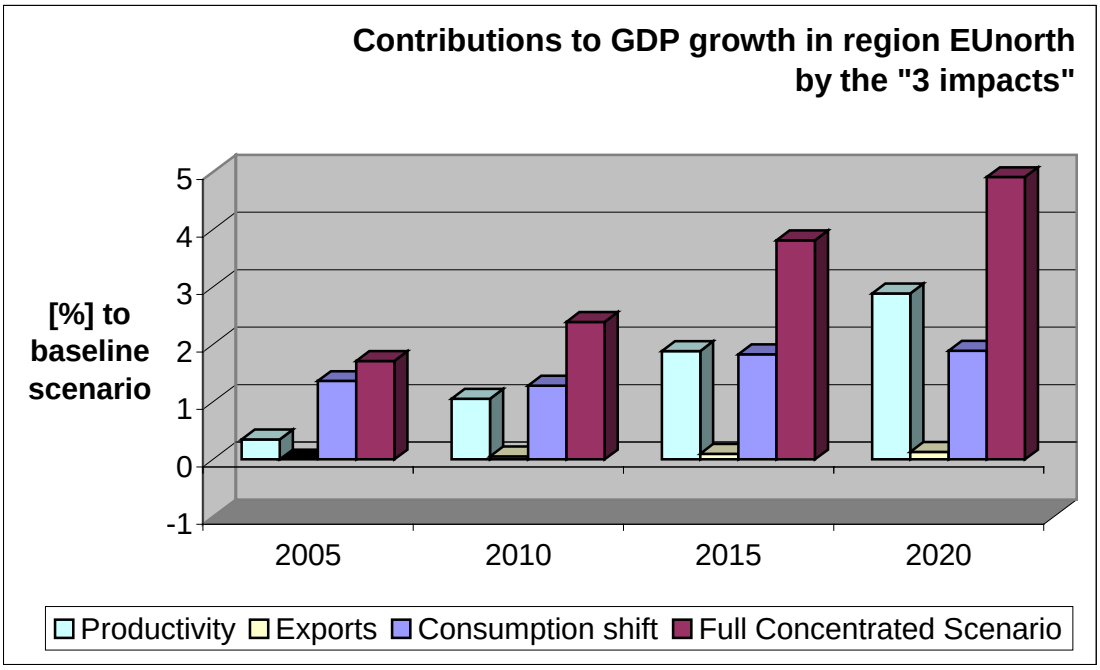

Figure 69: influence of "3 impacts" on GDP in region EUnorth for the Concentrated Scenario

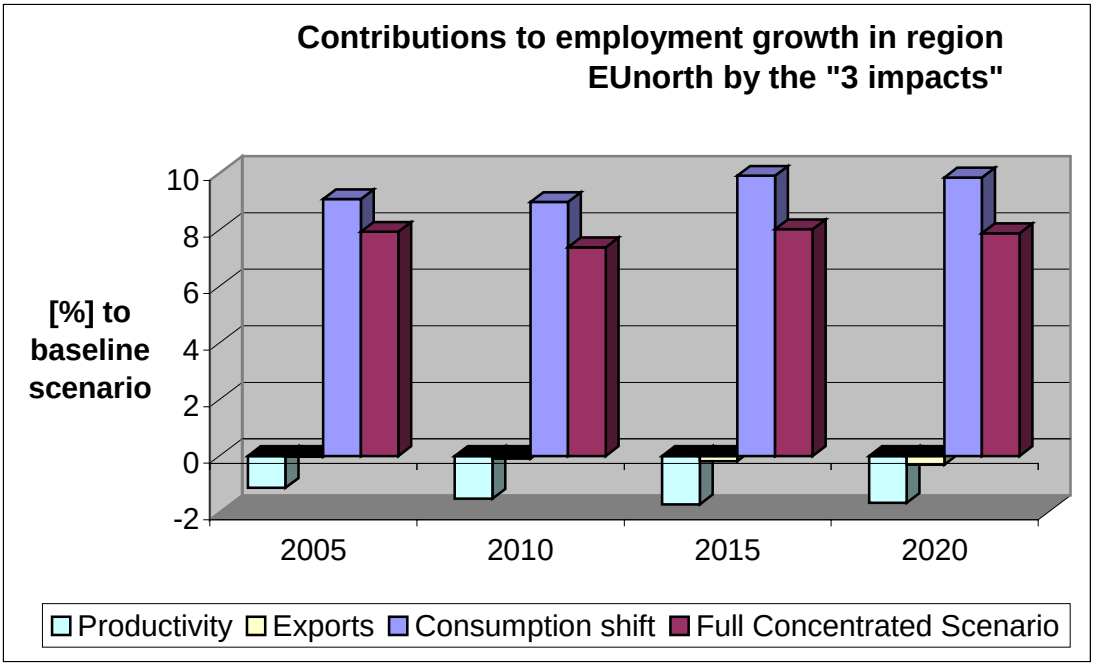

Figure 70: influence of "3 impacts" on employment in region EUnorth for the Concentrated Scenario

5.6 Sensitivity results for major drivers in the policies

Sensitivity testing with System Dynamics models provides a powerful tool to analyse models and the impacts of policy variations and model parameters. A first example for sensitivity testing of a model parameter is presented in Figure 71. Investments in the ASTRA-E model depend on consumption and on the changes in exports. To model the latter a kind of elasticity of investments to changes in total exports of a region is applied. Calibration led to values between 0.15 and 0.3. To analyse the importance of the parameter a sensitivity test was carried out such that for the four regions the investment elasticities are varied between 0.1 and 0.6 with steps of 0.05. This amounts to more than 14000 simulations each causing a different reaction of GDP and employment. The range of results for changes of GDP in the EU15 compared to GDP in the *Baseline Scenario* (Figure 71) is between –15% and +50% and for employment (Figure 72) between –8% and +30% compared to the *Baseline Scenario*. The graphs show different variance intervals starting with middle 50% of all simulations (yellow) to the middle upper and lower 12.5% (green), to the upper and lower 10% (blue) and the extreme upper and lower 2.5% (grey). So, we realize that about 75% of all combinations lead to GDP deviations from the *Baseline Scenario* in a bandwidth of 0 to 20%.

