Modelling future interlinkages

van Drunen, M.A.; Kuik, O.J.; Lutz, C.H.M.; Wiebe, K.

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INDI-LINK

Indicator-based evaluation of interlinkages between different sustainable development objectives

Modelling Future Interlinkages

DELIVERABLE

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Abstract

This report selected five methods, methodologies and tools (MMTs) to investigate likely interlinkages among sustainability indicators in the future. Key question is: are the MMTs capable of establishing scores on sustainability indicators in the coming ten years *and* interlinkages among these scores? The selected MMTs are Multi-criteria analysis (MCA), GVAR, GINFORS, DEAN and ASA.

We conclude that future interlinkages between sustainable development indicators cannot be observed. Nevertheless, in some cases some information about future interlinkages can be revealed if one has an idea (a theory) about the interlinkages. This idea can be simple – a simple correlation between two SDI's (MCA) – or complex – embodied in a large simulation model (GINFORS). Some ideas can be tested on historic data (GVAR), but this is always subject to methodological difficulties and data constraints. Moreover, interlinkages that held in the past, may not automatically hold in the future. Future interlinkages are dependent on future policy scenarios (including no-policy scenarios); this interdependence can be represented in relatively simple models (ASA) or complex applied general equilibrium models (DEAN). All potential future interlinkages are therefore conditional and uncertain, but – in relative terms – we have better 'ideas' or 'theories' on future interlinkages between indicators within and between the economic and environmental pillars of sustainable development than between the social pillar and the other pillars.

1. Introduction

This report is the fifth deliverable of the Workpackage 2 in the European Commission funded INDI-LINK project (INDI-LINK, 2007). In Deliverable 2.1 (Van Herwijnen, 2007), we assessed thirty-one methodologies, methods and tools (MMTs) that are potentially capable of identifying linkages (synergies, trade-offs) among the sustainable development indicators (SDIs) defined in Workpackage 1 (Hak *et al.* 2007). These assessments were based on literature reviews and expert judgments. Deliverable 2.4 (Van Drunen et al., 2008) discussed studies that actually applied the MMTs on subjects relevant for EU sustainability policies and compares the results to Deliverable 2.1 that assessed their potential abilities to identify:

- **Loose interlinkages**, which apply when a method manages to take into account two or more specific sustainability aspects or indicators, or
- **Strong interlinkages**, which apply when a method can actually establish and/or explain a specific cause-effect relationship between two or more sustainability aspects or indicators.

There are only few MMTs that have proven to be able to identify quantitative and strong interlinkages including GINFORS and DEAN. Only few MMT case studies (including MCA, GVAR[1] and DEAN) dealt with social indicators such as literacy rate and life expectancy.

This report selected five MMTs to investigate likely interlinkages in the future. Key question is: are the MMTs capable of establishing scores on sustainability indicators in the coming ten years *and* interlinkages among these scores? The selected MMTs are MCA, GVAR, GINFORS, DEAN and ASA. They were chosen because Van Drunen et al. (2008) showed that they are able to establish quantitative relationships (in case of MCA with the help of an additional model) and they represent either *ex ante* (MCA, GINFORS, DEAN) or *ex post* (GVAR, ASA) MMTs. Again we took a case study approach that enabled us to show what the MMTs are capable to in practice.

In the chapters 2 to 6 the case studies are elaborated. They are focused on either performance of policies on SDIs or on SDI trends, and on future interlinkages. Chapter 7 discusses the overall results and provides overall conclusions and recommendations for future research.

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[1] In previous reports referred to as *VAR|VECM*.

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2. Multi-criteria analysis

Michiel van Drunen (IVM)

2.1 Introduction

Multi-criteria analysis methods are methods that support comparison of different policy options on the basis of a set of criteria. They are very effective in supporting decision making on complex sustainability issues because they can integrate a diversity of criteria in a multidimensional guise and they can be adapted to a large variety of contexts (Janssen and Van Herwijnen, 2008; Van Herwijnen, 2008).

Within the policy scenario assessment discussed here, weighted summation has been applied. This method is a special form of Multi Attribute Value Theory (MAVT) (Keeney and Raiffa, 1976) and is also called linear additive model. Weighted Summation uses a compensatory decision rule and can handle quantitative data and qualitative data under strict conditions.[2] The process to be followed to carry out weighted summation is simple. The following steps have to be followed (Janssen,1992):

1. Definition of alternative options: identify the alternative options, which are to be compared with each other;
2. Selection and definition of criteria: identify the effects or indicators relevant for the decision;
3. Assessment of scores for each alternative option: assign values to each effect or indicator for all options;
4. Standardization of the scores in order to make the criteria scores comparable with each other;
5. Weighting of criteria, in order to assign priorities to them;
6. Ranking of the alternative options. A total score for each alternative option is calculated by multiplying the standardized scores with its appropriate weight, followed by summing the weighted scores of all criteria.

In this study steps 1 and 2 were determined by the study *Optiedocument energie en emissies 2010/2020* by the Energy Research Center (ECN) of the Netherlands (Daniëls et al., 2006).

2.2 Policy scenarios

The policies concerned in this study concern options for electricity production in the Netherlands. These options were outlined in Daniëls et al. (2006). The effects of the options on emissions of carbon dioxide, sulphur dioxide, nitrogen oxides, and on the natural gas consumption and the costs were modelled by ECN based on the Global Economy scenario that was developed by the study Welfare, Prosperity and Quality of the Living Environment (WLO, 2006). Table 2.1 describes the criteria in more detail. They represent the objectives:

1. To reduce costs;
2. To reduce greenhouse gas emissions;

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[2] Weighted summation cannot handle real qualitative data, only pseudo qualitative data (Janssen, 2001).

3. To preserve national natural gas reserves for future generations;
4. To improve local air quality.

The schematic outline of the analysis model is shown in Figure 2.1. For each option the analysis model calculates the optimal electricity production mix that includes the specific option. This calculation is based on interactions between options, emissions effects and cost effectiveness. Then the model calculates the costs, CO_2 emission reduction, natural gas depletion and environmental benefits compared to a reference without the specific option implemented. E.g. according to the model the options nuclear plant and off shore wind parks will be built instead of gas fired power plants, whilst coal fired plants with carbon capture and storage (CCS) will be built in addition to gas fired plants. Therefore the latter will not contribute to a reduction of natural gas consumption.

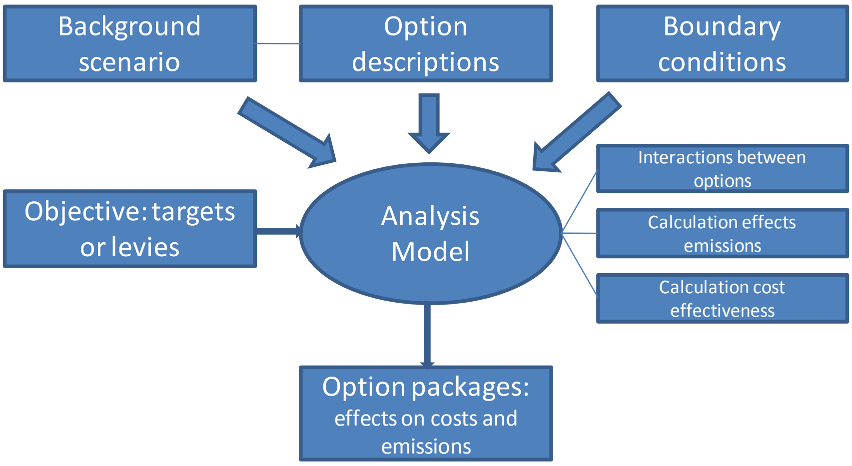

Figure 2.1 Analysis model for the options for decreasing carbon dioxide emissions in the Optiedocument energie en emissies 2010/2020 *(Daniëls et al., 2006).*

Table 2.1 Evaluation criteria options for CO_2 emission reduction in the electricity sector.

Criteria	**Description**
Costs	The costs involve the total national costs, including investment costs, operational costs and energy costs of the end users. The applied discount rate was 4%.
CO_2 emission reduction	Total reduction of CO_2 emissions.
Natural Gas depletion	The national effect on the natural gas use.
Other Environment	
SO_2 emission reduction	Total reduction of SO_2 emissions.
NO_X emission reduction	Total reduction of NO_X emissions.
PM_{10} emission reduction	Total reduction of PM_{10} emissions.
Nuclear waste	Generation of nuclear waste.

The Multi-criteria analysis described here, compares four electricity production alternatives for 2020: a 2000 MW nuclear power plant, a 2000 MW_e coal fired power plant with CCS, a 2000 MW_e natural gas fired plant with a combined heat cycle (CHP) and a 6300 MW off shore wind power park. The inputs for the analysis were the factsheets provided by ECN on the website of the *Optiedocument 2010/2020* (ECN, 2008). These four options were chosen from a list of 28 options for CO_2 emission reduction by the electricity sector because they result in comparable levels of CO_2 emission reduction and because they constitute four totally different types of options.

The options were compared to the Global Economy reference scenario mentioned above. The coal fired power plant with CCS and the gas fired plants with CHP would be implemented instead of the 'normal' coal fired plants envisaged in the reference scenario. Off shore wind power parks and a nuclear plant would be installed instead of the some average mix of electricity production options in the reference scenario.

2.3 Indicators

Overview

The evaluation criteria considered here are closely related to Eurostat Sustainable Development Indicators (SDIs; Eurostat, 2009). Table 2.2 shows the SDIs relevant here. The criterion Costs applied here is not specifically addressed by the Eurostat SDIs, but it is of course related to the theme Socio-economic development. The criterion 'Nuclear waste' does not seem to be addressed by the Eurostat SDIs.

Table 2.2 SDIs considered here.

Theme	Subtheme (Level)	Criteria applied here
Sustainable consumption and production	Emissions of acidifying substances by source sector (L3)	SO_2 emission reduction
	Emissions of acidifying substances by source sector (L3), Emissions of ozone precursors by source sector (L3)	NO_X emission reduction
	Emissions of particulate matter by source sector (L3)	PM_{10} emission reduction
Climate change and energy	Greenhouse gas emissions (L1)	CO_2 emission reduction
	Energy dependency (L2)	Natural Gas depletion

Emissions of acidifying substances by source sector (L3)

The Level 3 Indicator "Emissions of acidifying substances by source sector" is an aggregate of acidifying substance emissions (sulphur dioxide, nitrogen oxides and ammonia) in terms of their acidifying effects, and expressed in acid equivalents. The indicator reports emissions for eight source sectors. This study only considers SO_2 emission reduction and NO_X emission reduction compared to the reference scenario without the investigated options.

Emissions of ozone precursors by source sector (L3)

The Level 3 Indicator "Emissions of ozone precursors by source sector" reports on emissions of ozone precursors (nitrogen oxides, carbon monoxide, methane and non-methane volatile organic compounds), by source sector. Ozone precursor emissions are combined in terms of their tropospheric ozone-forming potential, and expressed in NMVOC equivalents. This study only considers nitrogen oxides emission reduction compared to the reference scenario without the investigated options.

Emissions of particulate matter by source sector (L3)

The Level 3 Indicator "Emissions of particulate matter by source sector" reports on emissions of primary particles, secondary particulate precursors (sulphur dioxide, nitrogen oxides and ammonia). Particulates and particulate precursor emissions are combined in terms of their particulate-forming potential and expressed in terms of particulate-forming equivalents. This study includes PM_{10} emission reduction in terms of primary particles only compared to the reference scenario without the investigated options.

Greenhouse gas emissions (L1)

The Level 1 Indicator "Greenhouse gas emissions" is an index of non-fluorinated gases (CO_2, CH_4 and N_2O), and fluorinated gases (HFC, PFC and SF_6), weighted by their global warming potentials (GWPs), with base year = 100. In general, the base year is 1990 for the non- fluorinated gases and 1995 for the fluorinated gases. In this study only the reduction of CO_2 emission compared to the reference scenario without the investigated options is considered.

Energy dependency (L2)

Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers. In this study the change in natural gas consumption of the investigated option was considered. Natural gas in the Netherlands is partly domestically extracted and partly imported (e.g. in 2007 the domestic consumption amounted 1395 PJ, the export 1670 PJ and the import 772 PJ, source: Milieu & NatuurCompendium, 2009).

2.4 Effects table

In this study, DEFINITE (Janssen and Van Herwijnen, 2008) was used to carry out the MCA. Table 2.3 shows the effects table for the four alternatives investigated. It shows the total effects on a national level. Off Shore Wind and Coal Fired Plant / CCS are the most expensive options. The latter results in the highest CO_2 emission reduction whilst the first would lead to a much lower natural gas depletion. The Gas Fired Plant / CHP is the only one that is beneficial compared to the reference in terms of costs and it leads to significant air pollutants emission reductions, but its CO_2 emission reduction is relatively low and of course the natural gas depletion is very high. The nuclear power plant performs quite well on most criteria, but is the only option that generates nuclear waste.

Table 2.3 Effects table for the four alternatives defined in Daniëls et al. (2006). C/B is either cost or benefit.

	C/B	Unit	Nuclear Powerplant	Coal Fired Plant / CCS	Gas Fired Plant / CHP	Off Shore Wind
Costs	C	mln €	73.1	461	-3.5	470
CO_2 emission reduction	B	Mt	8.5	19.6	7	7.5
Natural gas depletion	C	PJ	-59.8	0	171	-52.9
Other Environmental criteria						
SO_2 emission reduction	B	kt	3.6	8.8	11.5	3.2
NO_X emission reduction	B	kt	5.1	-0.9	2	4.6
PM_{10} emission reduction	B	kt	0.1	0.1	0.4	0.1
Nuclear waste	-	Yes/No	Yes	No	No	No

The effects table suggests no clear trade-offs between costs and CO_2 emission reduction: The Coal Fired Plant / CCS and Off Shore Wind are both expensive options, but lead to very different emission reductions. There seems to be a trade-off between Costs and Natural Gas Depletion. There is synergy between Natural gas depletion and SO_2 and PM_{10} emissions for these four investigated options. A more detailed overview of the trade-offs and synergies can be derived from the correlation matrix in Table 2.4. The table also suggests a trade-off between CO_2 emission reduction and NO_X emission reduction, and between Costs and PM_{10} emission reduction. Of course these correlations cannot be considered statistically significant, because there were only four different alternatives investigated.

Table 2.4 Correlation matrix of the criteria in the effects table.

	Costs	CO_2 emission reduction	Natural gas depletion	SO_2 emission reduction	NO_X emission reduction	PM_{10} emission reduction	Nuclear waste
Costs	1						
CO_2 emission reduction	0.55	1					
Natural gas depletion	-0.55	-0.17	1				
SO_2 emission reduction	-0.33	0.26	0.91	1			
NO_X emission reduction	-0.28	-0.82	-0.41	-0.75	1		
PM_{10} emission reduction	-0.67	-0.41	0.97	0.78	-0.17	1	
Nuclear waste	0.47	0.29	0.46	0.52	-0.58	0.33	1

2.5 Standardization and weighting

In this MCA it was decided to apply maximum standardization on all criteria except for Costs and Natural gas depletion, because the latter have both positive and negative values. Formally the weights need to be established by either experts (within groups of criteria, in this case in the group Other environmental effects) or by policymakers (between the main groups Costs, CO_2 emission reduction, natural gas depletion and Other environmental effects). In this study the weights have been established by the author. The weight set was challenged by a sensitivity analysis (Section 2.7).

Table 2.5 shows the weight set. Since the greenhouse gas emission reduction is the driver for implementing the options, this is given the highest weight. Second most important are costs. The weights chosen here reflect a CO_2 'price'[3] of €18/ton (0.3*70/0.4*19.6). Within the group Other environmental criteria, NO_X, PM_{10} and nuclear waste were given the same weight (0.3), whilst SO_2 was given the lowest weight (0.1). The group weight was set to 0.1.

Table 2.5 The weight set that was applied to the effects table.

	Unit	Standardization method	Minimum Range	Maximum Range	Weight level 1	Weight level 2	Weight
Costs	mln €	interval	-3.5	470.0	0.3		0.300
CO_2 emission reduction	Mt	maximum	0.0	19.6	0.4		0.400
Natural gas depletion	PJ	interval	-59.8	171.0	0.2		0.200
Other Environmental criteria					0.1		
SO_2 emission reduction	Kt	maximum	0.0	11.5		0.1	0.010
NO_X emission reduction	Kt	maximum	0.0	5.1		0.3	0.030
PM_{10} emission reduction	Kt	maximum	0.0	0.4		0.3	0.030
Nuclear waste	Yes/No	maximum	-1	0		0.3	0.030

2.6 Ranking

Figure 2.2 shows the ranking of the four alternatives. The nuclear power plant ranks first, because it scores reasonably well on all criteria. However, it should be noted that political feasibility and risks related to proliferation and terroristic attacks were not considered here. The Coal Fired Plant / CCS ranks second and the Off Shore Wind option ranks fourth, mainly because it is expensive and because the CO_2 emission reduction is relatively limited.

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[3] This does not mean that this is a realistic weight set if the market price would be €18/ton. It only shows that for society as a whole being able to spend €18 is equivalent to reducing one ton of CO_2 emission.