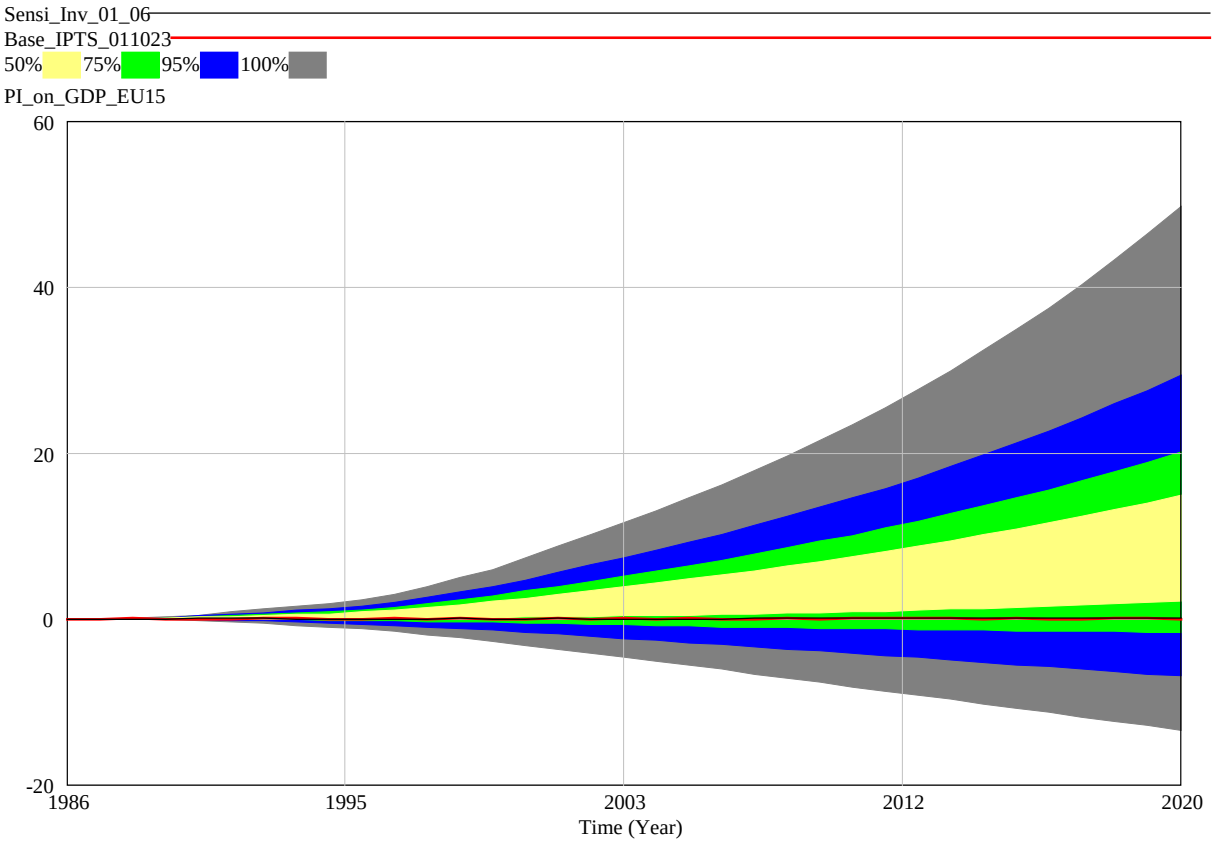

Figure 71: Sensitivity test for investment elasticity to exports: influence on GDP (y-axis = percent change compared to Baseline Scenario [%])

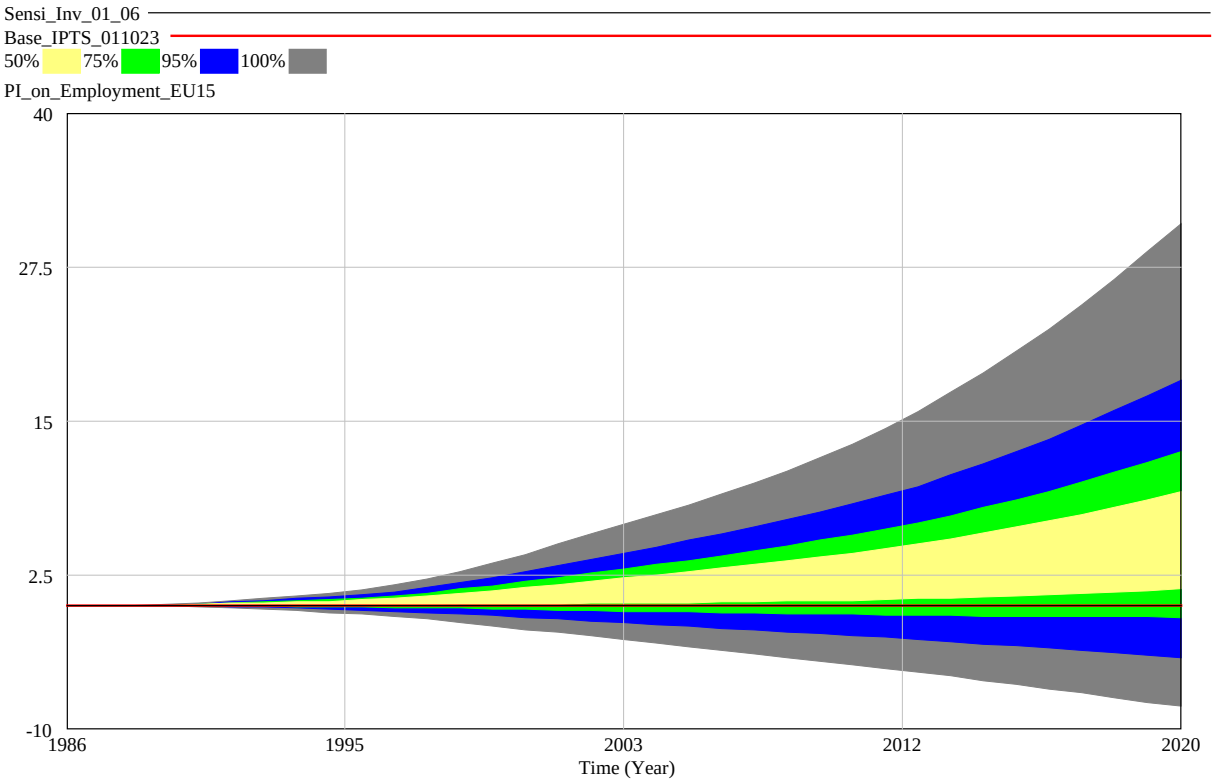

Figure 72: Sensitivity test for investment elasticity to exports: influence on employment (y-axis = percent change compared to Baseline Scenario [%])

A sensitivity test related to the policies is the variation of labour productivity. For this purpose the productivity growth rates after 1995 are multiplied with a factor between 0.5 and 1.5 with steps of 0.01. This means to half productivity growth rates compared with the *Baseline Scenario* or to increase it by 50% in the extreme case. The range of EU15 GDP compared to *Baseline Scenario* in this case is between –8% and +22% (Figure 73), which would be smaller than the sensitivity to the investment elasticity. Employment changes range from –15% to +12% (Figure 74), which is for the negative case more sensitive than the reaction to changes in the investment elasticity.