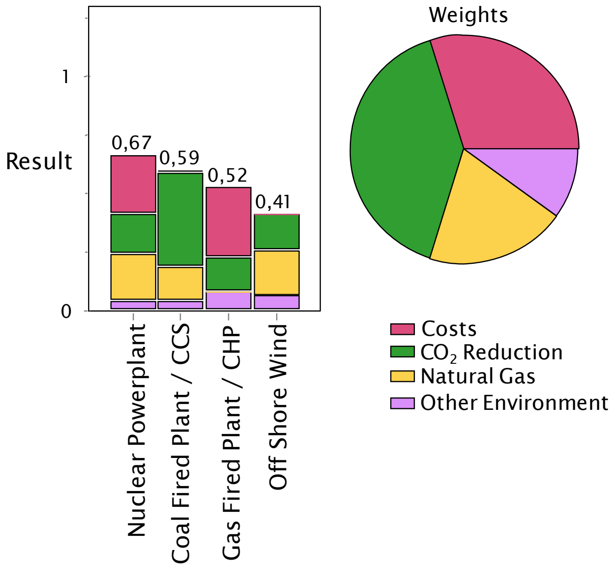
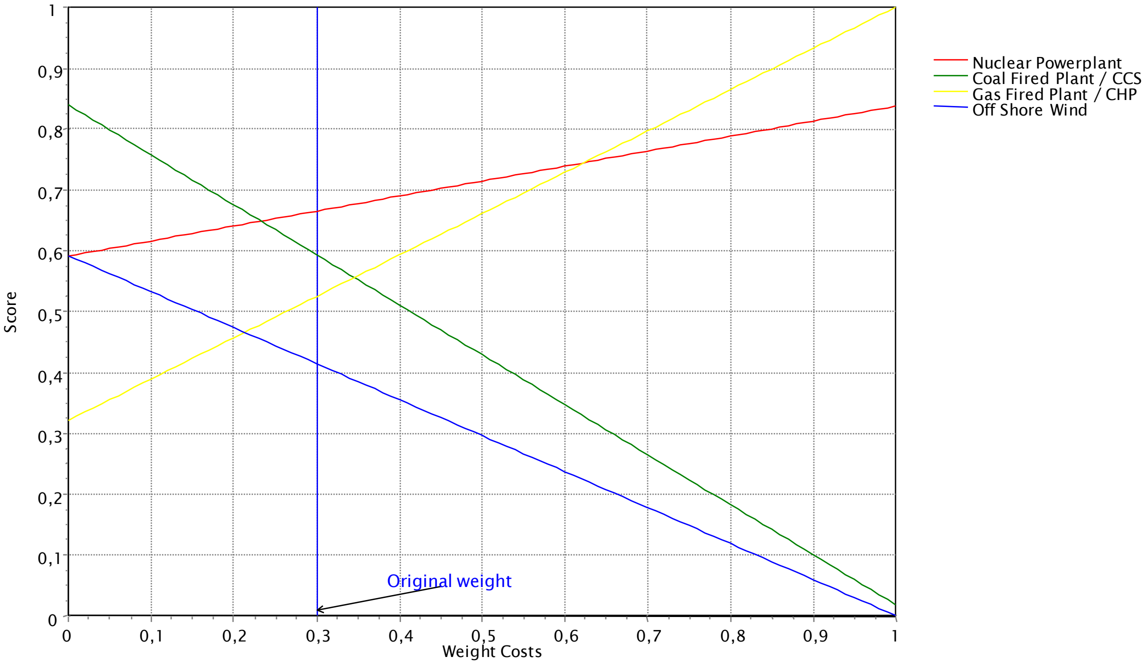


Figure 2.2 Ranking with the first weight set (relatively low weight to costs).

2.7 Sensitivity and an uncertainty analysis

The ranking is not very sensitive for uncertainty in the scores. If all scores have a 25% uncertainty[4] the probability that the Nuclear plant remains at the first position is 77%. The Coal Fired Plant / CCS has a probability of 21% to become first. In any case the Offshore Wind Power Option remains last.



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[4] DEFINITE assumes that the uncertainties of the scores are independent and that they are normally distributed. The 25% is equivalent to twice the standard deviation of the probability density.

Figure 2.3 Sensitivity analysis for the weight for costs.

Figure 2.3 shows that if the weight for costs would be increased to 0.35, the Gas Fired Plant / CHP will rank second and if it is 0.62 it will rank first. The weight set would need to be totally adapted to enable the Off Shore Wind option to become first: 0.077 for Costs, 0.216 for CO_2 emission reduction, 0.383 for Natural gas depletion and 0.325 for Other environmental impacts. Basically the weight for Costs[5] must become very low and for Other environmental criteria very high compared to the initial weight sets.

Figure 2.4 shows that if the weight for CO_2 emission reduction would be increased to 0.47, the Coal Fired Plant with CCS will rank first. If it would be decreased to 0.33, the gas fired Plant / CHP will rank second and the Coal Fired Plant / CCS will rank third. For weights between 0.15 and 0.85 Off Shore Wind ranks fourth and outside these limits it ranks third.

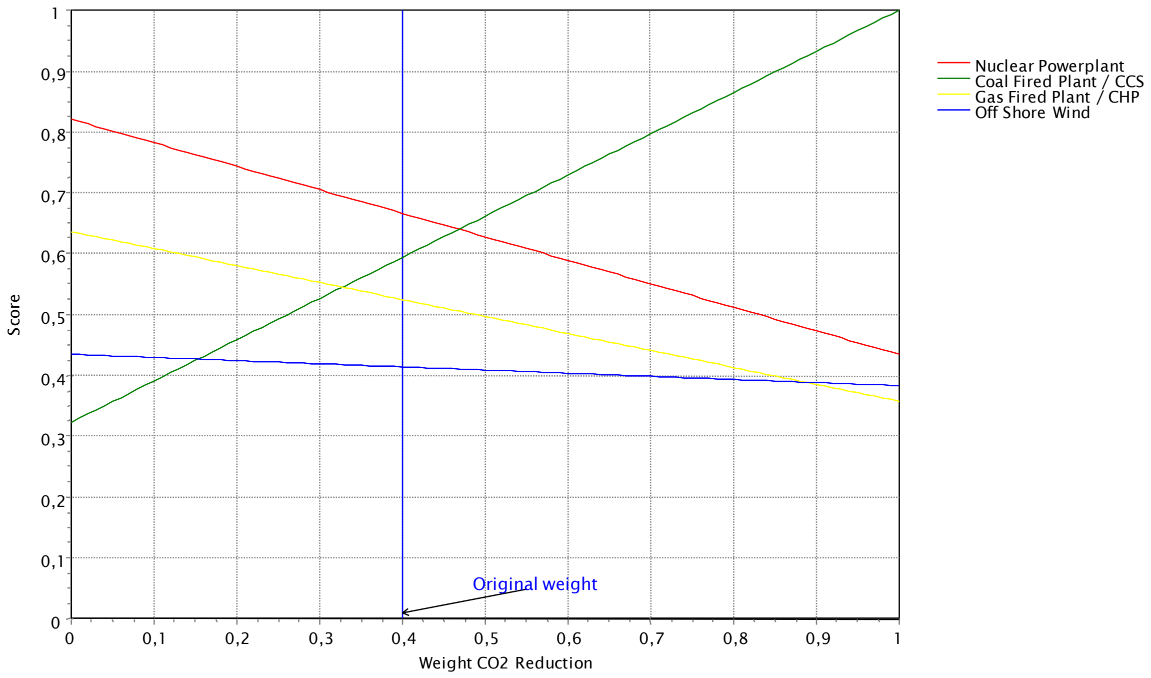

Figure 2.4 Sensitivity analysis for the weight for CO_2 emission reduction.

2.8 Synergies and trade-offs

The INDI-LINK project is interested in synergies and trade-offs (‘interlinkages’) among sustainability indicators. This study investigated some relevant indicators – criteria in MCA jargon – and it tried to discover to what extent it is possible to conclude something about these interlinkages.

From the effects table (Table 2.3) it was concluded that there seems to be a trade-off between Costs and Natural Gas Depletion and that there is a synergy between Natural gas depletion and SO_2 and PM_{10} emissions. In this case there is no clear trade-off between Costs and CO_2 emis-

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[5] In this case the possibility for society as a whole to spend €8,55 would be equivalent to reducing one ton of CO_2 emission.

sion reduction, because the Nuclear Plant, Natural gas plant / CHP and Offshore Wind have similar CO_2 emission reductions at very different costs.

A close look at the weights sensitivities (Figure 2.3 and Figure 2.4) reveals that the weights for Costs and for CO_2 emission reduction have significant impacts on the ranking. Especially the Coal Fired Plant / CCS is very sensitive for both weights, since it scores highest on both criteria. However it is difficult to conclude something about interlinkages between sustainability indicators based on these sensitivity analyses, because they refer to the specific characteristics of the options, which are determined by combinations of scores on the specific indicators.

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3. Global Vector AutoRegressive (GVAR) model

Kirsten Wiebe

3.1 Introduction

The key objectives of the renewed EU Sustainable Development Strategy (EU SDS) are environmental protection, social equity and cohesion, economic prosperity and meeting the EU's international responsibilities. One of the targets of the strategy is to "break the link between economic growth and environmental degradation" (p.3). The fact that there exist some trade-off between economic development and environment is well known. To overcome this trade-off the exact linkages between the economy and the environment have to be identified and analysed. Additionally, "social development" needs to be considered as well. Knowing the exact nature of relations between the different objectives of the EU SDS is very useful for policy-makers allowing them not to disregard social consequences of environmental policies and vice versa. It is not enough to raise awareness that trade-offs, interdependencies and possibly synergies may exist; they will also have to be identified, analyzed and, if possible, quantified.

The European Commission developed indicators to monitor the progress towards a more sustainable development in Europe. These indicators are further developed in several EU Framework Programme 6 and 7 (FP6/7) projects and are used in the FP6 project INDI-LINK (Indicator-based evaluation of interlinkages between different sustainable development objectives) to assess possible relations between sustainable development indicators (SDIs). The indicators are disaggregated into 10 themes: 1) Socio-economic development, theme 2) sustainable consumption and production, 3) social inclusion, 4) demographic changes, 5) public health, 6) climate change and energy, 7) sustainable transport, 8) natural resources, 9) global partnership and 10) good governance. So far only descriptive analyses of the development of the SDIs during the last decade exist, see for example EUROSTAT (2007). Some of the indicators developed favourably, e.g. GDP per capita, while others remain unchanged, e.g. R&D expenditure, or even developed unfavourably, e.g. greenhouse gas (GHG) emissions in the last decades. The descriptive analysis gives rise to two questions: First, can all indicators actually evolve favourably at the same time? And second, are there synergies between the indicators, i.e. is it enough to stimulate one indicator and this indicator will then track favourable developments of other indicators?

The linkages between different elements of sustainable development have not been subject to econometric investigations to a great extend yet. The subsequent analysis will identify possibly conflicting and synergetic sustainable development policy targets using a global vector autoregressive (GVAR) model. Global VAR modelling is a recent approach for macro-econometric time series modelling developed by M. Hashem Peseran and several others. The global VAR model is deduced from a set of country VAR models. First a vector autoregression model is estimated for each country. It delivers linkages or relations between different variables within a country. Second using specific weights, the coefficients of the global VAR model, which is composed of the country VAR models, can be calculated. This disaggregation is useful, since the number of coefficients that need to be estimated is significantly lower than it would be when directly estimating the global model. GVAR modelling has mainly been applied in the context of economic and financial interlinkage assessment, forecasting and impact response analysis. We first applied this method to 10 SDIs covering 5 themes of the EU SDS (socio-economic development, sustainable consumption and production, social inclusion, public health and climate change and energy). The selected SDIs were growth rate of real GDP per inhabitant, total employment rate, total R&D expenditure, resource productivity, electricity consumption by households, early school leavers, public expenditure on education, life expectancy at birth, total GHG emissions and renewables in gross inland energy consumption. The time series provided by EUROSTAT on these issues start in 1990 and are available on a yearly basis until 2004, or 2005/06/07 for some cases. Due to large data gaps in the time series provided for the new member states the analysis is conducted for the EU15 countries only. Still, the results were unsatisfactory as the model specification might have been spurious. We therefore also used data from the World Development Indicators (WDIs) online database on 5 indicators covering the same EUSDS themes. The results of this analysis are presented in this chapter.

The next section provides an overview over the global VAR method and the data used. Section 3 summarizes the empirical results. Section 4 interprets the results with respect to interlinkages between the SDIs and section 5 concludes.

3.2 The global VAR method

The global VAR modeling approach has been developed by Peseran and several others in recent years (Dées et al. 2005, Peseran et al. 2004, 2006). A global VAR model consists of a vector of different variables in different countries, z_t, as the left hand side of a vector autoregression model, and its lag, z_{t-1}, a constant and an error term on the right hand side:

$$z_t = \alpha + \mathrm{B}\, z_{t-1} + \varepsilon_t \,. \tag{1}$$

In a 3-variable 4-country example z_t could consist of economic growth in Germany, unemployment rate in Germany and GHG emissions in Germany, economic growth in France, unemployment rate in France, GHG emissions in France, economic growth in Belgium, unemployment rate in Belgium and GHG emissions in Belgium, and economic growth in Italy, unemployment rate in Italy and GHG emissions in Italy.

The advantage of the global VAR modelling approach is its applicability to rather short time series, since it does not aim at estimating all coefficients of the global VAR model at a time. Rather, one VAR model per country or region is estimated first and these models are then stacked together into the global VAR model. By this, we are able to overcome computational difficulties due to degree of freedom problems when incorporating too many variables with too few observations in one model. As soon as there are more than two variables and three countries involved, the number of coefficients to estimate becomes significantly less with this approach. Each country VAR model includes country specific domestic variables and country specific foreign variables. Country specific foreign variables are weighted averages of the respective variables in all other countries.

In the example from above, vectors z_t and z_{t-1} each consist of four (countries) times three (variables) equal twelve variables. In the method introduced above, for each country, the variables from the three other countries are aggregated into one variable, so that the estimation equation consists of only three lagged domestic variables, three contemporary foreign variables and three lagged foreign variables, making a total of nine variables, which is already significantly less than twelve variables.

Most papers apply the GVAR method to macroeconomic and financial variables such as real GDP, price level or inflation, level of short term or long term interest rate, equity prices, money supply, exchange rate and world oil price, see Pesaran et al. (2004), Dées et al. (2005), Pesaran and Smith (2006), Dées et al. (2007), Pesaran et al. (2008). Cologni and Manera (2008) use the same variables, but only estimate country VAR models without computing the global model. Their aim is to identify the short run and long run influence of the oil price on macro economic variables in Canada, France, Germany, Italy, Japan, UK and US. For that they use quarterly data from 1980Q1 to 2003Q4. As the oil price is the only common variable across countries, feedback effects of the macroeconomic variables are assumed away.

These feedback or second-round effects though are important as Dées et al. (2005) emphasize. They basically update the GVAR model by Pesaran et al. (2004) to include a longer time period (1979Q1 to 2003Q4 instead of 1999Q1), more countries (33 countries grouped into 26 regions instead of 26 countries grouped into eleven regions), additional financial market variables (long term interest rate) and feedback effects into the US economy. As discussed in Pesaran et al. (2004) it is not necessary to include the same number of domestic country specific and foreign country specific variables for all countries. While for example the exchange rate (always based on USD) is a country specific domestic variable for all countries but the US, it is a country specific foreign variable for the US, but not for the remaining countries.

The application of the GVAR model differs; while Pesaran et al. (2004) investigate the effects of various global risk scenarios on a bank's loan portfolio, Dées et al. (2005) focus on the effects of external shocks, e.g. shocks in the US, on the Euro area economy. They find that financial shocks are transmitted rather quickly through the system and are amplified along the way, while for example changes in the US monetary policy do not have a significant effect on the Euro area. Pesaran and Smith (2006) relate the GVAR representation to a classical 3 equation dynamic stochastic general equilibrium (DSGE) model, thus providing a theoretical interpretation, as the 3 equations cover inflation (new Keynesian Phillips curve), the output gap depending on the real interest rate (optimising IS curve) and the short term interest rate as a function of inflation, output gap and expected foreign inflation (Taylor rule). Pesaran et al. (2008) test the forecasting properties of the country VAR model against forecasts from random walk and random walk with drift models, and AR(1) and AR(1) with trend processes. They find that the best forecasts are given when averaging over different country VAR model specifications and different time periods, an approach they call AveAve. Forecasts considering global interactions, i.e. based on the GVAR specification, are left for future research.

3.2.1 Model theory

We will use the VARX* specification of the GVAR model as defined in Pesaran, Smith and Weiner (2004). We will look at the EU-15 countries, i.e. N, the number of countries, is equal to 15: $i = 1,\dots,15$. Due to data limitation we restrict ourselves to a VARX*(1,1), i.e. considering one lag for the country specific domestic and one lag for the country specific foreign variables. Let x_{it} be a vector of k_i domestic variables and $x*_{it}$ a vector of $k*_i$ foreign variables. The corresponding VARX* specification then is:

$$x_{it} = a_{i0} + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{i,t-1} + u_{it}. \qquad (2.1)$$

The foreign variables specific to country *i* are constructed as weighted averages of the country specific variables of the other countries:

$$x_{it}^{*} = \sum_{j=0}^{N} w_{ij} x_{jt} , \qquad (2.2)$$

where the weights correspond to some kind of trade weights of the respective countries. Trade weights might not be the best choice for weighing the influence of other countries in this case, since it seems to solely display the economic interactions between countries. We can argue though that trade does not only influence the financial and goods markets, but also display preferences (for goods), geographical distance and influence intercultural exchange. While Peseran et al. (2004) use trade integration, we decided to use trade participation ratios, because they better reflect the actual goods interchange taking place between each pair of countries. By interchanging goods, not only the monetary value of the goods but also the society's preferences are reflected. The trade participation weights are calculated using data from the OECD.stat International Trade and Balance of Payments (in US2000$) as:

$$w_{ij} = \frac{(M_{ij} + X_{ij})}{\sum_{k=1}^{N} (M_{ik} + X_{ik})} , \qquad (2.3)$$

where M_{ij} and X_{ij} are import and export averages of country *i* with country *j* between 2000 and 2004. The ratio reflects how much a country traded with each of its partners compared to the other partners. The trade weights are displayed in Table 1.