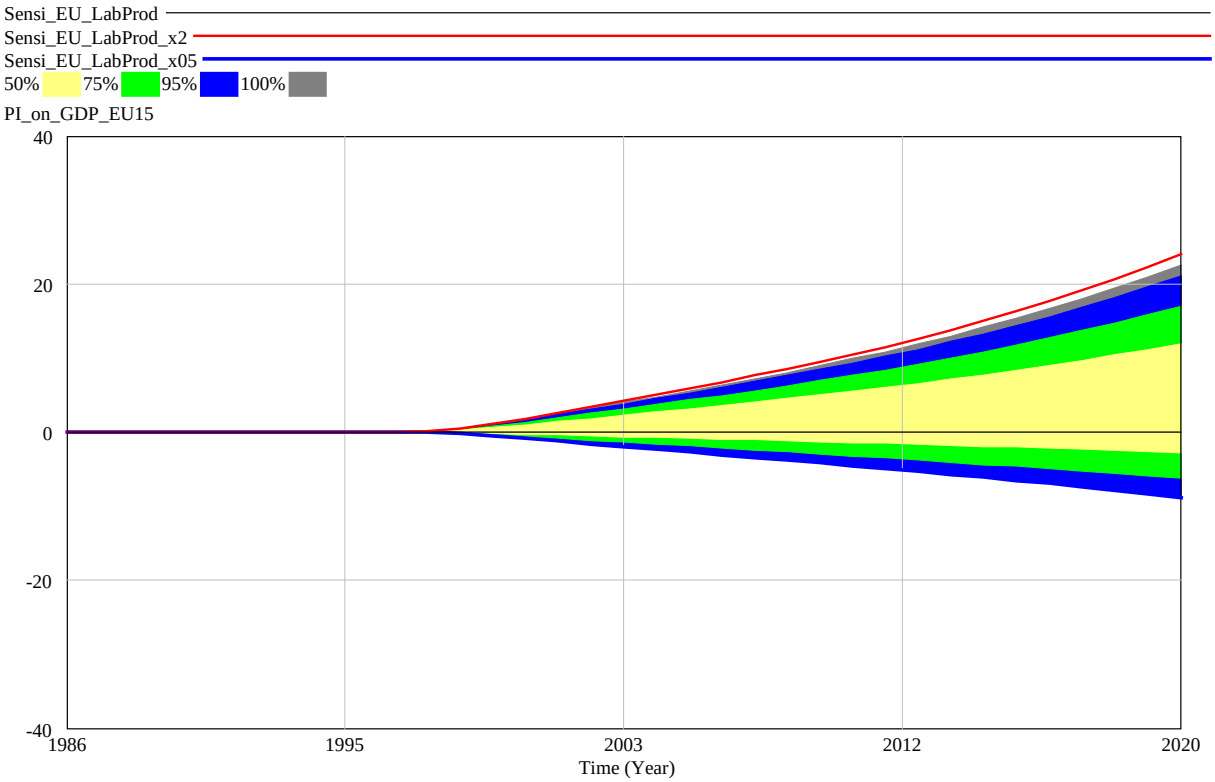

Figure 73: Sensitivity of GDP to labour productivity changes in European regions (y-axis = percent change compared to Baseline Scenario [%])

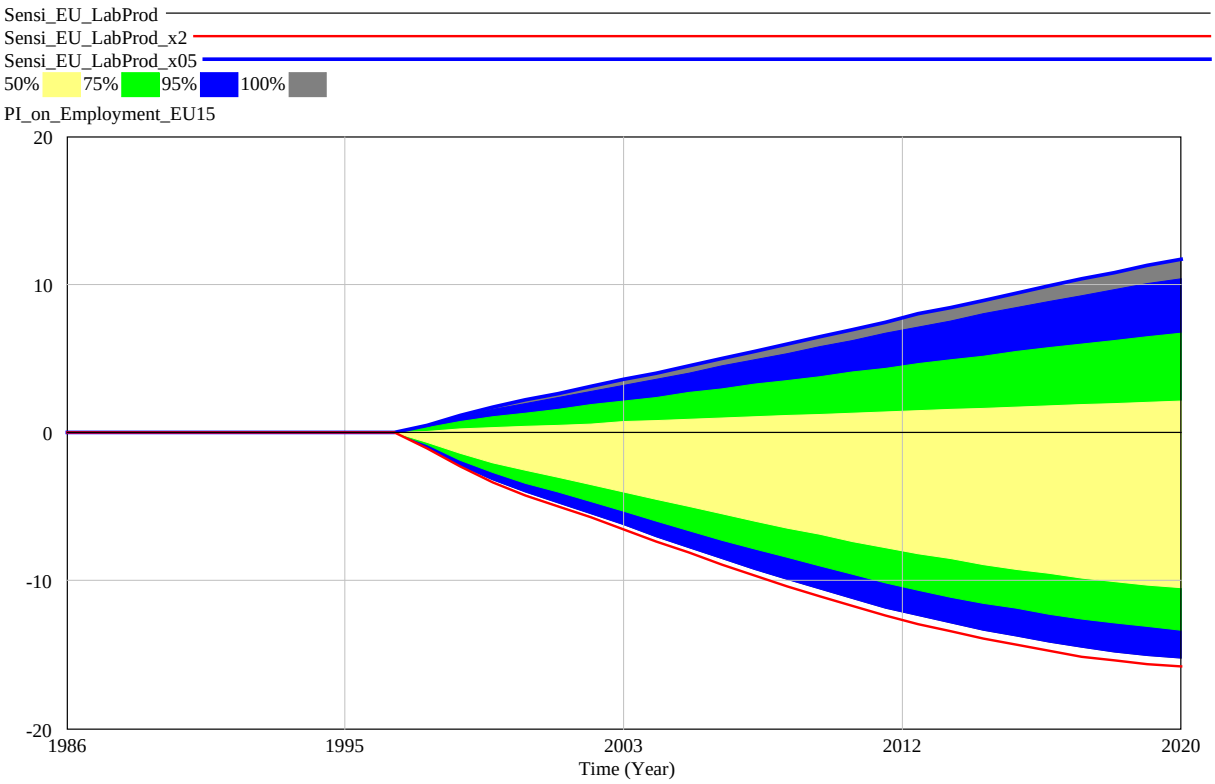

Figure 74: Sensitivity of employment to labour productivity changes in European regions (y-axis = percent change compared to Baseline Scenario [%])

One can also combine the previous sensitivity test with changes in productivity growth rates for the rest-of-the-world regions, which then are also varying in a range of 50% to 150%. The results are shown for GDP compared to *Baseline Scenario* in Figure 75 and for employment compared to *Baseline Scenario* in Figure 76. The remarkable point is that this only changes the bandwidth of both results slightly. If one agrees that the model reactions concerning foreign trade are meaningful, it seems that the counteractive forces in foreign trade, mentioned in section 3.1, that produce winning **and** loosing sectors because of the productivity changes in those sectors do balance the impacts.

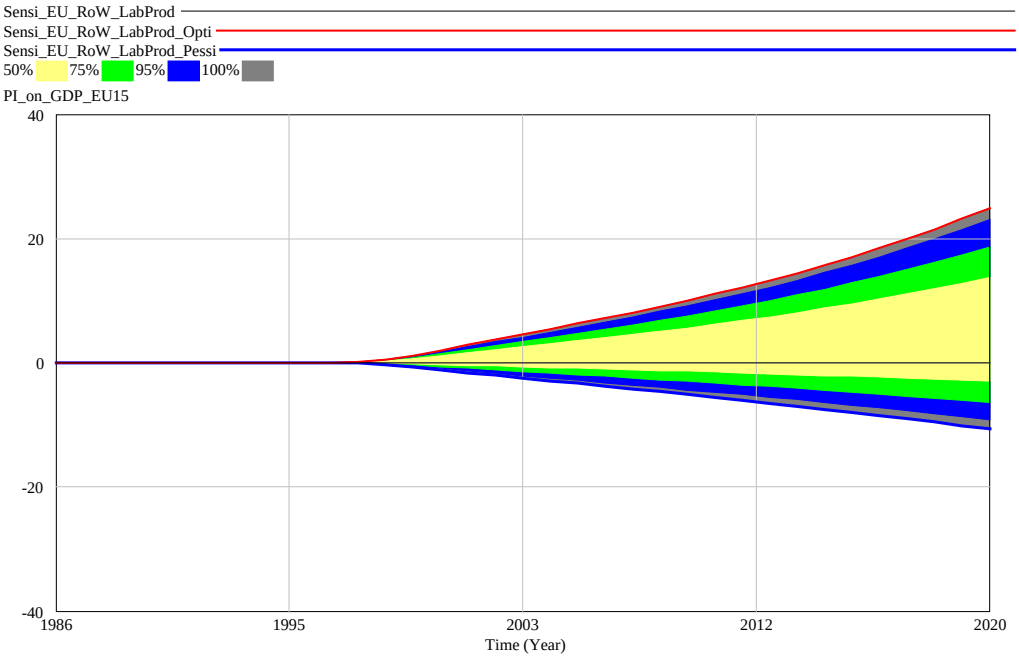

Figure 75: Sensitivity of GDP in EU15 to labour productivity in European regions and in RoW regions (y-axis = percent change compared to Baseline Scenario [%])