Table 3.1 Trade weights w_{ij}

country	AT	BE	DK	FI	FR	DE	GR	IE	IT	LU	NL	PT	ES	SE	UK
Austria	0.000	0.030	0.010	0.012	0.067	0.586	0.006	0.012	0.124	0.003	0.041	0.007	0.032	0.019	0.054
Belgium	0.012	0.018	0.009	0.008	0.208	0.250	0.005	0.039	0.063	0.018	0.196	0.010	0.040	0.025	0.117
Denmark	0.016	0.040	0.000	0.042	0.075	0.302	0.008	0.021	0.055	0.003	0.088	0.009	0.033	0.188	0.124
Finland	0.020	0.048	0.057	0.000	0.081	0.245	0.010	0.015	0.068	0.002	0.079	0.010	0.040	0.190	0.137
France	0.016	0.124	0.013	0.010	0.009	0.260	0.008	0.023	0.147	0.008	0.071	0.020	0.139	0.023	0.138
Germany	0.089	0.102	0.030	0.020	0.190	0.000	0.011	0.028	0.130	0.008	0.129	0.018	0.075	0.037	0.140
Greece	0.017	0.061	0.018	0.020	0.112	0.245	0.000	0.014	0.225	0.004	0.092	0.007	0.068	0.026	0.096
Ireland	0.006	0.122	0.015	0.009	0.092	0.133	0.004	0.006	0.057	0.001	0.071	0.006	0.036	0.021	0.423
Italy	0.044	0.069	0.013	0.011	0.213	0.289	0.024	0.018	0.000	0.005	0.074	0.016	0.101	0.021	0.107
Luxembourg	0.014	0.290	0.005	0.004	0.192	0.294	0.002	0.006	0.044	0.000	0.057	0.004	0.024	0.009	0.054
Netherlands	0.016	0.166	0.018	0.016	0.123	0.328	0.008	0.022	0.068	0.004	0.000	0.010	0.046	0.032	0.146
Portugal	0.009	0.049	0.010	0.007	0.145	0.194	0.004	0.008	0.074	0.002	0.057	0.000	0.334	0.017	0.092
Spain	0.014	0.048	0.011	0.009	0.264	0.213	0.009	0.016	0.138	0.002	0.056	0.089	0.000	0.018	0.115
Sweden	0.018	0.073	0.123	0.095	0.089	0.233	0.007	0.018	0.059	0.002	0.098	0.009	0.038	0.000	0.140
United Kingdom	0.014	0.097	0.022	0.018	0.164	0.229	0.008	0.102	0.084	0.003	0.127	0.014	0.070	0.038	0.013

The weights w_{ij} should be as small as possible to ensure weak exogeneity of the foreign variables. Weak exogeneity of the foreign variables is necessary for the individual estimation of the country specific model. Weak exogeneity of these variables means that the country we look at in the country model does not dominate all other countries, i.e. developments within the country do not influence developments in the other countries to a great extend and therefore do not change the country specific foreign variables. Further w_{ij} is taken as constant over time. Peseran et al. (2004) did test the robustness of this assumption by using a $w_{ij,t}$ that differed for all t, and a three year rolling window of the weights. They found that the model specification is robust to these alterations.

The global VAR model can be calculated from the country VAR models using the linking matrices consisting of the weights calculated from the trade shares. First all country specific domestic variables x_{it} are stacked into one vector with the country specific foreign variables x_{it}^{*} : $z_{it} = \begin{pmatrix} x_{it} \\ x_{it}^{*} \end{pmatrix}$. The new equation corresponding to (2.1) is:

$$A_i z_{it} = a_{i0} + B_i z_{i,t-1} + \varepsilon_{it}, \qquad (3.1)$$

where the matrices $A_i = (I, -\Lambda_{i0})$ and $B_i = (\Phi_i, -\Lambda_{i1})$ are of size $k_i \times (k_i + k_i^*)$ and A_i is of full column rank. This can easily be proven considering that the first k_i columns of A are the identity matrix and therefore span the column space. Since vector x_{it}^{*} has been constructed from $x_{jt}, j \neq i$, for the regression using the weights calculated above, we can construct the vector z_t from vectors z_{it}, $z_t' = (x_{1t} \quad x_{2t} \quad . \quad . \quad . \quad x_{nt})$, so that:

$$A_i W_i z_t = a_{i0} + B_i W_i z_{t-1} + \varepsilon_{it}. \qquad (4.1)$$

The link matrices, W_i, are constructed from the trade weights and are of size $(k_i + k_i^*) \times k$, with $(k_i + k_i^*) = 2k_i$ and $k = N*K_i$ in this case. The columns of the matrix correspond to all country specific domestic variables, while the first k_i rows correspond to the country specific domestic variables and rows k_i+1 to $2k_i$ correspond to the country specific foreign variables of country *i*. Then, all entries of the first k_i rows of the matrix are zero but those on the diagonal corresponding to the sub-matrix of country specific domestic variables of country *i*. The remaining rows of W_i also have non-zero entries on the diagonals of the sub-matrices. These diagonals have entries w_{ij}, where *i* and *j* correspond to the countries of the sub-matrix, i.e. *i* is the country to which W_i belongs and *j* is the country to which the sub-matrix corresponds. An example for the W_i 's for three countries and five variables is:

W_1:

$$\begin{pmatrix}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&1&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&w_{1,2}&0&0&0&0&w_{1,3}&0&0&0&0\\
0&0&0&0&0&0&w_{1,2}&0&0&0&0&w_{1,3}&0&0&0\\
0&0&0&0&0&0&0&w_{1,2}&0&0&0&0&w_{1,3}&0&0\\
0&0&0&0&0&0&0&0&w_{1,2}&0&0&0&0&w_{1,3}&0\\
0&0&0&0&0&0&0&0&0&w_{1,2}&0&0&0&0&w_{1,3}
\end{pmatrix}$$

W_2:

$$\begin{pmatrix}
0&0&0&0&0&1&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&1&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&1&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&1&0&0&0&0&0\\
w_{2,1}&0&0&0&0&0&0&0&0&0&w_{2,3}&0&0&0&0\\
0&w_{2,1}&0&0&0&0&0&0&0&0&0&w_{2,3}&0&0&0\\
0&0&w_{2,1}&0&0&0&0&0&0&0&0&0&w_{2,3}&0&0\\
0&0&0&w_{2,1}&0&0&0&0&0&0&0&0&0&w_{2,3}&0\\
0&0&0&0&w_{2,1}&0&0&0&0&0&0&0&0&0&w_{2,3}
\end{pmatrix}$$

W_3:

$$\begin{pmatrix}
0&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&1&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&1&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\
w_{3,1}&0&0&0&0&w_{3,2}&0&0&0&0&0&0&0&0&0\\
0&w_{3,1}&0&0&0&0&w_{3,2}&0&0&0&0&0&0&0&0\\
0&0&w_{3,1}&0&0&0&0&w_{3,2}&0&0&0&0&0&0&0\\
0&0&0&w_{3,1}&0&0&0&0&w_{3,2}&0&0&0&0&0&0\\
0&0&0&0&w_{3,1}&0&0&0&0&w_{3,2}&0&0&0&0&0
\end{pmatrix}$$

Now, assume $G_i = A_i W_i$ and $H_i = B_i W_i$ with

$$G=\begin{pmatrix}G_1\\G_2\\\vdots\\G_N\end{pmatrix}, H=\begin{pmatrix}H_1\\H_2\\\vdots\\H_N\end{pmatrix},\ \varepsilon_t=\begin{pmatrix}\varepsilon_{0t}\\\varepsilon_{1t}\\\vdots\\\varepsilon_{Nt}\end{pmatrix},\ a_0=\begin{pmatrix}a_1\\a_2\\\vdots\\a_N\end{pmatrix},$$

then the global representation is equation

$$Gz_t = a_0 + Hz_{t-1} + \varepsilon_t. \qquad (5.1)$$

If matrix G is invertible, i.e. if its columns are linearly independent, we can obtain the global VAR model:

$$z_t = G^{-1}a_0 + G^{-1}Hz_{t-1} + \varepsilon_t. \qquad (5.2)$$

This can be solved forward recursively to obtain future values of z(t).

3.2.2 Data

The analysis was conducted twice; first using EUROSTAT data and then using data from the UN World Development Indicators (WDIs). The results presented in this paper are those using WDI data, since it was available for a longer time period (1980 – 2005), whereas the EUROSTAT data was only available for the years between 1992 and 2004. The indicators selected for this analysis are gross domestic product (GDP) per capita (Theme 1), carbon dioxide (CO2) emissions per capita (Theme 6), energy use per capita (Theme 2), life expectancy at birth (Theme 5) and the unemployment rate (Theme 3). These indicators cover the 3 pillars of sustainable development: economic (GDP per capita, unemployment rate), social (life expectancy, unemployment rate), and environmental (CO2 emissions per capita, energy use per capita). This is important, since the aim of WP 2 of the INDI-LINK project is to identify interlinkages between these 3 pillars. The indicators chosen are all measured on country levels (macro-level data). They further correspond to 5 out of the 10 themes of sustainable development, though they are not directly represented in the EUROSTAT SDI list as they are taken from the WDI data base. All indicators are available for all EU15 countries for the years between 1980 and 2005. Only CO2 emissions per capita are not available for the last year (2005) in any country.

A note on notation in text and tables: GDP per capita is the variable GDPC(t), with index t being the year, and correspondingly (t-1) being the year before; CO2 emissions per capita are abbreviated by CO2E, energy use per capita by EUPC, life expectancy at birth by LIFE and the unemployment rate by UNEM.

After taking logarithms of the data, all time series were tested for unit roots using the Kwaitowski, Phillips, Schmidt and Shin (KPSS) test. All data series seem to be I(1), i.e. have one unit root. We will therefore use first differences of the I(1) variables for the estimation. Test results from the Augmented Dickey-Fuller (ADF) test and the Elliot-Rothenberg-Stock (ERS) test do not contradict the results from the KPSS test. The detailed results of the tests are available from the author upon request.

We further need data on trade between the EU15 countries. This data was extracted from the OECD.stat International Trade and Balance of Payments (in US2000$).

Table 3.2: Descriptive statistics

	Mean	Std. Dev.	Years	Countries	# Obs.
GDPC	25471.986	4534.299	1980 - 2005	15	390
CO2E	9.233	0.356	1980 - 2004	15	375
EUPC	4114.181	326.260	1980 - 2005	15	390
LIFE	76.543	1.522	1980 - 2005	15	390
UNEM	8.148	1.218	1980 - 2005	15	390

3.3 Assessment of future interlinkages

3.3.1 Country models

For each country we estimated the VARX*(1,1) specification including lagged domestic variables, contemporary foreign variables and lagged foreign variables. Note that we use log-differences of all variables. Pesaran et al. (2004) estimate the vector error correction form specification and then calculate the VAR coefficients from there. Since we are uncertain with regard to the true number of cointegrating relations, we follow the suggestion of Pesaran et al. (2008) and set this number equal to zero for all country models. Hence, we estimate the GVAR model in first differences and set the maximum number of lags to be included to one. In style of Pesaran et al. (2008) we neither restrict the intercept nor include a trend in the country models. (The main motivation for this in our case is to keep the number of coefficients to be estimated as low as possible in order to not reduce the degrees of freedom to zero.) The residuals of the estimation are tested for normality with the Jarque-Bera test statistic. Further, we use the Ljung-Box test to test for autocorrelation in the residuals because of its small sample properties. The test results are displayed in Table A2 in the appendix, together with the estimation results. Most error terms are normally distributed and not autocorrelated.

Note that we did not test for Granger causality so that the relations found in the regressions below might not necessarily reflect cause-effect relationships. Neither did we explicitly test for weak exogeneity. We assume though that given the large number of countries (15), no country has a dominant influence on all other countries.

The regression results are mixed. While those for GDP per capita are rather good with adjusted R-squared greater than 0.75 for all but one country, the regressions for CO2 emissions per capita, energy use per capita and the unemployment rate have lower measures of fit (<0.8). The adjusted R-squared of life expectancy at birth is between 0.38 for Denmark and 0.89 for Spain. As we are interested not only in finding the best explanatory variables for the 5 indicators, but mainly in the relations between the indicators, low adjusted R-squared are not a problem at this stage of the analysis. Given the large number of regression equations, we will only have a closer look at one country, Germany. Estimation results and graphs are displayed in Table 3 and Figure 1, respectively: *** corresponds to a p-value of 0.00, ** to a p-value of 0.01, * to 0.05 and * to 0.1.

Table 3.3: Country model regressions: Germany

Germany	Δln(GDPC(t))		Δln(CO2E(t))		Δln(EUPC(t))		Δln(LIFE(t))		Δln(UNEM(t))	
		restricted		restricted		restricted		restricted		restricted
mR2	0.972	0.787	0.852	0.816	0.864	0.770	0.930	0.791	0.888	0.796
adjR2	0.909	0.725	0.513	0.761	0.554	0.703	0.771	0.729	0.632	0.736
Ljung-Box	1.970	5.247	3.294	2.900	0.092	0.215	0.497	0.497	2.625	1.012
p-value	0.001	0.022	0.110	0.089	0.087	0.643	0.012	0.012	0.051	0.314
Δln(GDPC(t-1	1.623 **	1.162 **	-1.494	-1.485	-0.696	-0.926	0.068	0.068	-1.274	-0.025
Δln(CO2E(t-1	0.346 *	0.363 *	-1.209 *	-1.212 **	-0.349	-0.273	-0.012	-0.012	-0.667	
Δln(EUPC(t-1	-0.159	-0.411 .	2.583 *	2.579 **	0.747	0.488	0.022	0.022	1.542	
Δln(LIFE(t-1))	-1.282	-1.963 .	-0.372	-0.338	-0.473	-1.543	-0.981 *	-0.981 *	-5.848	-2.478
Δln(UNEM(t-1	0.043	-0.008	-0.087	-0.084	-0.029	-0.031	0.020	0.020	-0.111	0.130
coefficient	-0.014	0.00	-0.01	-0.02	-0.01	0.003	0.00	0.00	0.116	0.00
Δln(GDPCf(t)	2.026 ***	1.616 **	-2.032 .	-1.993 *	-1.073	-1.220 .	0.056	0.056	-4.436	
Δln(CO2Ef(t))	-0.091		-0.318	-0.317	-0.397	-0.452 .	-0.101 *	-0.101 *	-0.691	
Δln(EUPCf(t))	0.281	0.062	0.652	0.669	1.206 *	1.248 *	0.127 .	0.127 .	-0.079	
Δln(LIFEf(t))	1.968	-0.359	9.134	9.340 .	3.301		-0.104	-0.104	8.200	10.923
Δln(UNEMf(t)	0.047	0.026	-0.180	-0.174	-0.136	-0.166	-0.003	-0.003	0.729	1.188 *
Δln(GDPCf(t-	-1.545 *	-1.110	2.721	2.704	0.960	0.995	-0.021	-0.021	1.336	-0.756
Δln(CO2Ef(t-1	0.307		0.434	0.444	-0.053	-0.248	-0.045	-0.045	-0.145	0.342
Δln(EUPCf(t-	-0.949 .	-0.146	-2.040	-2.050	-0.281	0.287	0.041	0.041	-0.283	-0.303
Δln(LIFEf(t-1)	0.807		-0.386		1.426	0.664	0.201	0.201	2.744	10.832
Δln(UNEMf(t-	-0.085		0.268	0.260	0.131	0.149	-0.020	-0.020	-0.021	-0.469

To test the robustness of the estimation, we restricted some coefficients in all country models. The coefficients to restrict to zero were chosen on the basis of their significance in the full estimation: Those variables that were not significant at the 10% level in any country, are restricted to zero. These were CO2Ef(t), CO2Ef(t-1), LIFEf(t-1), UNEMf(t-1) in the GDP per capita estimation, LIFEf(t-1) in the per capita CO2-emissions equation, LIFEf(t) in the per capita energy use estimation, none for the life expectancy estimation and CO2E(t-1), EUPC(t-1), GDPCf(t), CO2Ef(t) and EUPCf(t) in the unemployment rate estimation. The changes in the coefficients are surprisingly small, compare Table 3. In an earlier run with EUROSTAT data, the changes were considerable. Together with the fact that most adjusted R-squared were more than 0.8 and only very few variables were significant, we concluded the presence of multicollinearity, i.e. a joint significance of all variables. As this is not the case here, we can use both, the original and the results from the restricted estimation to continue with the global VAR analysis. The results of this restricted estimation are shown in Table 3 and Figure 1, having Germany as an example.

3.3.2 Global model

The global model is calculated by stacking all country specific domestic variables into one global vector and using the weight matrices applied in the calculation of the country specific foreign variables to compute the global coefficient matrices, assuming weak exogeneity of the country specific foreign variables. The global model is a system of equations having the country specific domestic variables as dependent variables and their lags as independent variables, see equations (5.1) and (5.2). Following the calculations described in section 4.1, we can calculate matrix matrix $G^{-1}H$ and vector $G^{-1}a_0$. Table 3.4 shows rows 26 to 30 of $G^{-1}H$ corresponding to Germany. Each row corresponds to one of the variables for Germany, each column to the lag of the variable in the respective country. The complete matrix is displayed in Appendix A3.

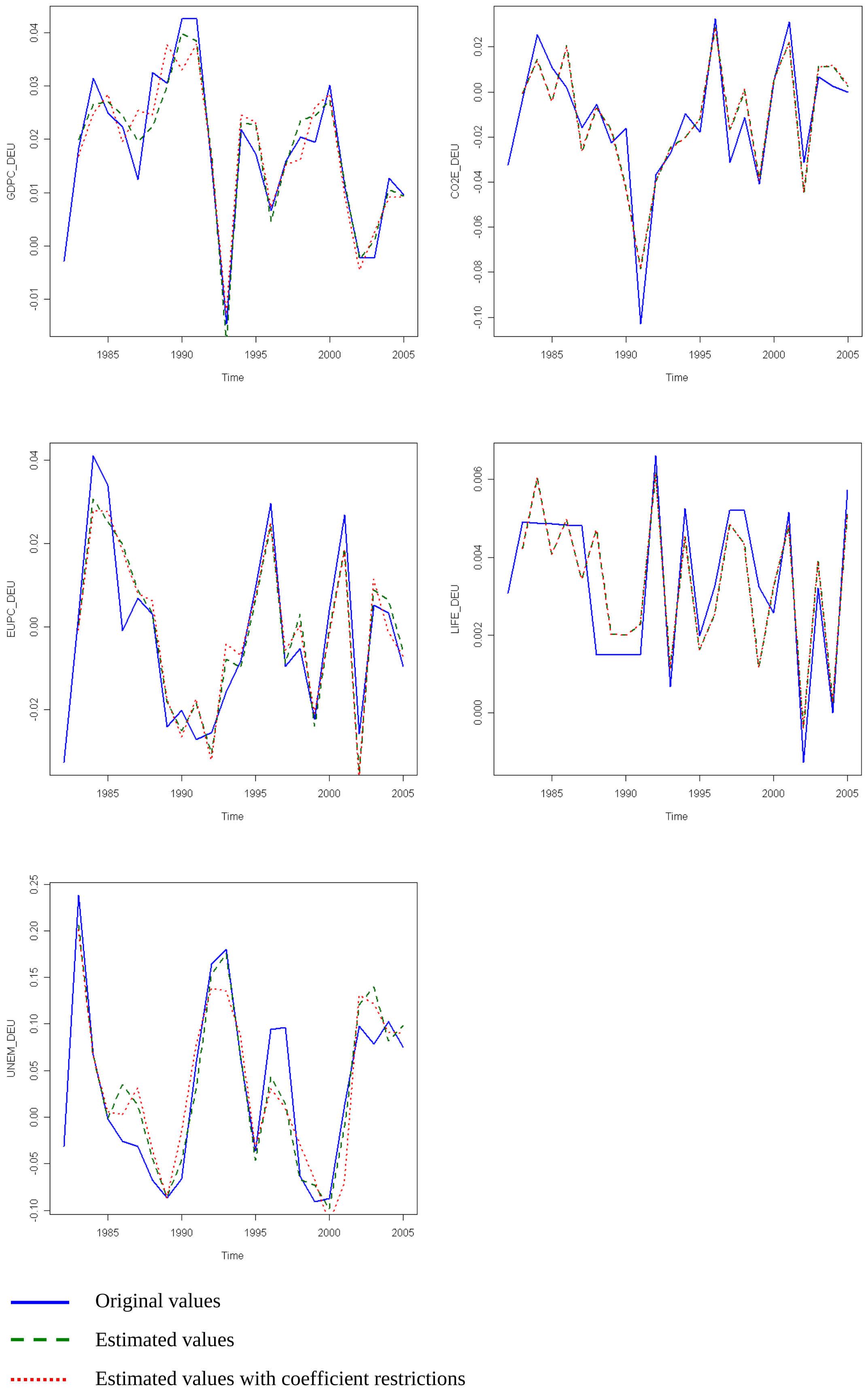

Figure 3.1 Country model regressions for Germany.

Table 3.4 Rows 26 to 30 (corresponding to Germany) of $G^{-1}H$

		AT					**BE**					**DK**				
		GDPC	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*
DE	26 *GDPC*	-0.0926	-0.0030	-0.0164	0.0731	0.0003	-0.2365	-0.0020	-0.0118	0.4362	0.0008	-0.0204	-0.0005	-0.0029	0.0356	0.0001
	27 *CO2E*	0.0187	0.0053	0.0355	0.0687	0.0000	-0.0662	-0.0022	0.0117	0.2494	-0.0020	-0.0047	0.0003	0.0035	0.0157	-0.0001
	28 *EUPC*	0.0121	-0.0005	0.0061	-0.1498	0.0001	0.0009	0.0001	0.0079	-0.5629	-0.0007	-0.0003	0.0000	0.0009	-0.0345	0.0000
	29 *LIFE*	-0.0001	0.0000	0.0000	0.0008	0.0000	-0.0003	0.0000	-0.0001	0.0041	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000
	30 *UNEM*	0.2053	0.0132	0.0578	-0.3391	0.0004	0.5646	0.0062	0.0470	-1.4738	0.0005	0.0467	0.0015	0.0082	-0.1074	0.0000
		FI					**FR**					**DE**				
		GDPC	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*
DE	26 *GDPC*	-0.0102	-0.0002	-0.0012	0.0169	0.0000	-0.6534	-0.0109	-0.0790	1.0211	0.0036	-3.4749	-0.0959	-0.0210	16.2397	0.0100
	27 *CO2E*	-0.0040	0.0001	0.0013	0.0079	-0.0001	0.1138	0.0205	0.1546	0.6204	-0.0016	-1.0332	-1.7323	-0.5267	-4.9272	-0.0162
	28 *EUPC*	-0.0007	0.0000	0.0004	-0.0155	0.0000	0.0543	-0.0015	0.0297	-1.2953	-0.0003	-0.1495	-0.1132	0.9706	-3.7097	-0.0041
	29 *LIFE*	0.0000	0.0000	0.0000	0.0002	0.0000	-0.0008	-0.0001	-0.0001	0.0115	0.0001	-0.0153	0.0000	0.0007	-0.5203	0.0006
	30 *UNEM*	0.0250	0.0005	0.0034	-0.0515	0.0000	1.4497	0.0641	0.3274	-3.5281	-0.0011	-9.7287	-0.6070	-0.1089	-3.2436	-0.1088
		GR					**IE**					**IT**				
		GDPC	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*
DE	26 *GDPC*	-0.0025	0.0000	-0.0002	0.0037	0.0000	-0.0150	-0.0006	-0.0032	0.0229	0.0002	-0.3337	-0.0015	-0.0202	0.5218	0.0012
	27 *CO2E*	-0.0001	0.0000	0.0003	0.0024	0.0000	0.0005	0.0008	0.0047	0.0220	-0.0002	-0.0001	0.0076	0.0614	0.2942	-0.0020
	28 *EUPC*	0.0002	0.0000	0.0001	-0.0053	0.0000	0.0007	0.0000	0.0010	-0.0455	-0.0001	0.0210	-0.0007	0.0152	-0.6050	-0.0007
	29 *LIFE*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	-0.0004	-0.0001	-0.0001	0.0063	0.0000
	30 *UNEM*	0.0061	0.0001	0.0008	-0.0138	0.0000	0.0361	0.0025	0.0114	-0.1037	-0.0001	0.7391	0.0178	0.0992	-1.7913	0.0009
		LU					**NL**					**PT**				
		GDPC	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*
DE	26 *GDPC*	-0.0014	0.0000	-0.0002	0.0020	0.0000	-0.2866	-0.0102	-0.0529	0.3494	0.0017	-0.0080	0.0002	0.0005	0.0198	0.0000
	27 *CO2E*	0.0001	0.0000	0.0004	0.0011	0.0000	0.0720	0.0180	0.1181	0.2442	-0.0007	0.0014	0.0000	-0.0004	0.0079	0.0000
	28 *EUPC*	0.0001	0.0000	0.0001	-0.0023	0.0000	0.0345	-0.0015	0.0209	-0.5111	-0.0002	0.0005	0.0000	0.0000	-0.0143	0.0000
	29 *LIFE*	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000	0.0043	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000
	30 *UNEM*	0.0030	0.0001	0.0007	-0.0067	0.0000	0.6151	0.0453	0.1979	-1.3362	-0.0005	0.0176	-0.0001	0.0001	-0.0559	0.0000
		ES					**SE**					**UK**				
		GDPC	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*	*GDPC*	*CO2E*	*EUPC*	*LIFE*	*UNEM*
DE	26 *GDPC*	-0.1473	-0.0024	-0.0111	0.1670	0.0006	-0.0287	0.0000	-0.0013	0.0300	0.0002	-0.3992	-0.0069	-0.0241	0.8684	0.0017
	27 *CO2E*	-0.0174	0.0019	0.0113	0.1202	-0.0008	-0.0005	0.0011	0.0090	0.0309	-0.0002	-0.0151	0.0025	0.0755	0.3853	-0.0019
	28 *EUPC*	0.0035	-0.0001	0.0040	-0.2567	-0.0003	0.0048	-0.0001	0.0022	-0.0711	0.0000	0.0339	-0.0007	0.0211	-0.8923	-0.0006
	29 *LIFE*	-0.0002	0.0000	0.0000	0.0015	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	-0.0005	0.0000	-0.0002	0.0101	0.0000
	30 *UNEM*	0.3358	0.0097	0.0369	-0.6308	-0.0001	0.0693	0.0019	0.0106	-0.1470	-0.0001	0.8948	0.0239	0.1186	-2.6115	0.0001

3.4 Reflection on future interlinkages

The interlinkages in the GVAR (global VAR) model are obtained through three separate but interrelated channels:

1. direct dependence of x_{it} on x_{it}^{*} and its lags;
2. dependence of x_{it} on common global exogenous variables d_t;
3. cross-country covariances $\Sigma_{ij} = Cov(\varepsilon_{it}, \varepsilon_{jt}) = E(\varepsilon_{it}\varepsilon_{jt}{}')$, where the elements of Σ_{ij} are $\sigma_{ij,ls} = Cov(\varepsilon_{ilt}, \varepsilon_{jst})$, that is the covariance of the l^{th} variable of country i with the s^{th} variable of country j.

The first channel, direct dependence of x_{it} on x_{it}^{*} and its lags, corresponds to an interpretation of the coefficients in the country models. This allows us to consider significant coefficients only:

GDPC: There is a positive relation of GDP per capita and its domestic lag, the lag of domestic CO2 emissions, and domestic unemployment rate in all countries in which the coefficient is significantly different fro zero. The significant coefficients of domestic energy use per capita are both, positive and negative, while those of domestic life expectancy at birth are negative. Contemporaneous foreign CO2 emissions are not significant; GDP per capita and energy use per capita have significant positive coefficients and life expectancy at birth and unemployment rate significant negative coefficients. Lagged foreign GDP per capita has negative significant coefficients and the significant coefficients of energy use per capita vary in sign.

CO2E: The coefficients of lagged domestic GDP per capita, life expectancy and unemployment rate, contemporaneous foreign GDP per capita, CO2 emissions and lagged foreign energy use per capita are positive if significant, those of lagged domestic CO2 emissions and contemporaneous foreign life expectancy are negative, and the signs of those of lagged domestic energy use per capita, contemporaneous foreign energy use per capita as well as unemployment rate, and lagged foreign GDP per capita, CO2 emissions per capita and unemployment vary in signs.

EUPC: Per capita energy use seems to be positively influenced by lagged domestic GDP per capita and negatively by per capita CO2 emissions, itself and unemployment. The influence of domestic life expectancy is mixed across countries, as is the influence of all foreign variables with the exception of lagged foreign energy use per capita, which has positive coefficients in all countries where it is significant.

LIFE: The signs of the coefficients in the estimation of life expectancy at birth only vary across countries for 3 variables: foreign contemporary GDPC, CO2E and EUPC. The coefficient is positive for lagged domestic variables GDPC and CO2E, contemporaneous foreign LIFE and UNEM, and lagged foreign, CO2E, LIFE and UNEM. The coefficients of the remaining variables are all negative if significant for at least one country.

UNEM: The estimation of the unemployment rate has fewest significant coefficients. It seems to be positively influenced by lagged domestic LIFE and UNEM, contemporaneous foreign UNEM, and lagged foreign GDPC and UNEM; negatively influenced by lagged domestic GDPC, and contemporaneous and lagged foreign LIFE; positively and negatively influenced by lagged foreign CO2E and EUPC. The coefficients of the remaining variables were not significant in any country.

With regard to cross-country interlinkages we have a positive linkage between domestic and foreign GDPC as well as between domestic and foreign CO2E and domestic and foreign EUPC for most countries. We can further identify the following indicator interlinkages for several countries: a positive influence of domestic and foreign energy use per capita on CO2 emissions per capita, a positive influence of GDP per capita on energy use per capita and on life expectancy at birth, as well as a negative influence on the unemployment rate, i.e. as GDPC increases, the unemployment rate decreases, which actually is a positive development or synergy. Further, increases in energy use per capita seem to decrease life expectancy. That means that lowering energy use, which is favorable from a sustainable development perspective as it decreases CO2 emissions, increases life expectancy, leaving us with an indirect synergy between the latter two indicators. Increasing CO2 emissions seem to have a negative influence on energy use per capita, which could already indicate some progress with regard to environmental awareness of the population in the EU15 countries.

The second channel, dependence of x_{it} on common global exogenous variables d_t, is not available here since we did not use common global exogenous variables, such as the oil price. The third channel on the other hand is available.

These interrelations link the 3 pillars of sustainable development, as well as different themes of sustainable development, defined by EUROSTAT (2008). As all 5 variables are part of direct interlinkages, so that there are indirect interlinkages between all 5 themes considered here: 1) Socio-economic development, theme 2) sustainable consumption and production, 3) social inclusion, 5) public health, 6) climate change and energy. The scope of interlinkages covered here is inter and intra pillar as well as between the key challenges of the EU SDS. The interlinkages are “strong” interlinkages, as they can be quantified, though the exact scope differs between the different countries.

3.5 Conclusions and outlook

The project partners of INDI-LINK selected this method as one of 4 methods for the assessment of interlinkages between sustainable development indicators. It is important to note that the presented method for assessing interlinkages is very interesting, but not fully exploited in this paper yet. The next steps in this analysis would therefore be to apply forecasting and impulse response analysis, as “the VAR in differences is a relatively robust forecasting device …” (Wallis, 2004). Though, at this stage the rather low fit of some regressions might cause problems.

Some interlinkages between the SDIs could be identified, though most of these are not too surprising. If data of other SDIs are available for a comparably long period of time, this method can be used to assess interlinkages between them. Further, it is easily extendable to include more countries. A pinch of salt in this analysis is that we are using annual and not quarterly data, as generally the VAR method is more applicable to and more reliable for short run changes and forecasts up to at most 3 quarters. Ratto et al. (2005), for example, compare forecasts from DSGE and VAR respectively the corresponding vector error correction model. The latter outperforms the former for 1 period forecasts, while they are equally applicable for 4 quarter forecasts.

The data on sustainable development indicators provided by EUROSTAT are not sufficient for a thorough analysis with the GVAR method. Hence, we applied this method using data from the World Development Indicators of the UN on GDP per capita, CO2 emissions per capita, energy consumption per capita, life expectancy and the unemployment rate. The above analysis was able to estimate country models for the EU15 countries and calculate the global representation from these models. We could identify interlinkages between and within the pillars of sustainable development and between key priorities of the EU SDS. Global VAR models can therefore provide interesting insights into the short and, if sufficient data is available, long run interactions (interlinkages) between sustainable development indicators.

To identify long run relations the model has to be estimated in its vector error correction form. Further, the GVAR approach “provides a theoretically coherent framework for modeling the global interactions” (Pesaran and Smith, 2008). The work reviewed in section 4 applies generalized impulse response functions to analyze the effect of a shock on exchange rates or the world oil price. The natural way to extend the analysis in this paper is to use impulse response analysis to analyze the effects of climate change policies, e.g. a restriction of CO2 emissions or an increase in energy prices and the subsequent reduction of energy use per capita.

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4. GINFORS

4.1 Introduction

In task 2.3.2, extrapolations and modelling of future interlinkages, of the INDI-LINK project we apply the economy-energy-environment model GINFORS, to analyse possible interlinkages between sustainable development indicators (SDIs). GINFORS is based on international statistics providing a base for analyzing interlinkages of SDIs in national, EU and global context. A detailed description of GINFORS is given in Section 4.2. Different SDIs with a focus on the economic and environmental pillar are explicitly modelled. Some social aspects that are related to the economic sphere such as unemployment or general government gross debt are also explained. Section 4.2.3 summarizes which SDIs are included in GINFORS and Section 4.2.4 shows how they are included. Section 4.3 explains how GINFORS is used to assess the interlinkages between SDIs. In a first step, the future development of the SDIs is projected. Due to the full interdependency of the system, variations in exogenous variables such as policy instruments in model simulations deliver a consistent picture of the changes in the different SDIs. A scenario analysis considering a unilateral reduction of GHG emissions of 20% within the EU is conducted. Comparing results of this “climate-protection” scenario with a reference scenario allows us to identify possible synergies and trade-offs in the indicators affected by such a policy.

4.2 The GINFORS Model

4.2.1 General description of the model

Introduction

The model GINFORS (**G**lobal **IN**terindustry **FOR**ecasting **S**ystem) has been developed to allow for a global analysis of the economic-environmental interdependencies as a tool for concrete policy planning (Lutz et al. 2009). GINFORS is an economy-energy-environment model with global coverage. All EU-25 countries, all OECD countries and their major trade partners are explicitly modelled. The model is based on time series of international statistics data from 1980 to 2004. Behavioural parameters are derived from econometric estimations assuming bounded rationality of agents with myopic foresight. Due to the large number of equations, the simple and robust OLS estimation method is applied. The model ensures global consistency. For instance, energy use anywhere in the world is only possible after extraction of some energy carriers. Imports of one country are exports of another. The whole system is consistently linked and simultaneously solved at the global level.