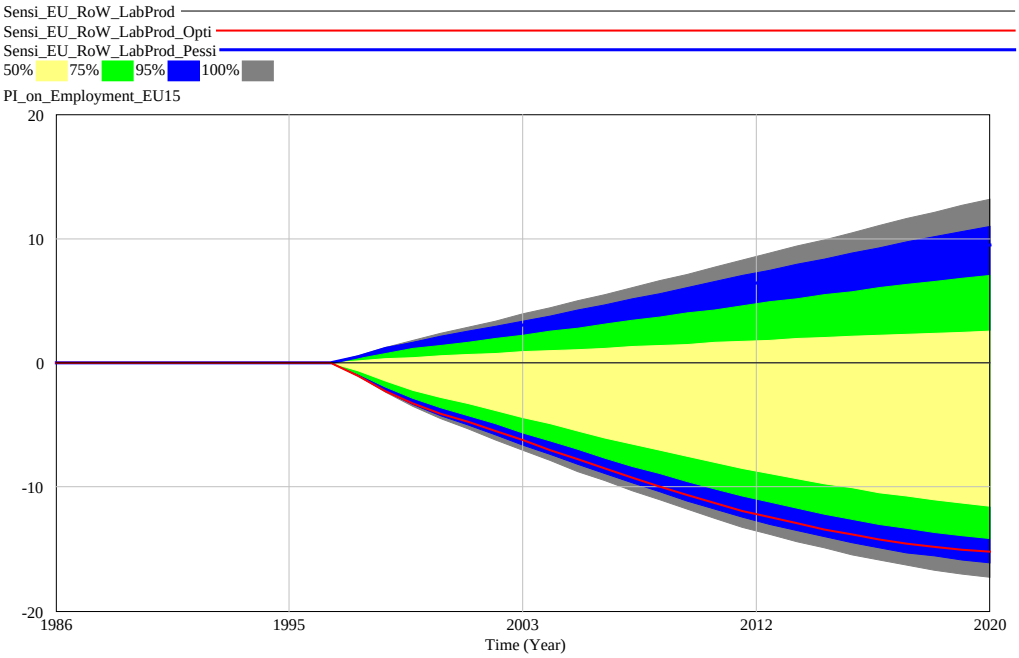

Figure 76: Sensitivity of employment to labour productivity in European regions and in RoW regions (y-axis = percent change compared to Baseline Scenario [%])

The changes in consumption split representing the demand for new products is phased in in the *Concentrated Scenario* between 1998 and 2003. In fact it makes some differences when phasing in starts at another point of time. In Figure 77 the changes of GDP and employment as percentages compared to *Baseline Scenario* for two alternatives of phasing in is shown. Starting phasing in at 1995 instead of 2000 leads to a continously higher GDP. While for employment the later commencing causes serious reductions of employment in a 15 years period from 1995 to 2010. After 2010 it can be observed that only a lower level of employment is reached.

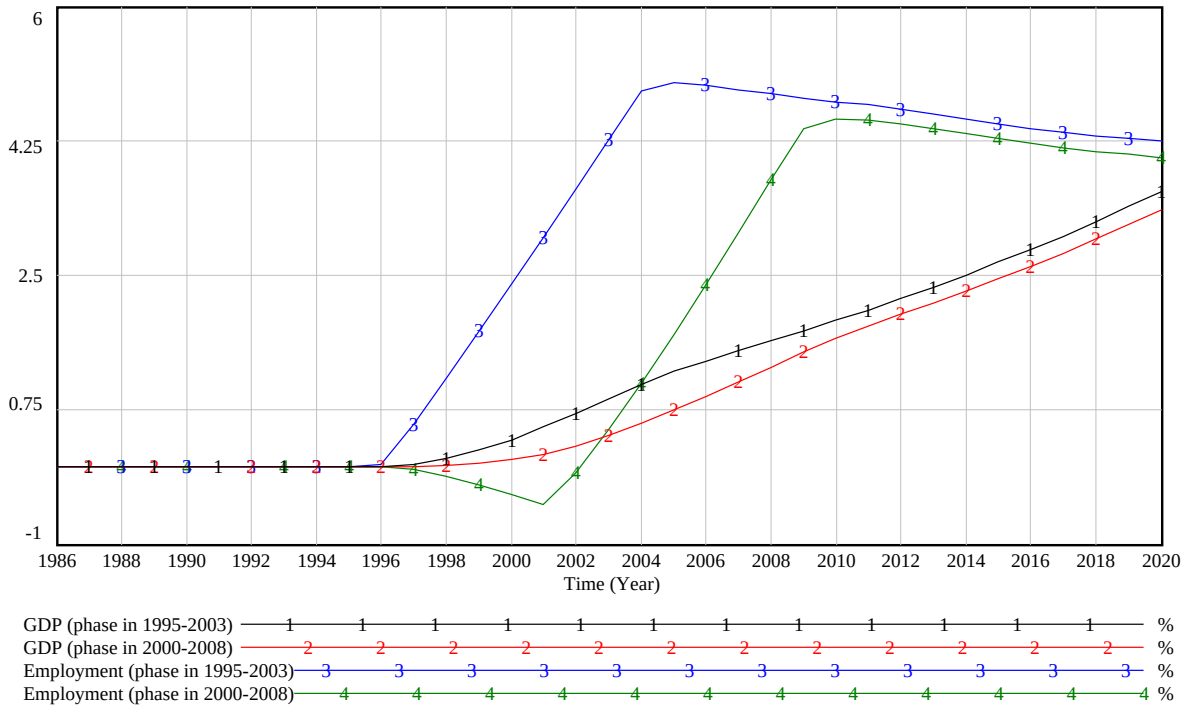

Figure 77: Influence of phasing in consumption changes at different points of time

The order of magnitude of consumption split changes is also examined by sensitivity analysis. In doing so the changes in consumption split in the *Concentrated Scenario* are multiplied with a factor ranging from 0 to 1.5 with steps of 0.01. This means the lowest value indicates no changes in the policy while the highest value implies a 50% stronger change than applied in the policy. Figure 78 shows the results for GDP in EU15 for this sensitivity analysis. With no consumption split change GDP growth in 2020 is close to +2%. A 50% higher change than in the policy leads to nearly +4.5% while the actual change applied in the policy causes about +3.6%.[25]

For employment (Figure 79) the bandwidth is much broader. The worst case leads to more than 3% loss of employment (see also Figure 62) while the increase in the best case is 8% in 2020. The blue curve "Concentrated_Split_x040" indicates the line with the minimum change

[25] The final results of the *Concentrated Scenario* are slightly higher than in this sensitivity test with an intermediate version of ASTRA-E as the link between productivity change and output growth was improved in the final version.

in consumption split to have zero employment losses. This requires 40% of the changes actually applied in the *Concentrated Scenario*.