GINFORS is a multi-sector, multi-country macro-econometric model with global coverage that can be used for economic-environmental policy analysis (Lutz et al. 2009, Meyer et al. 2007). It has been used for policy simulations for example in the FP 5 MOSUS project (Giljum et al. 2008), a post-2012 project for the German Federal Ministry of Economics and Technology (GWS/Prognos 2007, Lutz et al. 2008), highlighting economic impacts of high energy prices

(Lutz and Meyer 2008) and is currently applied in the AGF petrE project[6] and for the European Environmental Agency to analyse Environmental Tax Reforms in Europe.

According to Van den Bergh and Janssen (2004) it is an integrated system that adds economics to industrial ecology and thus favours policy realism. The model combines econometric-statistical analysis with input-output analysis embedded in a complete macroeconomic framework. The link between the economic developments in the different countries is given by international trade, which is determined by global competition in deep sector disaggregation.

The parameters of GINFORS are estimated econometrically using international time series data sets from the OECD, the IEA and the IMF. Only in a few cases it is necessary to use national data, e.g. some national accounts and sector data of China.

GINFORS is based on experiences made with the development of the global energy-economy-environment model COMPASS (Meyer, Lutz 2002a, Meyer, Lutz 2002b, Meyer, Uno 1999). GINFORS can be seen as an improved version of COMPASS using more comprehensive data, enhanced software, a different regional emphasis and an additional focus on material consumption. For the relation between GINFORS and COMPASS see Meyer et al. (2005).

Overview

GINFORS explicitly covers about 95% of World GDP as well as 95% of global CO_2 emission by modelling 50 countries and one region (OPEC). Figure 4.1 shows the country coverage of GINFORS.

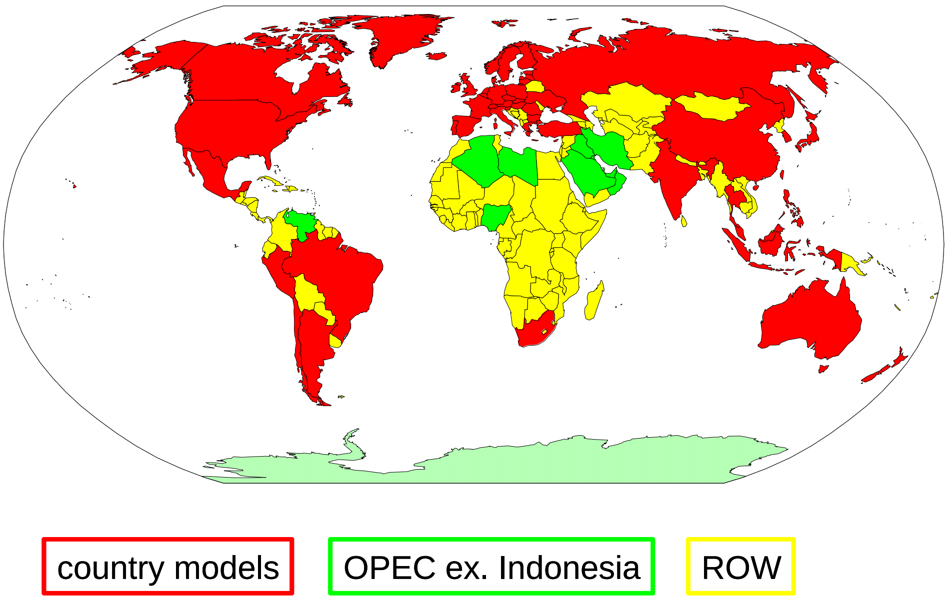

Figure 4.1 Country Coverage of GINFORS.

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[6] http://www.petre.org.uk

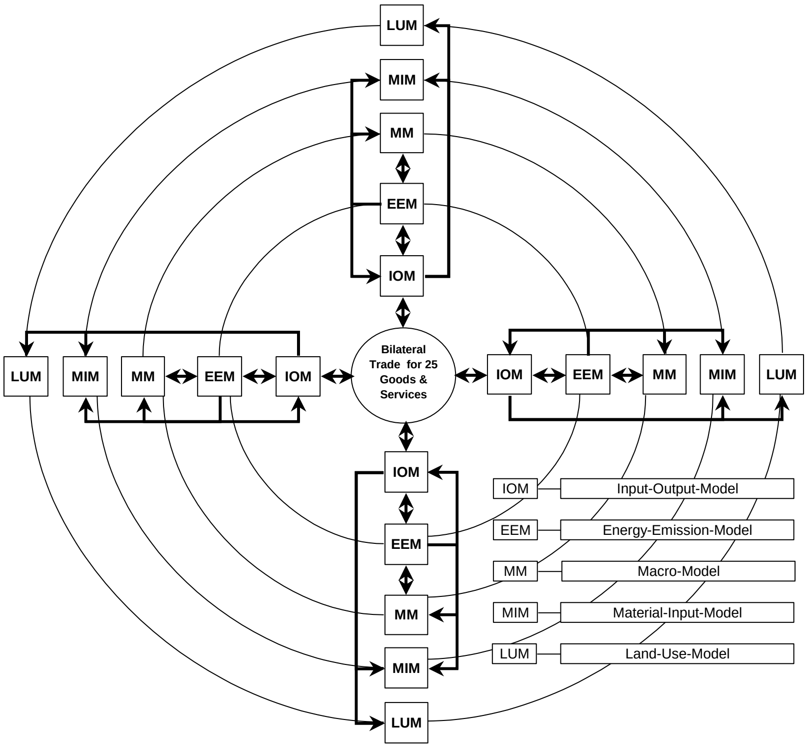

Figure 4.2 The Wheel of GINFORS.

Table 4.1 Global Coverage: Gross national income (GNI) and emissions.

		GNI 2004 (Atlas method, World bank) Bio. US $	%	Sum	CO_2 Emissions 2004 (IEA) without bunkers Mill. tonnes	%	Sum
1	🟦 United States	12150	30,50	30,50	5800	22,60	22,60
2	🟦 Japan	4749	11,92	42,42	1215	4,73	27,34
3	🟦 Germany	2488	6,25	48,67	848	3,30	30,64
4	🟦 United Kingdom	2016	5,06	53,73	537	2,09	32,73
5	🟦 France	1858	4,66	58,40	387	1,51	34,24
6	🟦 China	1676	4,21	62,60	4732	18,44	52,68
7	🟦 Italy	1503	3,77	66,38	462	1,80	54,48
8	🟦 Canada	905	2,27	68,65	551	2,15	56,63
9	🟦 Spain	875	2,20	70,85	330	1,29	57,91
10	🟩 Mexico *	703	1,76	72,61	373	1,45	59,37
11	🟦 India	674	1,69	74,30	1102	4,29	63,66
12	🟩 Korea, Rep *	673	1,69	75,99	462	1,80	65,46
13	🟦 Brazil	552	1,39	77,38	323	1,26	66,72
14	🟦 Australia	541	1,36	78,74	354	1,38	68,10
15	🟦 Netherlands	515	1,29	80,03	185	0,72	68,82
16	🟩 Russian Federation *	487	1,22	81,25	1529	5,96	74,78
17	🟩 Switzerland *	356	0,89	82,15	45	0,18	74,96
18	🟦 Belgium	322	0,81	82,95	116	0,45	75,41
19	🟦 Sweden	321	0,81	83,76	52	0,20	75,61
20	🟩 Turkey *	268	0,67	84,43	209	0,81	76,42
21	🟦 Austria	262	0,66	85,09	75	0,29	76,72
22	🟩 Indonesia *	248	0,62	85,71	336	1,31	78,03
23	🟨 Saudi Arabia	242	0,61	86,32	325	1,27	79,29
24	🟦 Norway	238	0,60	86,92	36	0,14	79,43
25	🟦 Poland	232	0,58	87,50	296	1,15	80,59
26	🟦 Denmark	219	0,55	88,05	51	0,20	80,78
27	🟦 Greece	183	0,46	88,51	94	0,37	81,15
28	🟩 Hong Kong, China	183	0,46	88,97	36	0,14	81,29
29	🟦 Finland	171	0,43	89,40	69	0,27	81,56
30	🟩 South Africa	165	0,41	89,81	343	1,34	82,90
31	🟩 Thailand	158	0,40	90,21	207	0,81	83,70
32	🟨 Iran	153	0,38	90,59	369	1,44	85,14
33	🟩 Portugal *	149	0,37	90,97	60	0,23	85,38
34	🟩 Argentina *	142	0,36	91,32	136	0,53	85,91
35	🟩 Ireland *	137	0,34	91,67	41	0,16	86,06
36	🟧 Israel	118	0,30	91,96	62	0,24	86,31
37	🟩 Malaysia	117	0,29	92,26	136	0,53	86,84
38	🟩 Singapore	105	0,26	92,52	38	0,15	86,98
39	🟨 Venezuela	105	0,26	92,78	128	0,50	87,48
40	🟨 United Arab Emirates	103	0,26	93,04	103	0,40	87,88
41	🟩 Philippines	97	0,24	93,29	72	0,28	88,17
42	🟦 Czech Republic	93	0,23	93,52	119	0,46	88,63
43	🟧 Pakistan	90	0,23	93,75	116	0,45	89,08
44	🟧 Colombia	90	0,23	93,97	57	0,22	89,30
45	🟧 Egypt	90	0,23	94,20	140	0,55	89,85
46	🟦 Hungary	83	0,21	94,41	57	0,22	90,07
47	🟩 New Zealand *	82	0,21	94,61	33	0,13	90,20
48	🟩 Chile	78	0,20	94,81	59	0,23	90,43
49	🟨 Algeria	73	0,18	94,99	78	0,30	90,73
50	🟩 Peru	65	0,16	95,15	29	0,11	90,85
51	🟩 Romania	64	0,16	95,32	91	0,35	91,20
52	🟧 Bangladesh	61	0,15	95,47	33	0,13	91,33
53	🟩 Ukraine	60	0,15	95,62	305	1,19	92,52
54	🟨 Nigeria	55	0,14	95,76	48	0,19	92,71
55	🟨 Kuwait	55	0,14	95,90	65	0,25	92,96
..	..	..	..	..	..	..	..
59	🟩 Slovak Republic *	35	0,09	95,98	38	0,15	93,11
60	🟧 Kazakhstan	34	0,09	96,07	162	0,63	93,74
..	..	..	..	..	..	..	..
73	🟩 Bulgaria	21	0,05	96,12	45	0,18	93,91
	🟦 Cinese Taipei (Taiwan)	n.a.			255	0,99	94,91
	🟩 Rest of EU-25				174	0,68	95,58
	🟨 Rest of OPEC				322	1,25	96,84
	World	39833	100	100	25662	100	100
	🟦 IO model, M+E, BT (without C. Taipei)	32626	81,91		18046	70,32	
	🟩 National M+E, BT	4945	12,41		4797	18,69	
	🟨 OPEC M+E, BT	786	1,97		1390	5,42	
	🟧 Rest of World M+E, BT	1476	3,71		1429	5,57	

Those countries for which there are individual country models are red (dark). The green (grey) area corresponds to the OPEC (without Indonesia, which is explicitly modelled) and the yellow (bright) area represents the rest of the world (ROW). This group consists of economies in Central and South America, in Asia, in Africa and very few in Europe that play a minor role concerning GDP, trade and environmental pressure. The model is open to include further countries in more detail. A model for Rest of World ensures global coverage and closure of the model.

Table 4.1 lists each country that is explicitly modelled in GINFORS with its gross national income, share in world GNI, CO_2 emission and share in global CO_2 emission in 2004. Almost 82% of world economic output and 70% of global emissions originate from those countries which are modelled in detail by input-output models (IOM), and macro and energy model (M+E) and bilateral trade. These countries are highlighted in blue in Table 4.1. The countries highlighted in green are those for which no IO model, but an explicit macro model exists. These countries cover an additional 12% of world economic output and 19% of global CO_2-emissions. The countries of the OPEC region (highlighted in yellow) cover 2% of world economic output and 5% of emissions. As can be seen from the table, no major emitter is left out of the explicit modelling exercise. All developed as well as all newly emerging economies are explicitly covered. This also ensures a global coverage of CO_2 emissions, also in the coming years.

Figure 4.2 summarizes the model structure. The trade model is at the heart of the model. Bilateral trade matrices are available for 25 commodities as well as service trade covering all OECD countries, EU-25 countries and 16 further major trading partners. Each spoke of the wheel represents the model of one country. Each country model in turn consists of a macro model (MM), an input-output model (IOM), an energy-emission (EEM), a material-input (MIM). In the MOSUS project additional land-use models had been included for a few countries, but due to lack of data, no full coverage had been possible. Each model will be explained in detail in the next section.

The rings connecting the EEM, MM, MIM and LUM models show the significance of international relations between these models. The balance of payments, for example, being part of the macro model, ensures that global imports and exports have to be identical, at least when ascertained the same price concept. These global interdependencies require the national models to be consistent among them and with the global trade model, which is the case in GINFORS.

The economic core of the country models are the macro model and the input-output model. Whilst macro models by GINFORS are at hand for all countries, input-output models are available for 21 countries only. The economies of the remaining countries are solely displayed by a macro model. The energy-emission models (EEM) are based on the energy balances of the International Energy Agency (IEA) and are available for all countries and regions. They picture the energy consumption structured by the relevant energy carriers. The CO_2 emissions are linked with the fossil energy carriers by constant carbon relations. The material-input models (MIM) were added to GINFORS in the course of the MOSUS project. They distinguish between six material categories and are available for all countries that are explicitly modelled. The MI models are linked either with the input-output model, or, for the countries lacking an input-output model, with the macro model.

GINFORS is based on five main data sources: (1) OECD, (2) the International Monetary Fund (IMF), (3) Eurostat, (4) the COMTRADE data banks of the UN and (5) the International Energy Agency (IEA). Additionally, national statistics for two important countries (China and Taiwan), for which international data is not sufficiently available, are used. The trade data results from merging OECD and UN data. The macro models are based on data of the OECD “National Accounts of OECD Countries, Detailed Tables” and the data set “International Financial Statistics” by the International Monetary Fund (IMF). In the majority of the cases, the input-output tables were taken from OECD publications and Eurostat. The energy models exclusively correspond to the energy balances published by the IEA. The material input models are based on data provided by the Sustainable Europe Research Institute (SERI) during the MOSUS project.

Table 4.2 Main data sources.

model type		data sources	Source	global coverage
trade		OECD	www.oecd.org (Bilateral Trade Data)	50 countries,
		UN	http://comtrade.un.org/	2 regions (OPEC, ROW),
country models	input-output / sector	OECD	www.oecd.org (Input Output Tables)	21 countries
		OECD	www.oecd.org (National Accounts: Detailed Tables)	
		national sources	www.oecd.org (STAN)	
	macro	OECD/IMF	www.oecd.org (Detailed Tables), http://www.imfstatistics.org/imf/	52 countries/regions
	energy	IEA	www.iea.org	53 countries/regions
	material	SERI	www.materialflows.net	54 countries/regions
	Population	UN	http://esa.un.org/unpp/	52 countries/regions

The different models mentioned above are explained in more detail below, starting with the bilateral trade model, which links the individual country models.

Bilateral trade model

In the bilateral trade model trade quantities and prices are allocated among the 50 countries and two regions. The trade data distinguishes between 25 composite commodities and one service trade aggregate. Each of the 52 unaffiliated countries or regions[7] demands import commodities corresponding to vector $m(t)$ and sets an export price vector in domestic currency, $p(t)$. In turn, every country model receives export demand $x(t)$ and import prices $q(t)$, both in domestic currency as well.

Dividing exports, imports and their prices in national currencies by the exchange rate (national currency/USD) yields the corresponding variables in USD: $\tilde{x},\tilde{m},\tilde{p},\tilde{q}$. The cube of trade flow matrices $\tilde{\mathbf{T}}(t)$ has dimensions $26\times52\times52$ (25 composite commodities + 1 service good, indexed by i, 52 exporters (rows) and importers (columns) indexed by l and k). Dividing each element of the trade matrix for a good i by the column sum gives the matrix of export shares $S(\mathrm{t})$, which shows for a commodity i the share of this commodity of exporting country l in the imports of country k:

$$s_{ilk}(t)=\frac{\tilde{T}_{ilk}(t)}{\sum_l \tilde{T}_{ilk}(t)}\,. \tag{1}$$

This trade share matrix is necessary for the calculation of exports of good i of country l:

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[7] In the remainder of this paper, “countries” also includes the two regions OPEC and ROW, if not mentioned otherwise.

$$\tilde{x}_{il} = \sum_{k=1}^{52} s_{ilk}(t)\tilde{m}_{ik}(t), \tag{2}$$

where $\tilde{x}_{i,l}$ is nominal export of good i of country l in USD, $\tilde{m}_{i,k}$ is nominal import of good i of country k in USD and $s_{i,lk}$ is the share of country l in the imports of country k for good i.