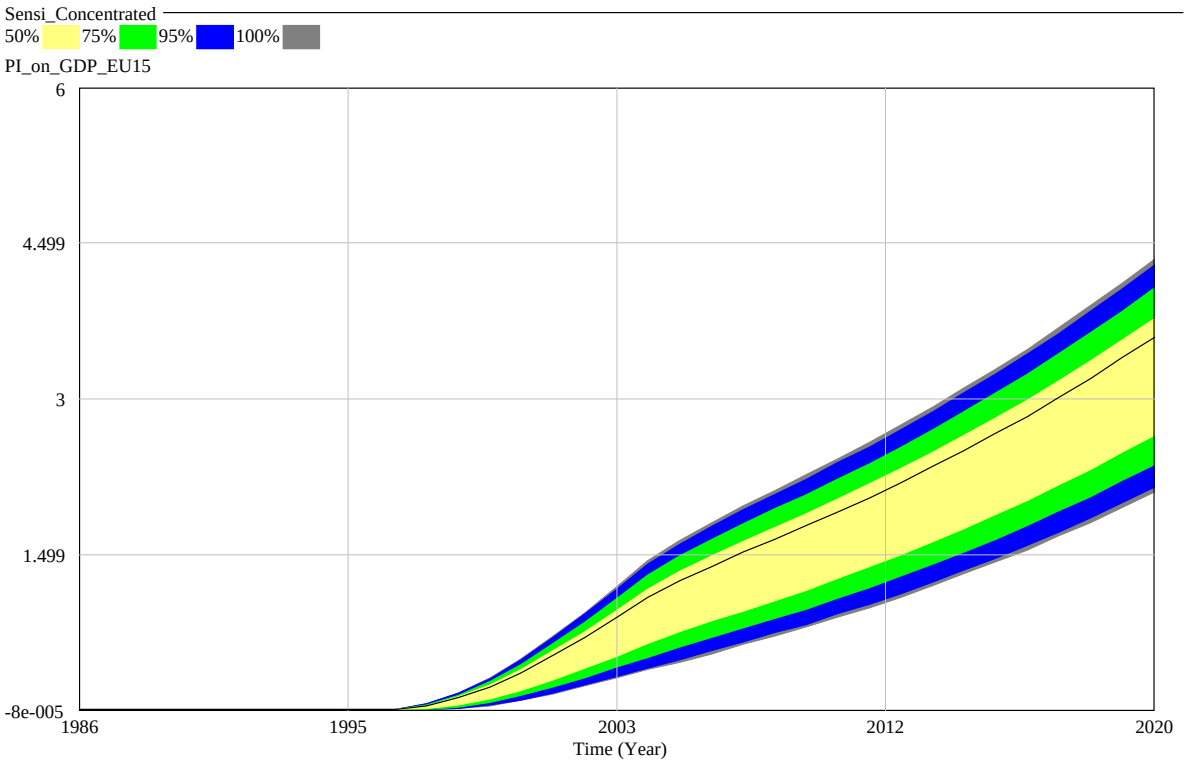

Figure 78: Results for GDP in EU15 with sensitivity tests on variations of the consumption split (y-axis = [%])

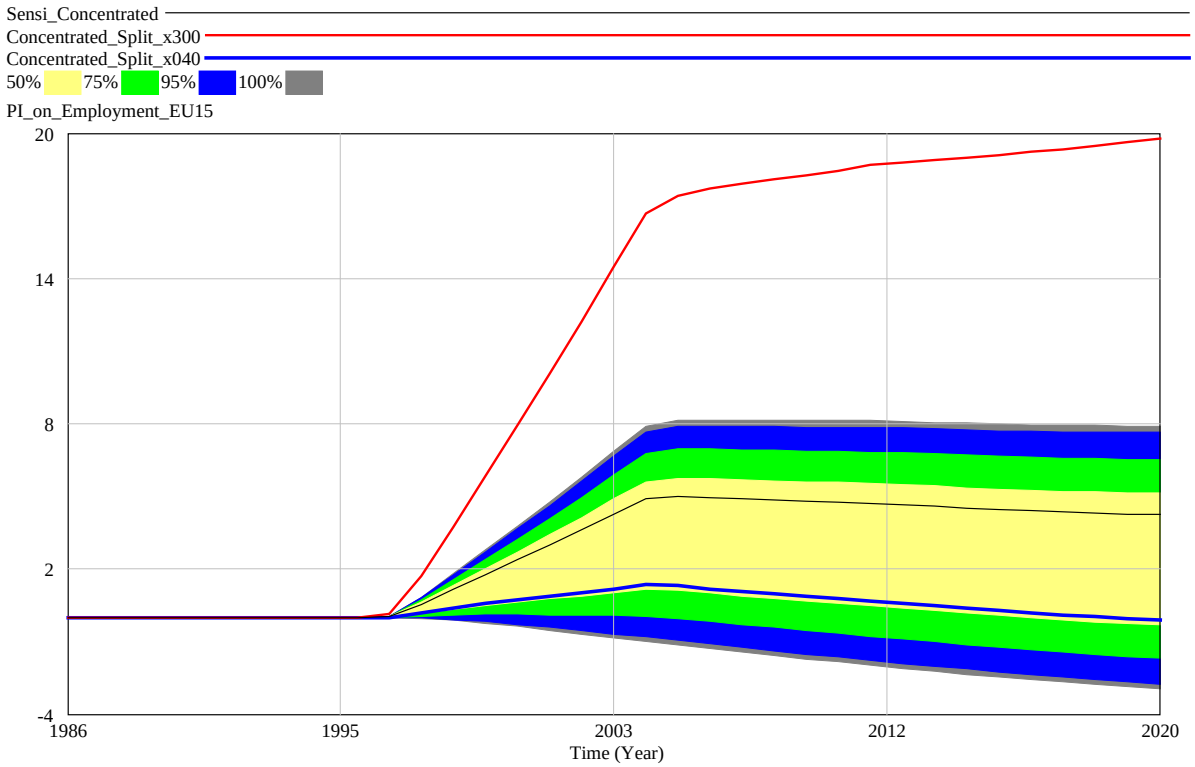

Figure 79: Results for employment in EU15 with sensitivity tests on variations of the consumption split (y-axis = [%])

6 Brief comparison of ASTRA-E results with GEM-E3

In the IPTS project two models are applied to produce quantitative results for the three policy scenarios. Besides ASTRA-E the computable general equilibrium model (CGE) GEM-E3 is used. GEM-E3 is a world model covering the European Union with a distinction of four regions: Germany, United Kingdom, Nordic Countries and Rest of the EU. Table 22 and Table 23 present an overview on the results of GEM-E3 and ASTRA. In general the ranking of policy scenarios is the same seeing the *Concentrated Scenario* as the best in both models.

Looking at GDP it seems that GEM-E3 reacts more sensitive to productivity changes, as the GDP difference to the *Baseline Scenario* of the best scenario is 13,6 points compared to 7,2 points in ASTRA-E. Employment growth between 2000 and 2020 in the *Baseline Scenario* is rather similar in both models. However, in GEM-E3 all scenarios significantly increase employment growth while in ASTRA the *Uniform Scenario* does not change employment growth and the *Diversified Scenario* even results in slowed down employment growth. Considering that in both scenarios the growth of GDP is similar (59,9 to 62,5% for Uniform and 64,3 to 63,1% for *Diversified Scenario*) it seems that output growth in GEM-E3 is better transferred into employment growth than in ASTRA-E or in other words the GDP-elasticity of employment is higher in GEM-E3 than in ASTRA-E. Two reasons could explain this: first productivity growth might be slower in GEM-E3 decreasing the labour saving impact of process innovations or, second, sectoral behaviour is different between the models e.g. the effect of changes in sectoral final demand on intermediate products and sectoral GVA could

differ. It has been shown throughout this report that the sectoral structure does matter a lot for the scenario results.

Looking at investments the two models seem to have a different treatment of those. In GEM-E3 the changes in productivity seem to be closely connected with increased investments leading nearly to a doubling of growth in investments between the *Concentrated Scenario* and the *Baseline Scenario*. In the ASTRA-E model investments depend on the development of consumption and exports. Neither they depend on the sectoral labour productivity changes directly nor do they influence them directly. However, investments drive TFP and consequently output. To realize the strong increase of investments as in GEM-E3 also in ASTRA-E the introduction of additional exogenous investments to implement the new technology would have been a solution. But since other mechanisms that would "control" investments e.g. financial markets by producing interest rates are not considered in the model an exogenous increase of investments is not implemented in the model.

The biggest numerical difference seems to be the exports and imports for which ASTRA-E forecasts more than doubling, while GEM-E3 only foresees a 50% increase. However, this should not be that grave as what really matters is the trade balance, where the difference would be much smaller.

Table 22: Comparing the outcomes of the scenarios, changes between 2000 and 2020 in the EU-15 countries (per cent): ***GEM-E3***

	Baseline Scenario	Uniform Scenario	Diversified Scenario	Concentrated Scenario
Employment	5.6	7.7	8.5	8.6
GDP	52.1	59.9	64.3	65.7
Average annual growth of GDP	2.12	2.37	2.51	2.56
Investment	49.8	72.2	83.5	89.9
Consumption	55.0	62.8	66.9	68.9
Exports	49.8	53.7	57.3	56.0
Imports	33.0	41.4	46.1	48.2

Table 23: Comparing the outcomes of the scenarios, changes between 2000 and 2020 in the EU-15 countries (per cent): ***ASTRA-E***

	Baseline Scenario	Uniform Scenario	Diversified Scenario	Concentrated Scenario
Employment	5.0	4.9	3.8	12.4
GDP	60.1	62.5	63.1	67.3
Average annual growth of GDP	2.27	2.34	2.36	2.48
Investment	55.8	57.6	58.1	60.2
Consumption	61.5	64.1	64.5	69.5
Exports	120.7	122.2	123.7	123.2
Imports	127.4	128.9	130.6	130.0
Exports Extra-EU	129.8	132.1	134.7	133.0

7 Conclusions

The results demonstrate that it is feasible to simulate GDP and employment effects of innovation policies in the EU considering international trade within the ASTRA-E model and that meaningful results are generated. The *Baseline Scenario,* which establishs a reference scenario against that the policy scenarios are tested, shows a roughly 60% increase of GDP but employment growth that is less than one tenth of GDP growth. This is accompanied by the continuing growth of importance of service sectors for output and employment.

Three innovation strategies for the EU are tested that vary in their sectoral focus of R&D investments and productivity growth. Briefly described, the *Uniform Scenario* uniformly distributes R&D and innovation expenditures, the *Diversified Scenario* focuses R&D and innovation expenditures on the current regional strengths of the EU regions and the *Concentrated Scenario* concentrates them on High Technology sectors. The results of the three policy scenarios also foresee an increase of output and employment for the EU15. However, compared to the *Baseline Scenario* all scenarios indicate a positive influence on European level for output and foreign trade but Uniform and *Diversified Scenario* result into slower growth of employment than in the *Baseline Scenario*. In the *Concentrated Scenario* it is assumed that new products are invented by the R&D efforts such that consumer demand is slightly shifted towards sectors that make use of the new products. This shift of consumer demand has a positive impact on employment such that at the end of the day employment is strongly increased by the policy.

Analysis of the causes for the differences in the policies revealed that sectoral specifics of the sectors affected by the productivity change play the most important role. These specifics could be the sectoral share of total value added or of total employment or the absolute value for productivity. E.g. a 2%-productivity increase in a sector that contributes only 1% to total output is less effective than a 2%-productivity increase in a sector contributing 10% to total output. As a general conclusion it can be stated that absolute output growth is largely taking place in the service sectors though looking at the growth rates electronics, machinery and market-services are the top three sectors. In terms of employment growth market-services, trade&transport&communication and transport equipment are the top sectors.

On the regional level the results for each scenario can vary surprisingly strong due to the sectoral and other structural differences of the regions. Important regional differences concern the sectors in which productivity is altered by the policy. It can be crucial whether these sectors show high contributions to total employment or a high above-average local content. In this case employment reactions can be severe. Another important question would be whether there are competitors on the world-market, which also increase their productivity in the same sectors, which then means for the policy that it just would help to keep the levels of trade. Nevertheless, foreign trade plays a subordinate role in the most cases.

Comparing the overall results of the three scenarios the *Concentrated Scenario* seems to be the most promising scenario as it provides the highest GDP and employment growth and also the second best position in foreign trade. The best scenario for exports compared with *Baseline Scenario* would be the *Diversified Scenario* providing a 1,3% increase in overall exports and a 2.1% increase in exports to the rest-of-the-world regions.

Two points have to be emphasised. Without the consumption shift of private households towards new products the *Concentrated Scenario* would also result into slowed down employment growth compared to the *Baseline Scenario*. This implies that the question how to foster the consumption shift in this scenario e.g. by accompanying policy measures should also play a role in the design of the technology policy. This could even bring us to the question of the willingness of consumers to accept the new products and change their consumption patterns.

The second point concerns the similar question with regard to new demand in the rest-of-the-world (RoW). In the ASTRA-E model the sectoral demand structure of the RoW is mainly modelled as far as it concerns influences caused by changes in relative productivity but not caused by altering general demand patterns. However, there are some arguments that if Europe is taking a leading role in new high technology or environmental friendly technology this could pay if the world decides to move towards the corresponding hig-tech or sustainable future making Europe a major supplier of the required technology. In this case a more positive development for exports in the scenarios could also be expected.

8 ANNEX

8.1 Definition of rest-of-the-world regions (RoW)

For the sake of comparability of model results between GEM-E3 and ASTRA the definition of the rest-of-the world regions for the ASTRA-E model is taken directly from the GEM-E3 model (see Table 24).

Table 24: Assignment of countries to 13 rest-of-the-world regions

NAM or NAFTA	**AUZ**	**AFR**	**RotW**
USA	Australia	Botswana	Afghanistan
Mexico	New Zealand	Lesotho	Albania
Canada	**TOTAL Australia**	Namimbia	Andorra
TOTAL North-America		South Africa	Bermuda
	JAP	Swaziland	Bosnia Herzegovina
LAM	Japan	Angola	British India Ocean Terr.
Argentina	**TOTAL Japan**	Malawi	Brunei
Brazil		Mauritius	Cambodia
Chile	**EAS**	Mozambique	Christmas Island
Uruguay	Korea	Tanzania	Cocos Islands
Anquila	Indonesia	Zambia	Cook Islands
Antiqua & Barbuda	Malaysia	Zimbabwe	Croatia
Aruba	Philipinnes	Benin	Cyprus
Bahamas	Singapore	Burkina Faso	Falkland Islands
Barbados	Thailand	Burundi	Fiji
Belize	Vietnam	Cameroon	French Polynesia
British Virgin Islands	Hong-Kong	Cape Verde	Greenland
Cayman Islands	Taiwan	Central African Republic	Johnston Island
Costa Rica	**TOTAL East Asia**	Chad	Kiribati
Cuba		Comoros	Laos
Dominica	**CHI**	Congo	Macao
Dominican Republic	China	Cote d'Ivoire	Malta
El Salvador	**TOTAL China**	Djibouti	Marshall Islands
Grenada		Equtorial Guinea	Micronesia
Guatemala	**IND**	Eritrea	Mongolia
Haiti	India	Ethiopia	Myanmar
Honduras	Sri Lanka	Gabon	Nauru
Jamaica	Bangladesh	Gambia	New Caledonia
Montserrat	Bhutan	Ghana	Niue
Netherlands Antilles	Maldives	Guinea	North Korea
Nicaragua	Nepal	Guinea - Bissau	Pacific Islands
Panama	Pakistan	Kenya	Palau
Saint Christopher a Nevis	**TOTAL India**	Liberia	Papua New Guinea
Saint Lucia		Madagascar	Pitcairn Islands
Saint Vincent and the Grenadines	**FSU**	Mali	Saint Helena
Trinidad and Tobago	Russian Federation	Mauritania	Solomon Islands
Turks and Caicos Isl.	Armenia	Mayotte	Tokelau
Guyana	Azerbaijan	Nigeria	Tonga
Paraguay	Belarus	Rwanda	Tuvalu
Suriname	Estonia	Sao Tome and Principe	Vanuatu