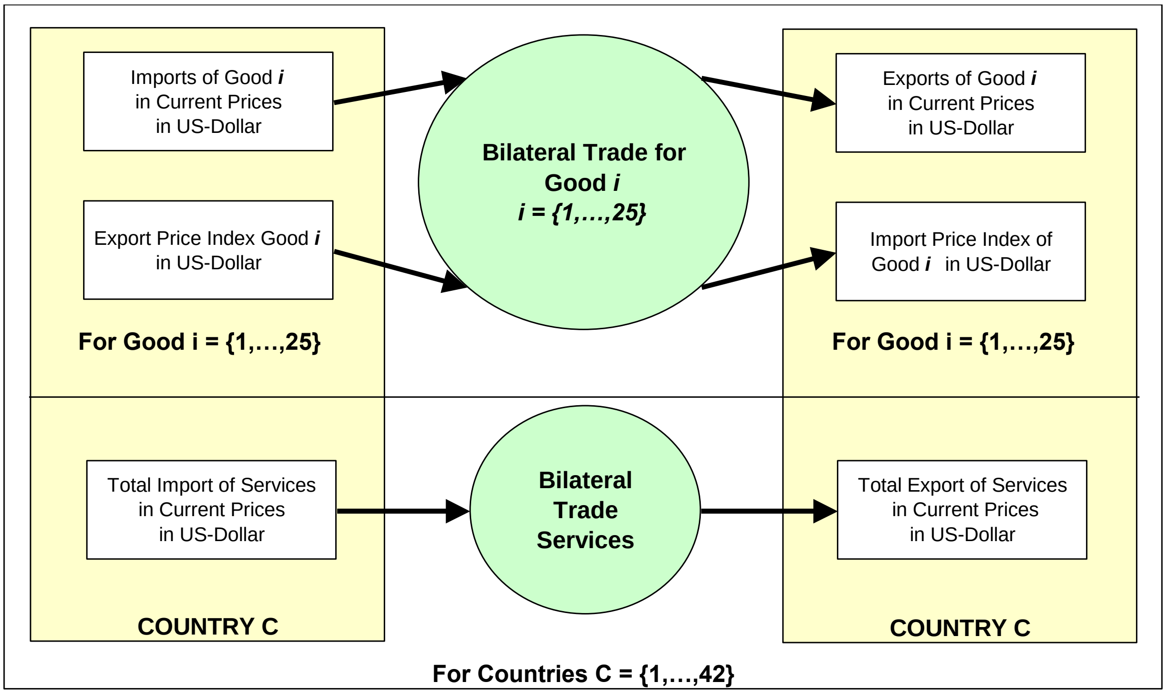


Figure 4.3 Schematic Presentation of the Bilateral Trade Model.

The import price of good i, $\tilde{q}_{i,k}$, is the weighted mean average of all export prices of good i with the market shares being the weights:

$$\tilde{q}_{i,k}(t) = \sum_{l=1}^{52} s_{i,kl}(t) \cdot \tilde{p}_{i,l}(t). \tag{3}$$

$s_{i,lk}$ depends on the relative price of exports of good i of country l to imports of good i in country k. It is necessary to also include a trend variable in the estimation of future values of $s_{i,lk}$:

$$s_{i,lk}(t) = s_{i,lk}\left(\frac{\tilde{p}_{i,l}(t)}{\tilde{q}_{i,k}(t)}, t\right), \tag{4}$$

with $\tilde{p}_{i,l}$ being the export price of good i in country l in USD and $\tilde{q}_{i,k}$ being the import price of good i in country k in USD.

The nominal export share matrix $\mathbf{S}(t)$ is estimated for the time period 1992 – 2004 using 4 different specifications:

$$\log\left(s_{ilk}(t)\right) = a_{ilk} + b_{ilk} \cdot \log\left(p_{il}(t) / q_{ik}(t)\right) \tag{4.1}$$

$$\log\left(s_{ilk}(t)\right) = a_{ilk} + b_{ilk} \cdot \log\left(p_{il}(t) / q_{ik}(t)\right) + c_{ilk} \cdot \log(t) \tag{4.2}$$

$$\log\left(s_{ilk}(t)\right) = a_{ilk} + b_{ilk} \cdot \log\left(p_{il}(t) / q_{ik}(t)\right) + d_{ilk} \cdot \log\left(s_{ilk}(t-1)\right) \tag{4.3}$$

$$\log\left(s_{ilk}(t)\right) = a_{ilk} + c_{ilk} \cdot \log(t) \tag{4.4}$$

The resulting $52 \times 52 \times 26 \times 4 = 281216$ equations are tested regarding to their statistical significance and economic validity. All specifications with an absolute t-value of less than 2 and a Durbin-Watson coefficient outside the interval [1,3] are discarded.

In the double-logarithmic specification, parameters b_{ilk} can directly be seen as elasticities. In the first specification an economically acceptable upper bound on b_{ilk} is 1. This corresponds to an upper bound of zero for the price elasticity of real trade shares, which ensures that there are no positive real price elasticities. The lower bound on price elasticities for nominal trade shares is set to -5, hence to -6 for real trade shares.

The second specification additionally includes a logistic time trend with maximum coefficient of ten, i.e. $c_{ilk} \leq 10$, resulting in a maximum growth of 150% within the estimation period. An explicit lower bound on this coefficient is not needed due to the double logarithmic specification.

Specification 3 includes the relative price and a lagged term of the export share. The coefficient of this term is bounded to be between 0 and 0.7, i.e. $0 < d_{ilk} \leq 0.7$. This allows for a lagged adjustment to the long-run equilibrium of maximal 70%. 30% of the adjustment has to take place during the period of the price change. The lower bound in the price elasticity is set to -2, hence, lower than in specification 1.

If more than one specification fulfils the corresponding criteria, the one with the highest R^2 is selected. If none fulfils the criteria, the nominal trade shares are set constant.

The trade model is based on data from two sources: the bilateral trade database of the OECD and the UN COMTRADE database. The OECD trade matrices are available from 1988 on an annual basis and include import and export data of 52 producing countries disaggregated into 25 commodity groups. These data do not explicitly consider the trade between non-OECD countries though. The corresponding data gaps are filled using UN COMTRADE data and data of the COMPASS model (Uno 2002). The data fed into GINFORS consists of 25 bilateral trade matrices of dimension 52×52, one matrix per commodity group i, 52 exporting countries l and 52 importing countries k. A new version of OECD BTD data published in October 2008, will offer a consistent dataset in the future.

The aggregated service good trade matrix is also based on OECD and UN trade in services data. This data is extended with balance of payments data of the International Monetary Fond (IMF, 2006). The result of combining these data is a bilateral service trade matrix covering all 52 countries and regions.

The bilateral trade model has multiple application possibilities: First, global effects of the economic development in one country on all other countries participating in international trade can be analysed. Second, it provides the basis for a differentiated analysis of trade of single commodity groups. Further, in combination with input-output models, not only direct effect of for example import demand for final goods can be calculated, but also indirect effects on intermediate and primary goods trade. These models will be explained in detail in the next section.

Input-output and sector models

As mentioned earlier, input-output models based on OECD data exist for 21 countries only. The OECD provides input-output tables, disaggregated into 41 sectors (compare Table 4.4) for the second half of the 1990s.

Table 4.3 Countries with Input-Output Tables.

no.	country	year	no.	country	year
1	Australia	1994/1995	12	Japan	1997
2	Belgium	1995	13	Netherlands	1998
3	Canada	1997	14	Norway	1997
4	China	1997	15	Austria	1995
5	Denmark	1997	16	Sweden	1995
6	Germany	1995	17	Spain	1995
7	Finland	1995	18	Taiwan	1999
8	France	1995	19	Czech Republic	1999
9	Greece	1994	20	Hungary	2000
10	United Kingdom	1998	21	United States	1997
11	Italy	1992			

Energy input coefficients of sectors 2 (mining and quarrying), 7 (coke, refined petroleum products) and 25 (electricity, gas and water supply) directly depend on corresponding time series data from the IEA energy balances. Private consumption is broken down into private consumption ex energy C, and private energy consumption, Ce.

Central equations in the input-output models are final consumption equations for each good i:

$$f_i(t) = c_i(t) \cdot C(t) + o_i(t) \cdot Ce(t) + b_i \cdot I(t) + d_i \cdot G(t) + X_i(t) \quad \Big| \quad i \in (1,...,41) \quad (5)$$

where d_i are exogenously determined constant coefficients, o_i is positive for $i = 2,7,25$ and zero else, c_i depends on o_i, bi on

Table 4.4 Sector structure in GINFORS.

OECD IO Industry	Nomenclature	ISIC Rev 3 Class	Original Country Table Class - USES NACE
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	01-05	01-05
2	MINING AND QUARRYING	10-14	10-14
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16	15-16
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	17-19	17-19
5	WOOD AND PRODUCTS OF WOOD AND CORK	20	20
6	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	21-22	21-22
7	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23	23
8	CHEMICALS EXCLUDING PHARMACEUTICALS	24ex2423	24
9	PHARMACEUTICALS	2423	24,4
10	RUBBER AND PLASTICS PRODUCTS	25	25
11	OTHER NON-METALLIC MINERAL PRODUCTS	26	26
12	IRON & STEEL	271 2731	271,272 part 273
13	NON-FERROUS METALS	272 2732	274, part 273
14	FABRICATED METAL PRODUCTS, except machinery and equipment	28	28
15	MACHINERY AND EQUIPMENT, N.E.C.	29	29
16	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30	30
17	ELECTRICAL MACHINERY AND APPARATUS, NEC	31	31
18	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32	32
19	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33	33
20	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34	34
21	BUILDING AND REPAIRING OF SHIPS AND BOATS	351	351
22	AIRCRAFT AND SPACECRAFT	353	353
23	RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.	352, 359	352.354
24	MANUFACTURING NEC; RECYCLING	36-37	36-37
25	ELECTRICITY, GAS AND WATER SUPPLY	40-41	40-41
26	CONSTRUCTION	45	45
27	WHOLESALE AND RETAIL TRADE; REPAIRS	50-52	50-52
28	HOTELS AND RESTAURANTS	55	55
29	TRANSPORT AND STORAGE	60-63	60-63
30	POST AND TELECOMMUNICATIONS	64	64
31	FINANCE, INSURANCE	65-67	65-67
32	REAL ESTATE ACTIVITIES	70	70
33	RENTING OF MACHINERY AND EQUIPMENT	71	71
34	COMPUTER AND RELATED ACTIVITIES	72	72
35	RESEARCH AND DEVELOPMENT	73	73
36	OTHER BUSINESS ACTIVITIES	74	74
37	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	75	75
38	EDUCATION	80	80
39	HEALTH AND SOCIAL WORK	85	85
40	OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	90-93	90-93
41	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS and EXTRA TERRITORRIAL ORGA.	95-99	95-99

If energy consumption or energy prices rise, consumption of all other commodities has to be reduced accordingly. The shares within the vector c remain constant over time, but the total share of c, i.e. the sum of all elements of c depends on the o_i's, $\sum_i c_i = 1 - (o_2 + o_7 + o_{25})$. $I(t)$ are investments, $G(t)$ public consumption and $X(t)$ exports. Gross output can then be calculated using final demand:

$$y(t) = [I - AR(t)]^{-1} [f(t) - m(t)], \tag{6}$$

where I is the identity matrix, $AR(t)$ the matrix of real input coefficients, and $m(t)$ is the vector of imports, depending on relative prices (in domestic currency) and final demand:

$$m_i(t) = m_i\left(\frac{q_i(t)}{p_i(t)}, f_i(t)\right) \tag{7}$$

Input coefficients can be treated differently. If time series data exists, input coefficients are estimated econometrically. In the current version this is realized for all energy inputs (see energy model) and important raw material inputs (see material model). If IO data is available for only one year, coefficients can either be treated as exogenous variables, either constant (classical

Leontief model) or following certain time paths (e.g. assuming a country will reach the economic structure of the US with a lag of ten or fifteen years, or based on technology foresight). A possible alternative is the assumption or different price elasticities of substitution as in CGE models. These different approaches can also be mixed.

The bilateral trade model provides time series for import and export goods. Import and export vectors are estimated. Import prices in domestic currency depend on export prices in domestic currency in the previous year and current prices in USD multiplied by the exchange rate:

$$q_i(t) = q_i\left(q_i(t-1), \tilde{q}_i(t) * EXRA(t)\right), \tag{8}$$

whereas export prices depend on average unit costs u :

$$p_j(t) = p_j\left(u_j(t)\right). \tag{9}$$

Average unit costs are calculated by multiplying all input coefficients including primary factors with the corresponding factor prices and then taking the sum over all different costs:

$$u(t) = \left[AR(t) - MR(t)\right]' p(t) + MR(t)' q(t) + LC(t) w(t) + \tau(t), \tag{10}$$

where MR is the matrix of import input coefficients, LC is a diagonal matrix of labour input coefficients, w is a vector of wages and τ is the net commodity tax per unit. Time series data for labour inputs are also available (OECD detailed tables).

Wage estimates are based on the Phillips curve approach: wages depend on labour productivity, Y/H (gross output divided by total employment), the consumer price index, P_C, and the employment ratio, H/Pop, where Pop is total population:

$$w_j(t) = w_j\left(\frac{Y(t)}{H(t)}, P_C(t), \frac{H(t)}{Pop(t)}\right). \tag{11}$$

Employment per sector, $h_i(t)$ can be estimated using gross output of the respective sector, the corresponding wage-price ratio and a time trend:

$$h_j(t) = h_j\left(y_j(t), \frac{w_j(t)}{p_j(t)}, t\right). \tag{12}$$

Labour input coefficients, LC, wage bills, l_j, and profits, g_j, are defined as:

$$LC(t) = \frac{h(t)}{y(t)} \tag{13}$$

$$l_j(t) = h_j(t) \cdot w_j(t) \tag{14}$$

$$g_j(t) = \left(p_j(t) - u_j(t)\right) y_j(t). \tag{15}$$

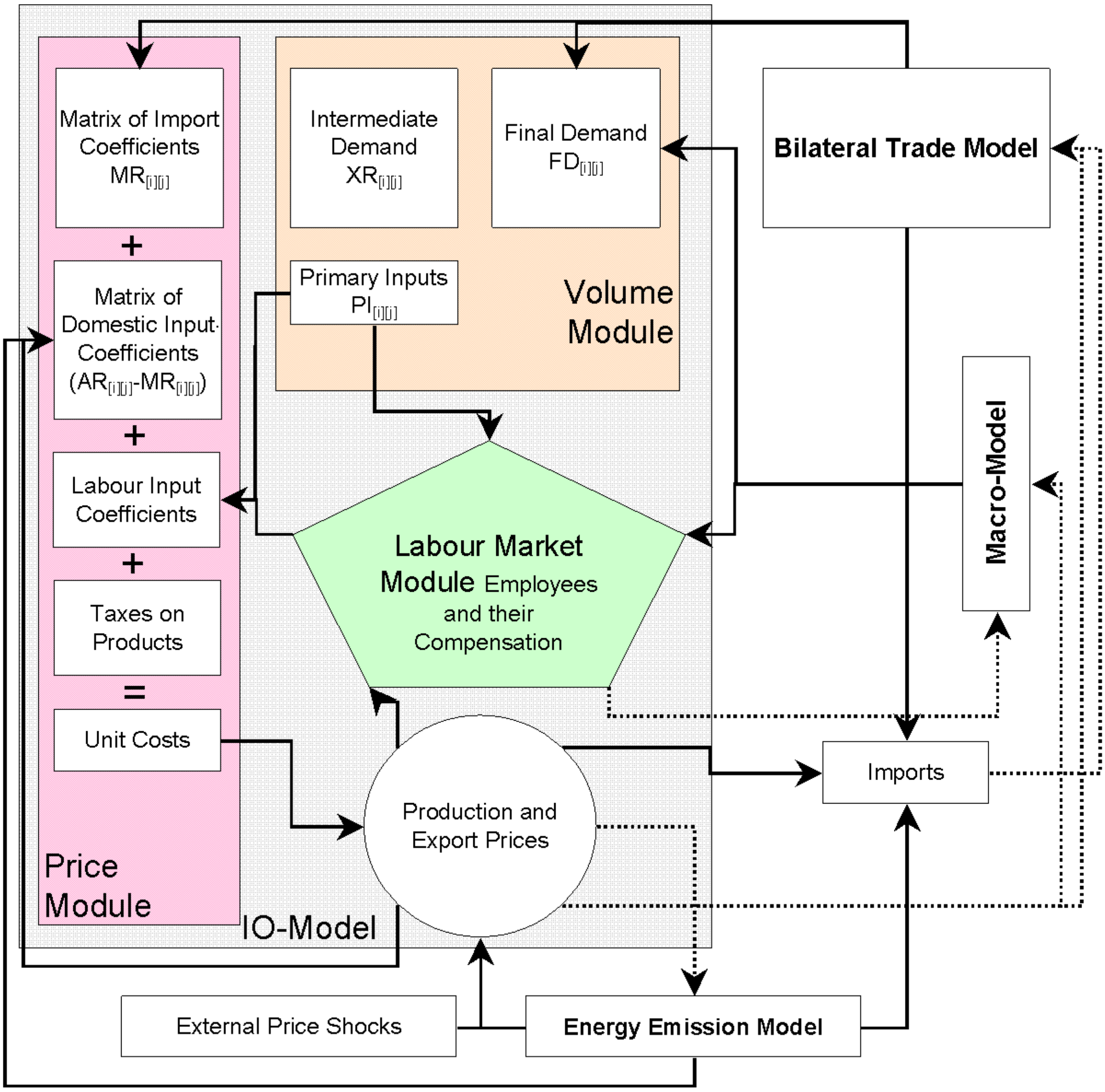


Figure 4.4 Internal and External Links of the Input-Output Model.

The links between the input-output model and the other components of GINFORS are displayed in Figure 4.4. If input-output data for a country exists, the input-output model is the centre of the corresponding country model. The bilateral trade model provides the input-output model with information about import prices and export demand. The macro model provides the basic data needed for the ascertaining the components of final demand in constant prices. Eventually, the energy-emission model displays energy prices and technological progress.

Assumptions concerning domestic demand and external trade are implemented within the input-output matrix together with the results of the import equations. By means of the Leontief Inverse, production can be calculated. In combination with base wage rate and production prices, the input-output model determines the results on the labour market (wages and employees structured by six sectors).

Prices are determined by the so-called “mark up” hypothesis, according to which companies levy a surcharge on unit costs taking into account competition intensity. Unit costs result from the summation of the component parts of costs, i.e. the costs of intermediate input are calculated using the import matrix. The costs of domestic intermediate inputs result from combining production prices and domestic input coefficient matrix. Eventually, labour costs, weighted with the labour input coefficients, are included. Moreover, commodity taxes are considered here.