Bolivia	Georgia	Senegal	Wake Island
Ecuador	Kazakhstan	Seychelles	Wallis and Futura Isl.
Peru	Kyrgyzstan	Sierra Leonne	Western Samoa.
TOTAL Latin America	Latvia	Somalia	Yugoslavia.
			TOTAL Rest of the World
	Lithuania	Sudan	
OEU	Moldova	Togo	
Iceland	Tajikistan	Uganda	
Norway	Turkmenistan	Zaire	
Switzerland	Ukraine	**TOTAL Africa**	
Turkey	Uzbekistan		
	TOTAL Former Soviet Union		
TOTAL Other Europe		**NAF**	
		Morocco	
CEA		Algeria	
Bulgaria		Egypt	
Czech Republic		Libya	
Hungary		Tunisia	
Poland		Bahrain	
Romania		Iran	
Slovakia		Iraq	
Slovenia		Israel	
TOTAL Central European Associates		Jordan	
		Kuwait	
		Lebanon	
		Oman	
		Qatar	
		Saudi Arabia	
		Syria	
		United Arab Emirates	
		Yemen	
		Yemen Democratic	
		TOTAL North Africa	

8.2 Transformation between statistical classification and model classification

To use sectoral data in ASTRA-E several transformations of data have to be applied to transform input from databases into the used structure in the model. The transformations are listed in the following tables.

Table 25: Original classification of ASTRA input-output-table based on 12 sectors (IO-12)

Row-Nr	ASTRA (= German IO-12)	German IO-58	Row-Nr
1	Agriculture, forestry and fishery;	Agriculture	1
		Forrestry, Fishery, a.s.o.	2
2	Energy, Water, Mining Products, Crude Oil;	Electricity, Steam, Warm Water	3
		Gas	4
		Water	5
		Coal, Products of Coal Mines	6
		Other Mining and Quarrying	7
		Crude Oil, Crude Gas	8
3	Chemical, Mineral, Plastic, Petroleum Products;	Chemical Products, Nuclear Products	9
		Mineral Oil Products	10
		Plastic Products	11
		Rubber Products	12
		Stone and Soil, Building Materials	13
		Ceramics	14
		Glas	15
4	Ferrous and non-ferrous ores and metals;	Ferrous ores and steel	16
		Non-ferrous ores, Non-ferrous intermediates	17
		Foundry Products	18
		Products of rolling mills and similar industry	19
5	Steel products, Machinery, Transport Equipment; Office and Data Processing,	Steel and light metal products, Railways	20
		Machinery	21
		Office machines and related equipment	22
		Road Vehicles	23
		Ships	24
		Planes and space crafts	25
6	Electrical, Optical Goods, Toys;	Electrical goods	26
		Micro-mechanic and optical goods, Watches	27
		EBM Goods	28
		Music instruments, Toys, Sport equipment	29
7	Textiles, Clothing, Paper, Wooden Goods;	Wood	30
		Wooden Products	31
		Pulp and Paper	32
		Paper Products	33
		Pinted Products, Other copied media (discs, tapes, ..)	34
		Leather Goods, Shoes	35
		Textiles	36
		Clothing	37
8	Food, Beverages, Tobacco;	Food	38
		Beverages	39
		Tobacco	40
9	Building and Construction;	Construction outside	41
		Construction inside	42
10	Services for Repair, Wholesale and Retail, Transport, Communication;	Wholesale Trade	43
		Retail trade	44
		Railway Services	45
		Ship Transport Services, Harbour Services	46
		Communication Services	47
		Other Transport Services	48
11	Other Market Services like Lodging, Catering, Credits, Insurances;	Banking	49
		Incurance Services	50
		Real Estate Services	51
		Hotels and restaurants	52
		Scientific Services, Cultural Services	53
		Market Health Services	54
		Other Market Services	55
12	Non-market Services.	Government Services	56
		Social Protection Services	57
		Services of Non-profit organizations, Household Services	58

Table 26: Assignment of EUROSTAT IO-25 sectors to ASTRA sectors

Structure of Aggregated I-O-Table (R12)			Structure of EUROSTAT I-O-Table (R25)	
Row-Nr	**Row-Name**	**% to R12**	**Row-Nr**	**Row-Name**
1	Agriculture, forestry and fishery	100	**1**	Agriculture, forestry and fishery products
2	Energy, Water, Mining Products, Crude Oil	50	**2**	Fuel and power products
3	Chemical, Mineral, Plastic, Petroleum Products	100	**4**	Non-metallic mineral products
		100	**5**	Chemical products
		100	**14**	Rubber and plastic products
		50	**2**	Fuel and power products
4	Ferrous and non-ferrous ores and metals	100	**3**	Ferrous and non-ferrous ores and metals
5	Steel products, Machinery, Transport Equipment	100	**6**	Metal products except machinery
		100	**7**	Agricultural and industrial machinery
		100	**10**	Transport equipment
		90	**8**	Office and data processing machines
6	Electrical, Optical Goods, Office and Data Processing, Toys	100	**9**	Electrical goods
		10	**8**	Optical Goods from Office and data processing machines
		75	**15**	Other manufacturing products
7	Textiles, Clothing, Paper, Wooden Goods	100	**12**	Textiles and clothing, leather and footwear
		100	**13**	Paper and printing products
		25	**15**	Wooden Goods out of Other manufacturing products
8	Food, Beverages, Tobacco	100	**11**	Food, beverages, tobacco
9	Building and Construction	100	**16**	Building and construction
10	Services for Repair, Wholesale and Retail, Transport, Communication	100	**17**	Recovery, repair services, wholesale, retail
		100	**19**	Inland transport services
		100	**20**	Maritime and air transport services
		100	**21**	Auxiliary transport services
		100	**22**	Communication services
11	Other Market Services like Lodging, Catering, Credits, Insurances	100	**18**	Lodging and catering services
		100	**23**	Services of credit and insurance institutions
		100	**24**	Other market services
12	Non-market Services	100	**25**	Non-market services

Table 27: Assignment of UN consumption split categories to ASTRA sectors

Code	Original UN Consumption Categories	Split to ASTRA sectors	Shares
M1	FOOD,BEVERAGES AND TOBACCO	Sector 1	0.08
		Sector 8	0.92
M2	CLOTHING AND FOOTWEAR	Sector 7	0.65
		Sector 11	0.35
M3	GROSS RENT, FUEL AND POWER	Sector 2	0.17
		Sector 3	0.3
		Sector 10	0.53
M4	FURNITURE, FURNISHINGS, HOUSEHOLD OPERATION	Sector 9	0.11
		Sector 10	0.33
		Sector 11	0.56
M5	MEDICAL CARE AND HEALTH EXPENSES	Sector 11	0.5
		Sector 12	0.5
M6	TRANSPORT AND COMMUNICATION	Sector 10	1
M7	RECREATION, ENTERTAINMENT, EDUCATION, CULT.	Sector 11	0.25
		Sector 12	0.75
M8	MISCELANNEOUS GOODS AND SERVICES	Sector 5	0.34
	S6	Sector 6	0.66