Production prices as well as export prices are mainly determined by unit costs. Energy prices are given by the energy-emission models. In addition, external shocks can be handled, among them there are e. g. changes of global market prices for primary commodities, e.g. changes in the price of iron ore can be displayed.

The dotted lines describe the backflow from the input-output model into the other components of GINFORS. The results of the import functions and the export prices are part of the trade model. The production prices of the energy sectors are consistently integrated into the energy-emission model, causing a change in the demand for energy. The macro model utilizes the aggregated results of the labour market and the price module.

Macro models

The macro models consist of five modules: balance of payments, final demand, money market, labour market and the System of National Accounts (SNA).

The balance of payments captures the international monetary transactions. All flows of the current account, such as goods exports and imports and income paid and received as well as transfers paid and received are endogenous. Table 4.5 summarizes the balance of payments. In the left column all monetary inflows are listed, whereas the right column displays the monetary flows leaving the country. All of these flows and hence also the overall current account balance are endogenous. Capital flows are directly covered by the capital and financial account, whereas the foreign exchange account is only indirectly captured in the overall balance. The balance of foreign exchange payments is assumed to be zero so that the capital and financial account can be determined as a residual.

Table 4.5 Balance of payments in GINFORS.

BPGE	Goods Exports	BPGI	Goods Imports
BPSC	Service Credit	BPSD	Service Debit
BPIC	Income Credit	BPID	Income Debit
BPTC	Transfers Credit	BPTD	Transfers Debit
BPCA	Current Account		
BPCF	Capital and Financial Account		
BPOB	Overall Balance		

Source: based on IMF (2006)

The model consistently links the balances of payments of the individual countries by calculating the respective payment balances for the region ROW as residuals. Goods and service trade are calculated in the trade model. Globally, incoming income and transfer flows must equal outgoing flows. Since ROW mainly consists of developing and least developed countries, we can assume that outgoing payment flows from those countries are negligible and set the respective variable equal zero in the model. The difference between the sum of all incoming and the sum of all outgoing flows than are the incoming flows into ROW. Using this, all balances (overall balance, current account balance, capital and financial account balance and foreign exchange account balance) can be calculated.

Real exchange rates of EURO, YEN and YUAN against the US Dollar are set constant, it is differences in price developments are reflected in nominal exchange rates. For other currencies exchange rate arrangements and restrictions are taken into account. Free exchange rates can depend on either a basket of currencies or a leading currency such as the EURO in Europe and the YEN in Asia and take reserve developments into account

The module for the System of National Accounts (SNA) displays the macroeconomic accounting of a country. Its prime objective is the determination of disposable income and financial accounts for private sector and government. Disposable income is an important determinant of final consumption. The financial accounts comprise important targets of economic policy. The central equations of these modules explain tax income and other government income, as well as transfers to the private sector, including redistribution by social security systems.

All components of GDP are endogenous variables. Private consumption depends on disposable income; public consumption is explained by GDP and population. Gross capital formation and imports are estimated in the input-output models and are given as aggregates by definition. If a country has no input-output model, an aggregated import function is estimated with GDP and relative import price serving as determinants. Exports are calculated in the trade model on sector level and are aggregated for the macro models.

Consumption and investment are endogenous to the model. They are either explicitly modelled if an IO model exists, or they are estimated as dependent on disposable income or change in production. Prices of the different components of final demand are estimated using aggregated prices from the input-output model. If there is no input-output model, aggregated labour unit costs explain aggregated macro prices. The vector of import prices in USD is given by the trade model. It is transformed into a vector of import prices in local currency by multiplying it with the exchange rate. A price for total imports can be calculated by aggregation.

Labour supply LFCE is estimated using population projections of the United Nations, and is hence exogenous. Labour productivity, Y/H, depends on wages WAGE, which itself in turn depend on labour productivity (GDPT/EMPL) and inflation GDPD, and a time trend and is therefore endogenous as is labour demand, which is inverse labour productivity multiplied by GDP. For countries with input-output models, labour demand and wage determination is described for six sectors, which are consistently linked with the 41 sectors of the input-output model. Unemployment UNEM is the difference between labour force and employment.

$$WAGE(t) = WAGE\left(\frac{GDPTR(t-1)}{EMPL(t-1)}, GDPD(t-1), \frac{UNEM(t)}{LFCE(t)}, t\right) \tag{16}$$

$$EMPL(t) = EMPL\left(\frac{WAGE(t)}{GDPD(t)}, GDPT(t), t\right) \tag{17}$$

$$LFCE(t) = LFCE(POPU(t), t) \tag{18}$$

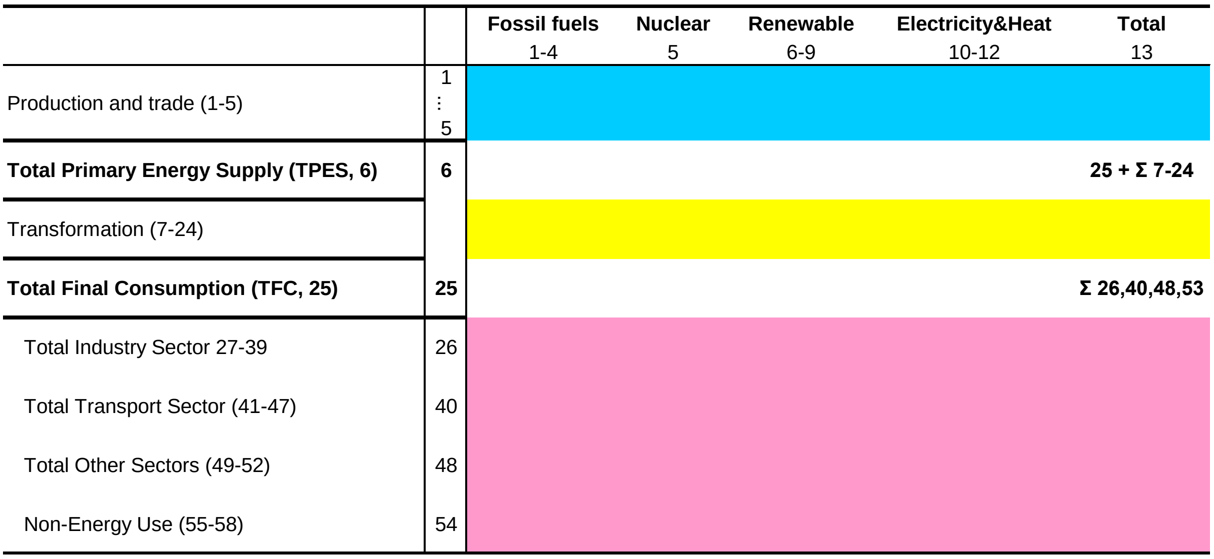
$$UNEM(t) = LFCE(t) - EMPL(t) \tag{19}$$

$$GDPD(t) = GDPD\left(\frac{WAGE(t) * EMPL(t)}{GDPT(t)}\right). \tag{20}$$

Money supply is endogenous and projected in reduced form depending on GDP. The discount rate on the other hand is an exogenous policy decision. The government bond yield in turn depends on GDP and the discount rate.

4.2.2 Energy-emission models

The energy emission models show the interrelations between economic development, energy consumption and emissions. The variables of the respective IO models and/or macro models are used as drivers for energy consumption. Energy consumption expenditure in turn has a direct influence on economic variables.



		Fossil fuels 1-4	**Nuclear** 5	**Renewable** 6-9	**Electricity&Heat** 10-12	**Total** 13
Production and trade (1-5)	1 ⋮ 5					
Total Primary Energy Supply (TPES, 6)	**6**					**25 + Σ 7-24**
Transformation (7-24)						
Total Final Consumption (TFC, 25)	**25**					**Σ 26,40,48,53**
Total Industry Sector 27-39	26					
Total Transport Sector (41-47)	40					
Total Other Sectors (49-52)	48					
Non-Energy Use (55-58)	54					

Figure 4.5 Energy balance.

Source: IEA(2006a)

The energy emission models are based on the energy balances of the International Energy Agency (IEA 2006a, 2006b). These balances, in physical units, are available for all countries on a yearly basis since 1960 or 1970. The IEA (2006c) also provides data for CO_2 emissions, which can be connected with Total Primary Energy Supply (TPES) via fixed emission factors.

The energy balances have 13 columns corresponding to 12 different (groups of) energy carriers and one column displaying the row sums. The energy carriers are 1) coal, 2) crude oil, 3) petroleum products, 4) gas, 5) nuclear, 6) hydropower, 7) geothermal power, 8)solar, wind and others, 9) combustible renewables and waste, 10) heat production from non-specified combustible fuels, 11) electricity and 12) heat. For a more detailed description of the energy carriers the reader is referred to IEA (2006a).

The 58 rows of the energy balances can be divided into three parts, energy production and trade (rows 1-5), energy transformation (rows 7-24) and final energy consumption (rows 26-58), compare Figure 4.5. Final energy is produced from primary energy in the transformation sector. The deployed primary energy is either extracted domestically or imported. Parts of the domestic extraction might also be exported.

Final Energy Consumption fe of sector j is explained by output y_j, the relation of the aggregate energy price pe – an average of the different carrier prices weighted with their shares in the energy consumption of that sector – and the sector price p_j, and technical time trends t:

$$fe_j(t) = fe_j\left(y_j(t), \frac{pe(t)}{p_j(t)}, t\right). \tag{21}$$

If a country does not have an input-output model, GDP is taken instead of the sectors output and the sector price is replaced by the GDP deflator in this estimation.

Final energy consumption of the transport sector, the other sectors – particularly the service sector and residential – as well as of non-energy use are also estimated using GDP in constant prices and the relation of the energy price to the price index of the GDP.

Final consumption of energy carrier i can be calculated by multiplying the share of energy carrier i in the energy demand cf of sector j, cfc_{ij}, with final energy demand fe of that sector and then summing over all sectors:

$$cf_i(t) = \sum_{j=1}^{n} cfc_{i,j}(t) \cdot fe_j(t). \tag{22}$$

For residential, services and manufacturing the shares depend on the relation of the carriers' prices to the aggregated energy carrier price of the corresponding sector:

$$cfc_{i,j}(t) = cfc_{i,j}\left(\frac{pe_i(t)}{pe(t)}, t\right). \tag{23}$$

The shares in the traffic sectors are exogenous. Bio fuel shares, for example, depend on policy targets.

Transformation from primary energy into final energy takes place for electricity ($i = 11$) and petroleum products ($i = 3$). The demand of carrier i for conversion cc is given by multiplying the production of the respective secondary energy carrier cf with the input coefficient ccc of primary energy carrier i:

$$cc_{i,11}(t) = ccc_{i,11}(t) \cdot cf_{11}(t) \tag{24}$$

$$cc_{i,3}(t) = ccc_{i,3}(t) \cdot cf_3(t) \tag{25}$$

The input coefficients of the energy carriers in the transformation sector are estimated using the relative prices of the energy carrier and the price in the transformation sector, which is taken from the IO model (sector 25 for electricity and sector 7 for fossil fuels):

$$ccc_{i,11}(t) = ccc_{i,11}\left(\frac{pe_i(t)}{p_{25}(t)}, t\right) \tag{26}$$

$$ccc_{i,3}(t) = ccc_{i,3}\left(\frac{pe_i(t)}{p_7(t)}, t\right). \tag{27}$$

The import of energy carriers, cm_i, is calculated as a fixed share of total carrier demand (final demand cf_i plus transformation cc_i:

$$cm_i(t) = cm_i\left(cf_i(t) + cc_i(t)\right) \tag{28}$$

Exports can be calculated adding up imports, cm_i, and import shares $esm_{i,lk}$, i.e. the share of country l in the imports of carrier i in country k:

$$cx_{i,l}(t) = \sum_{k=1}^{52} es_{i,lk} \cdot cm_{i,k}(t)\,. \tag{29}$$

Total production of energy carrier i can then be calculated:

$$cp_i(t) = cf_i(t) + cc_i(t) + cx_i(t) - cm_i(t)\,. \tag{30}$$

For some countries, especially those with low reserves in relation to current production (for example crude oil in the United Kingdom), an exogenously given supply path is assumed, and the total production equation (25) is solved to calculate imports as a residual. Total energy carrier supply cs is the sum of production cp and imports cm:

$$cs_i(t) = cp_i(t) + cm_i(t) \tag{31}$$

CO_2 emissions are linked with the fossil energy carriers by constant carbon relations. Since the 50 explicitly modeled countries plus the OPEC region cover 95% of world CO_2 emissions, the missing 5% are linked to the region Rest of World so that global coverage of CO_2 emissions is given.

Prices v of fossil fuels, crude oil, gas and coal are exogenous world market prices and drive the corresponding prices before taxes, peex, in the individual countries:

$$peex_i(t) = peex_i\left(v_i(t)\right) \tag{32}$$

Final energy prices, pe, are calculated as described in the energy price statistic of the IEA: the sum of prices before taxes, $peex$, and energy taxes, $petx$, multiplied by value-added tax, $pevt$, the CO_2 tax mark-up, $pect$, and the costs of certificates, $pece$:

$$pe_i(t) = \left(\left(peex_i(t) + petx_i(t)\right)\left(1 + pevt_i(t)\right) + pect_i(t) + pece_i(t)\right) \tag{33}$$

For the secondary energy carriers, electricity and petroleum, end use prices are given by the corresponding prices from the input-output model:

electricity: $pe_{11}(t) = p_{25}(t)$ (34)

petroleum: $pe_3(t) = p_7(t)\,.$ (35)

All domestic energy carrier prices are absolute prices measured in local currency per physical unit. The measured parameters reflect the historically given taxes as well. For forecasts tax rates can be changed and emission trading systems can be introduced.

Material-input models

The MI models model the extraction of coal, crude oil, gas, biomass, metal ores and other materials. For this, global economic drivers have to be linked to the resource extraction in the individual countries. The material extraction is driven by international trade and domestic production. It is therefore necessary to distinguish between domestic material demand and export demand for material. Then, global material extraction follows global economic development.

The driver for the extraction of coal, crude oil and gas is the production (in physical terms) provided by the energy models. These models distinguish the determinants of production according to domestic demand, imports and exports. It is therefore easy to separate domestic and foreign material demand. Modelling the international linkages is somewhat harder because coal, crude oil and gas are all subgroups of "mining and quarrying" and therefore not separately modelled in the trade model. This problem is overcome by calculating sub-matrices for these three materials using UN COMTRADE data. Trade of coal, crude oil and gas can then be explicitly modelled.

Production in agriculture (in local currency and constant prices) is used as a driver for biomass extraction in countries with an IOM. The production itself depends on domestic and foreign demand, so that export extraction dependency can easily be calculated. For countries without an IOM, agricultural exports extracted from the trade model are used to drive exported biomass extraction, and domestically used biomass extractions are driven by GDP.

Just as coal, crude oil and gas, metal ores are a subgroup of "mining and quarrying", but there exists no such alternative as above to explain the production of metal ores. We therefore use the information given by the metal-demanding sectors "iron and steel" and "non-ferrous metals" in the IO models. These two groups are aggregated into "metal production". Since those countries modelled with IO models capture about 90% of the world's metal production, the sum of the aggregate production sector over all countries can be used to drive global metal production.

The extraction of other minerals mainly consists of non-metallic minerals and it is assumed that trade does not have a major impact on extraction. Hence, for countries with an IO model, the extraction of other materials is explained by the extraction of non-metallic minerals. For those countries lacking an IO model, GDP in constant prices is used as a driver.

Resource productivity for fossil fuels is endogenously determined in the energy models. Since prices for the remaining materials are missing, the cost pressure as a determinant for productivity growth can not be identified. Hence, productivity growth rates for biomass, metal ores, and other non-metallic minerals are exogenously given based on historic trends.

4.2.3 Which SDIs are included in the model?

GINFORS is used for forecasts and scenario analysis in WP2 of INDI-LINK. Different Sustainable Development Indicators (SDIs) with a focus on the economic and environmental pillar are explicitly modelled. Due to the full interdependency of the system, variations in exogenous variables such as policy instruments in model simulations deliver a consistent picture of the changes in the different SDIs. Intra-pillar and extra-pillar interlinkages are covered. All linkages are quantitative.

GINFORS mainly links the economic and environmental pillar of SD with a focus on economic aspects. Some social aspects that are related to the economic sphere such as unemployment or general government gross debt are also explained. Population projections are part of the model as exogenous drivers, but no feed back to population development is integrated. As the economic dimension is a main driver for energy consumption and related environmental aspects such as air emissions as well as for total material consumption, these interlinkages are explicitly taken into account.

SDIs are linked indirectly via a complex modeling system. Therefore the linkages depend on the set of policy measures taken into account in scenarios. Synergies, anergies or trade-offs strongly depend on the policy measures. In a business as usual scenario based on historical developments, most economic indicators are positively linked (synergy), whereas some environmental indicators will worsen, if economic performance improves (trade-off).

Twelve level I and II SDIs are explicitly modelled in GINFORS: Growth rate of GDP per capita, total investment, total employment rate, resource productivity, electricity consumption by households, general government consolidated gross debt, total greenhouse gas emission, renewables in gross inland energy consumption, energy dependency, energy consumption by transport mode (rail, road, air, inland navigation), road fuel prices and CO_2 emissions per inhabitant, highlighted in green in Table 4.6.

GINFORS could quite easily be extended to include another eleven indicators, highlighted in yellow in Table 4.6, belonging to seven out of ten themes of sustainable development. The inclusion of the indicators could be realized best with an update of the database in 2009. These indicators cover all three pillars of sustainable development: public investment, business investment, labour productivity per hour worked, people living in jobless households, early school leavers, employment rate of older workers, GHG emissions by sector, modal split of passenger transport, GHG emissions by transport mode, EU imports of developing countries, total EU financing for developing countries, shares of environmental and labour taxes in total tax revenues.