Table 28: Assignment of OECD trade categories (SITC Rev 2) to ASTRA sectors

Code	OECD trade category	ASTRA sectors	Shares
0	Food and live animals		
00	Live animals chiefly for food	sector 1	1
01	Meat and meat preparations	sector 1	0.5
		sector 8	0.5
02	Dairy products and birds'eggs	sector 8	1
03	Fish, crustaceans, mollucs, preparations thereof	sector 1	0.5
		sector 8	0.5
04	Cereals and cereal preparations	sector 1	0.5
		sector 8	0.5
05	Vegetables and fruit	sector 1	1
06	Sugar, sugar preparations and honey	sector 8	1
07	Coffee, tea, cocoa, spices, manufactures thereof	sector 8	1
08	Feeding stuff for animals, not including unmilled cereals	sector 8	1
09	Miscellaneous edible products and preparations	sector 1	0.5
		sector 8	0.5
1	Beverages and tobacco		
11	Beverages	sector 8	1
12	Tobacco and tobacco manufactures	sector 8	1
2	Crude materials, inedible, except fuels		
21	Hides, skins and furskins, raw	sector 7	1
22	Oil seeds and oleaginous fruit	sector 1	1
23	Crude rubber (including synthetic and reclaimed)	sector 3	1
24	Cork and wood	sector 7	1
25	Pulp and waste paper	sector 7	1
26	Textile fibres (except wool tops) and their wastes	sector 7	1
27	Crude fertilizers and crude materials (excluding coal)	sector 3	1
28	Metalliferous ores and metal scrap	sector 4	1
29	Crude animal and vegetable materials, n,e,s,	sector 1	1
3	Mineral fuels, lubricants and related materials		

	32	Coal, coke and briquettes	sector 2	1
	33	Petroleum, petroleum products and related materials	sector 2	0.4
			sector 3	0.6
	34	Gas, natural and manufactured	sector 2	1
	35	Electric current	sector 2	1
4		Animal and vegetable oils, fats and waxes		
	41	Animal oils and fats	sector 1	1
	42	Fixed vegetable oils and fats	sector 1	1
	43	Animal0vegetable oils0fats, processed, and waxes	sector 1	1
5		Chemicals and related products, n,e,s,		
	51	Organic chemicals	sector 3	1
	52	Inorganic chemicals	sector 3	1
	53	Dyeing, tanning and colouring materials	sector 3	1
	54	Medicinal and pharmaceutical products	sector 3	1
	55	Essential oils & perfume materials; toilet polishing and cleansing preparations	sector 3	1
	56	Fertilizers, manufactured	sector 3	1
	57	Explosives and pyrotechnic products	sector 3	1
	58	Artificial resins, plastic materials, cellulose esters and ethers	sector 3	1
	59	Chemical materials and products, n,e,s,	sector 3	1
6		Manufactured goods classified chiefly by material		
	61	Leather, leather manufactures, n,e,s, and dressed furskisg	sector 7	1
	62	Rubber manufactures, n,e,s,	sector 7	1
	63	Cork and wood manufactures (excluding furniture)	sector 7	1
	64	Paper, paperboard, articles of paper, paper0pulp/board	sector 7	1
	65	Textile yarn, fabrics, made0up articles, related products	sector 4	1
	66	Non0metallic mineral manufactures, n,e,s,	sector 4	1
	67	Iron and steel	sector 4	1
	68	Non0ferrous metals	sector 4	1
	69	Manufactures of metal, n,e,s,	sector 4	1
7		Machinery and transport equipment		
	71	Power generating machinery and equipment	sector 5	1
	72	Machinery specialized for particular industries	sector 5	1
	73	Metalworking machinery	sector 5	1
	74	General industrial machinery & equipment, and parts	sector 5	1
	75	Office machines & automatic data processing equipement	sector 5	1
	76	Telecommunications & sound recording apparatus	sector 6	1
	77	Electrical machinery, apparatus & appliances n,e,s,	sector 6	1
	78	Road vehicles (including air0cushion vehicles)	sector 5	1
	79	Other transport equipment	sector 5	1
8		Miscellaneous manufactured articles		
	81	Sanitary, plumbing, heating and lighting fixtures	sector 7	1
	82	Furniture and parts thereof	sector 7	1
	83	Travel goods, handbags and similair containers	sector 7	1
	84	Articles of apparel and clothing accessories	sector 7	1
	85	Footwear	sector 7	1
	87	Professional, scientific & controling instruments	sector 6	1
	88	Photographic apparatus, optical goods, watches	sector 6	1
	89	Miscellaneous manufactured articles, n,e,s,	sector 6	1
9		Commodities and transactions not elswhere classified		
	91	Postal packages not classified according to kind		
	93	Special transactions not classified according to kind		
	94	Animals, live, zoo animals, dogs, cats etc,		

95	Arms, of war and ammunition therefor		
96	Coin (other than gold) , not being legal tender		
97	Gold, non0monetary		

The following categories of the OECD Structural Analysis Industrial Database (STAN) are based on the International Standard Industrial Classification of all Economic Activities (ISIC Rev 2), which are grouped into 26 STAN categories.

Table 29: Assignment of OECD STAN categories to ASTRA sectors

OECD STAN category	**ASTRA sector**
Food, Beverages & Tobacco	SECTOR **8**
Textiles, Apparel & Leather	SECTOR **7**
Wood Products & Furniture	SECTOR **7**
Paper, Paper Products & Printing	SECTOR **7**
Chemical Products	SECTOR **3**
Chemicals excluding drugs	SECTOR **3**
Drugs & Medicines	SECTOR **3**
Petroleum Refineries & products	SECTOR **3**
Rubber & Plastic Products	SECTOR **3**
Non-Metallic Mineral Products	SECTOR **2**
Basic Metal Industries	SECTOR **4**
Iron & Steel	SECTOR **4**
Non-Ferrous Metals	SECTOR **4**
Fabricated Metal Products	SECTOR **5**
Metal Products	SECTOR **5**
Office & Computing Machinery	SECTOR **5**
Machinery & Equipment, nec	SECTOR **5**
Radio, TV & Communication Equipment	SECTOR **6**
Electrical Apparatus, nec	SECTOR **6**
Shipbuilding & Repairing	SECTOR **5**
Motor Vehicles	SECTOR **5**
Aircraft	SECTOR **5**
Other Transport Equipment	SECTOR **5**
Professional Goods	SECTOR **6**
Other Manufacturing	SECTOR **6**

Table 30: Assignment of OECD categories in national accounts to ASTRA manufacturing sectors

Manufacturing Sectors according OECD National Accounts	ASTRA Sector
Agriculture, hunting and forestry	SECTOR 1
Fishing	SECTOR 1
Mining and quarrying of energy producing materials	SECTOR 2
Mining and quarrying except energy producing materials	SECTOR 2
Manufacture of food products, beverages and tobacco	SECTOR 8
Manufacture of textiles and textile products	SECTOR 7
Manufacture of leather and leather products	SECTOR 7
Manufacture of wood and wood products	SECTOR 7
Manufacture of pulp, paper and paper products; publishing and printing	SECTOR 7
Manufacture of coke, refined petroleum products and nuclear fuel	SECTOR 3
Manufacture of chemicals, chemical products and man-made fibres	SECTOR 3
Manufacture of rubber and plastic products	SECTOR 3
Manufacture of other non-metallic mineral products	SECTOR 4
Manufacture of basic metals and fabricated metal products	SECTOR 4
Manufacture of machinery and equipment n.e.c.	SECTOR 5
Manufacture of electrical and optical equipment	SECTOR 6
Manufacture of transport equipment	SECTOR 5
Manufacturing n.e.c.	SECTOR 6
Electricity, gas and water supply	SECTOR 2
Construction	SECTOR 9

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