For another group of indicators in brown a static inclusion might be possible, but there is no theory available how to link them to endogenous parts of the model. For other indicators, marked in red, the data situation is rather bad and in most cases there is no theory at hand of how to include the indicators into the model.

Build-up area is an indicator that could be included into the model, but data situation at EU level is very bad. In a large German project sector data on built-up area has been included into the German model PANTA RHEI.

4.2.4 How are the indicators integrated into the model?

Including the environmental indicators in GINFORS is rather straight forward, because GINFORS already covers a broad variety of environmental issues in deep sector disaggregation. The same holds for the economic indicators. Most social indicators on the other hand are hard to link to the energy-economy models, because most linkages existing between the economic and social pillar that we know of are more of a qualitative than of a quantitative nature. This is mainly due to low data availability, e.g. very short time series (very few observations), if any at all, so that cause-effect relationships cannot be identified using statistical methods.

Table 4.6: EUROSTAT SDIs in GINFORS

1	2	3	4	5	6	7	8	9	10
SOCIO-ECONOMIC DEVELOPMENT	**SUSTAINABLE CONSUMPTION AND PRODUCTION**	**SOCIAL INCLUSION**	**DEMOGRAPHIC CHANGES**	**PUBLIC HEALTH**	**CLIMATE CHANGE AND ENERGY**	**SUSTAINABLE TRANSPORT**	**NATURAL RESOURCES**	**GLOBAL PARTNERSHIP**	**GOOD GOVERNANCE**
🟩 Growth rate of GDP per inhabitant	🟩 Resource Productivity	🟧 At-risk-of-poverty rate after social transfers, by gender	🟨 Employment rate of older workers[1]	🟧 Healthy life years at birth, by gender	🟩 Total greenhouse gas emissions	🟩 Energy consumption by transport mode	🟧 Common Bird Index	🟧 Official Development Assistance [2]	
				🟧 Life expectancy at birth, by gender	🟩 Renewables in gross inland energy consumption		🟧 Fish catches taken from stocks outside safe biological limits		
ECONOMIC DEVELOPMENT	**RESOURCE USE AND WASTE**	**MONETARY POVERTY AND LIVING CONDITIONS**	**DEMOGRAPHY**	**HEALTH AND HEALTH INEQUALITIES**	**CLIMATE CHANGE**	**TRANSPORT GROWTH**	**BIODIVERSITY**	**GLOBALISATION OF TRADE**	**POLICY COHERENCE AND EFFECTIVENESS**
🟩 Total investment	🟧 Municipal waste generated	🟧 At-persistent-risk-of-poverty rate	🟧 Life expectancy at age 65, by gender	🟧 Death rate due to chronic diseases, by age group	🟨 Greenhouse gas emissions by sector (including sinks)	🟨 Modal split of passenger transport	🟧 Sufficiency of sites designated under the EU Habitats directive	🟨 EU imports from developing countries, by income group [3]	🟥 New infringement cases, by policy area
🟨 Public investment						🟩 Modal split of freight transport			
🟨 Business investment									
INNOVATION, COMPETITIVENESS AND ECO-EFFICIENCY	**CONSUMPTION PATTERNS**	**ACCESS TO LABOUR MARKET**	**OLD-AGE INCOME ADEQUACY**	**DETERMINANTS OF HEALTH**	**ENERGY**	**TRANSPORT PRICES**	**FRESH WATER RESOURCES**	**FINANCING FOR SUSTAINABLE DEVELOPMENT**	**OPENNESS AND PARTICIPATION**
🟨 Labour productivity per hour worked	🟩 Electricity consumption by households	🟨 People living in jobless households, by age group [4]	🟥 Aggregated replacement ratio	🟧 Salmonellosis incident rate in human beings	🟩 Energy dependency	🟩 Road fuel prices	🟧 Surface and ground water abstraction	🟨 Total EU financing for developing countries, by type	🟥 Voter turnout in national and EU parliamentary elections
				🟥 Index of production of toxic chemicals, by toxicity class					
EMPLOYMENT	**PRODUCTION PATTERNS**	**EDUCATION**	**PUBLIC FINANCE SUSTAINABILITY**			**SOCIAL AND ENVIRONMENTAL IMPACT OF TRANSPORT**	**MARINE ECOSYSTEMS**	**GLOBAL RESOURCE MANAGEMENT**	**ECONOMIC INSTRUMENTS**
🟨 Total employment rate[5]	🟧 Enterprises with an environmental management system	🟨 Early school leavers [6]	🟩 General government consolidated gross debt			🟨 Greenhouse gas emissions by transport, by mode	🟥 Concentration of mercury in fish and shell fish	🟩 CO_2 emissions per inhabitant in the EU and in developing countries [7]	🟨 Shares of environmental and labour taxes in total tax revenues [8]
						🟧 People killed in road accidents			
							LAND USE		
							🟧 Built-up area[9]		
							🟧 Forest increment and fellings		

🟩 Available in GINFORS

🟨 Inclusion in GINFORS possible

🟧 Static inclusion possible (but no theory how to dynamically include it in the model)

🟥 Unsufficient data

Additional indicators

Theme 2/8	🟨 Environmentally weighted indicator of material consumption
Theme 7	🟨 External costs of transport activities
Theme 2/8	🟨 Total material consumption and GDP at constant prices

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[1] Easily possible for Germany

[2] Guidelines for calculations too complex

[3] This indicator is already in GINFORS, but it differs in the income groups

[4] Exists for Germany in SOEB-INFORGE model

[5] GINFORS does not differentiate the population according to age groups yet, so that values after 2005 correspond to (employed persons)/(total population) and not (employed persons)/(population aged 16-64)

[6] Exists for Germany in SOEB-INFORGE model

[7] CO_2 emissions in developing countries are not displayed yet, the data available at EUROSTAT is not sufficient

[8] Might be included into GINFORS for a different project

[9] Built-up area: inclusion into GINFORS is possible (it has been included in the INFORGE model during the REFINA project), but the data available at EUROSTAT is not sufficient

Socio-economic development (Theme 1)

Growth rate of GDP per inhabitant (L101) can be calculated in GINFORS using GDP in constant prices and population data for all EU countries. GDP is an endogenous model result for all countries:

$$L101(t) = \left(\frac{GDPTR(t)}{POPU(t)} - \frac{GDPTR(t-1)}{POPU(t-1)} \right) / \frac{GDPTR(t-1)}{POPU(t-1)} \tag{36}$$

The level 2 indicator total investment (L102) is defined as total gross fixed capital formation (GFCF) expressed as a percentage of GDP, both in current prices. Both of which are available for the EU-15 countries and Czech Republic, Hungary, Poland and Slovak Republic.

$$L102(t) = \left(GFCF(t) / GDPTR(t) \right) \tag{37}$$

The employment rate (L114) is calculated by dividing the number of persons aged 15 to 64 in employment by the total population POPUW of the same age group. Employment is endogenous in all country models.

$$L114(t) = \left(EMPL(t) / POPUW(t) \right) \tag{38}$$

The employment rate is one of the few indicators available for all EU-27 countries.

Sustainable consumption and production (Theme 2)

For theme 2, the level 1 indicator resource productivity as GDP in constant prices in relation to domestic material consumption (DMC) in tons can be calculated. As GINFORS is calculating material extraction MAT in the material-input model based on SERI data (from materialflows.net) the calculated indicator can only be a proxy.

$$L201(t) = \left(GDPTR(t) / MAT(t) \right) \tag{38}$$

Electricity consumption by households is available in the energy balances of the IEA (in row 49), that are fully endogenized in GINFORS. It is calculated in a two-stage approach. First, overall energy demand of households (column 13) depends on household consumption HFCE and the price relation of weighted energy inputs to the CPI. On the second stage, the share of electricity consumption in overall energy consumption depends on relative energy prices (electricity pel to overall energy price pe) and trends.

$$L210 = \left(EB_{49,11}(t) \right) \tag{39}$$

$$EB_{49,13} = f\left(HFCE(t), \frac{pe_{49}(t)}{CPI(t)} \right) \tag{40}$$

$$EB_{49,11} = f\left(\frac{pel_{49}(t)}{pe_{49}(t)}, t \right) \tag{41}$$

Demographic changes (Theme 4)

For countries with a full System of National Accounts embedded in GINFORS, the change in general government consolidated gross debt (B9N0UT) is explicitly determined and can be related to GDP in current prices (GDPT):

$$L407(t) = \left(L407(t-1) + 100 * B9N0UT(t) / GDPT(t)\right) \quad (42)$$

The EU countries for which GINFORS is currently able to extrapolate this data are Austria, Belgium, Germany, Spain, Finland, France, Italy and the Netherlands.

Climate change and energy (Theme 6)

As most economy-energy-environment models, GINFORS focuses on energy-related emissions that are partly driven by economic variables. Therefore only energy related CO_2 emissions (CO2T) are explicitly modelled. CO_2 emissions are related to the energy balances of countries via fixed emission coefficients.

$$L601(t) = 100 * CO2T(t) / CO2T(1990) \quad (43)$$

Renewables in gross inland energy consumption can directly be taken from the energy balances as the sum of hydro (6), geothermal (7), wind, solar and others (8) and combustible renewables and waste (9) from row six (total primary energy supply) and related to the respective row total (13).

$$L602(t) = \left(EB_{6,6}(t) + EB_{6,7}(t) + EB_{6,8}(t) + EB_{6,9}(t)\right) EB_{6,13}(t) \quad (44)$$

Energy dependence as the import share in total primary energy supply can also be taken from the energy balances. Row 1 of the energy balances contains domestic production of energy carriers:

$$L607(t) = 100 * \left(- EB_{1,13}(t)\right) EB_{6,13}(t) \quad (45)$$

Sustainable transport (Theme 7)

Energy demand of transport is represented in rows 40 to 46 of the IEA energy balances. The total is displayed in row 40. The energy demand of rail traffic (44), road (43), air (41, 42) and inland navigation (46) depend on economic drivers such as GDP or production and price relations (e.g. fuel prices in relation to CPI).

$$L701(t) = \left(EB_{40,13}(t)\right) \quad (46)$$

$$L701B(t) = \left(EB_{44,13}(t)\right) \quad (47)$$

$$L701C(t) = \left(EB_{43,13}(t)\right) \quad (48)$$

$$L701D(t) = \left(EB_{41,13}(t) + EB_{42,13}(t)\right) \quad (49)$$

$$L701E(t) = \left(EB_{46,13}(t)\right) \quad (50)$$

Road fuel prices (here: automotive diesel) depend on international energy prices and domestic cost parts such as energy taxes:

$$L706(t) = \left(ptl_5(t)\right) \quad (51)$$

Global partnership (Theme 9)

As GINFORS explicitly covers 50 countries and two regions, CO_2 emissions for these countries are modelled. Population projections for all countries stem from the UN. We can therefore calculate per capita CO_2 emissions for 50 countries and two regions plus world average explicitly:

$$L911(t) = CO2T(t) / POPU(t) \tag{52}$$

4.3 Future assessment of interlinkages

4.3.1 Evaluation of Post-Kyoto regimes: Unilateral 20% GHG reduction of the EU until 2020

Project contents

The research project 21/05 "Economic criteria for assessing alternative negotiation results of a post-2012 climate regime" was accomplished between January 2006 and November 2007 on behalf of the German Federal Ministry of Economics and Technology. Detailed results are published in German (GWS/Prognos 2007). A summary is available in English (Lutz et al. 2008). Given the recent discussion on climate change, possible criteria for a distribution of targets for global action on mitigating climate change among the major economies have been highlighted and possible outcomes of the negotiation process substantiated in the course of this project. Using the extensive and disaggregated global GINFORS model, consequences of the different post-Kyoto regimes on the German and European economy and other major economies in the medium run until 2020 are depicted. The project has focussed on climate targets and does not go into detail on renewable energy. The 20% renewable target in 2020 is not reached.

Model based scenario analysis

When using a modelling approach in economic analyses, one usually conducts different simulation runs to compare the different possible developments (scenarios) with a reference scenario. The scenarios distinguish themselves by one or more different input specifications (in this case: particular climate protection actions). Differences in model outcomes are then ascribed to the differences in input specifications. The outcomes of the scenarios should not be seen as forecasts; they rather describe different, possible alternatives for future development.

During the project for the German Ministry of Economy GINFORS was run on the following alternative scenarios, some in different variants:

(1) a unilateral GHG emission reduction in the EU of 20% until 2020 compared 1990,
(2) a unilateral GHG emission reduction in the EU of 30% until 2020 compared 1990 with use of flexible mechanisms,
(3) inclusion of the remaining developed countries except the U.S. into (2),
(4) an extension of (3) by including the U.S. and
(5) an extension of (4) by additionally including the G5 countries China, India, Brazil, Mexico und South Africa, whereas less stringent reduction targets are applicable to these emerging economies.

Reference scenario

The reference scenario bases population development, economic growth, energy consumption and emission development on national and international projections, in particular on the reference scenario of the IEA World Energy Outlook 2006. According to this, the world population will increase to more than 8 billion by 2030. The world economy will grow considerably driven by the economic development in the developing countries. The international energy prices continue to be on high level, but below the recently attained maxima. Mitigation efforts are not increased world wide.

Global energy-related CO_2 emissions increase by 50% until 2030 compared to now (2004) without additional mitigation measures. Compared to the base year of the Kyoto Protocol, 1990, they almost double. The EU-27 will still produce about 10% of global emissions (15% in 2004). The main increase of global emissions can be ascribed to developing countries and emerging economies – particularly to China, which will be the world's biggest CO_2 emitter – for which there are no emission reduction targets set in the Kyoto Protocol. The EU target of cutting global GHG by 50% until 2050 will be severely missed without additional climate protection measures in all important countries; thus the 2°C target of the EU will most probably not be reached.

Germany will just succeed in meeting its EU burden sharing target to reduce GHG emissions by 21% until 2008-2012 compared to 1990/95. Afterwards emissions will continue to decrease only slightly. The recent policies (e.g. phasing out of nuclear energy, energy tax rates, support of renewable energies, etc.) will be maintained. The EU-15 will meet the targeted 8% reduction compared to the base year, but only under the inclusion of the reduction in other GHG emissions and the use of sinks (land use, land use change and forestry) and flexible mechanisms.

Basic assumptions and parameters of the reference scenario for Germany, the EU, the remaining developed countries and the G5 countries, China, India, Brazil, Mexico and South Africa, are displayed in Table 4.7.

Figure 4.6 shows the development of global energy related CO_2 emissions, which double between 1990 and 2030. This increase is mainly due to a quadruplicating of CO_2 emissions in the G5 countries, China, India, Brazil, Mexico and South Africa. The emissions of EU-27 countries remain at about the same level, while the other developed countries still slightly increase their emissions. The rest of the world, mainly consisting of developing countries, doubles its emissions, but still emits less than the developed countries.

There exists a high potential for cost-efficient reduction for non-energy-related emissions especially in developing and emerging countries, mainly from land use. A broad inclusion of these emissions into a post-Kyoto regime could further reduce the identified macroeconomic costs and create additional reduction potentials.

Table 4.7 Main values of the reference scenario.

GDP: average annual growth rates		**1990-2000**	**2000-2010**	**2010-2020**	**2020-2030**
	in %				
Germany		2,1	1,4	1,5	1,3
EU-15		2,3	1,9	2,0	1,7
NMS-12		2,3	4,0	4,0	3,2
EU-27		2,3	2,1	2,2	1,9
other developed countries		3,5	2,6	2,3	2,0
thereof USA		3,3	2,7	2,6	1,9
G5		6,7	6,8	5,1	3,6
World		**3,6**	**3,9**	**3,4**	**2,7**
share in world-GDP	**1990**	**2000**	**2010**	**2020**	**2030**
	in %				
Germany	5,7	4,9	3,9	3,2	2,8
EU-15	25,3	22,1	18,2	15,8	14,4
NMS-12	2,2	2,3	2,4	2,6	2,7
EU-27	27,5	24,4	20,7	18,4	17,1
other developed countries	37,9	37,4	33,2	29,7	27,8
thereof USA	23,6	22,9	20,4	18,8	17,4
G5	17,4	23,4	30,8	36,4	39,6
World	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**
CO_2 emissions from fossil fuel combustion	**1990**	**2005**	**2010**	**2020**	**2030**
	Mt CO_2				
Germany	966	829	806	797	757
EU-15	3.118	3.281	3.229	3.169	3.130
NMS-12	954	725	739	779	733
EU-27	4.072	4.007	3.968	3.949	3.863
other developed countries	8.716	9.542	10.160	11.374	12.001
thereof USA	4.842	5.729	6.108	7.085	7.405
G5	3.585	7.009	8.495	11.789	14.215
World	**20.683**	**26.703**	**29.613**	**35.975**	**40.326**
CO_2 emissions: deviations compared to 1990	**1990**	**2005**	**2010**	**2020**	**2030**
	in %				
Germany		-14,3	-16,6	-17,6	-21,7
EU-15		5,3	3,6	1,7	0,4
NMS-12		-24,0	-22,5	-18,3	-23,2
EU-27		-1,6	-2,5	-3,0	-5,1
other developed countries		9,5	16,6	30,5	37,7
thereof USA		18,3	26,2	46,3	52,9
G5		95,5	137,0	228,9	296,6
World		**29,1**	**43,2**	**73,9**	**95,0**
other figures	**1990**	**2000**	**2010**	**2020**	**2030**
world population in Mill.	5.264	6.086	6.843	7.578	8.199
population DE in Mill.	79,3	82,2	82,6	82,2	81,4
population EU-27 in Mill.	439,7	483,7	492,8	494,0	490,7
CO_2 allowance price in Euro2005/t			7,0	7,5	7,5
oil price in US$2000/bbl.	17,9	28,0	50,0	47,0	60,0

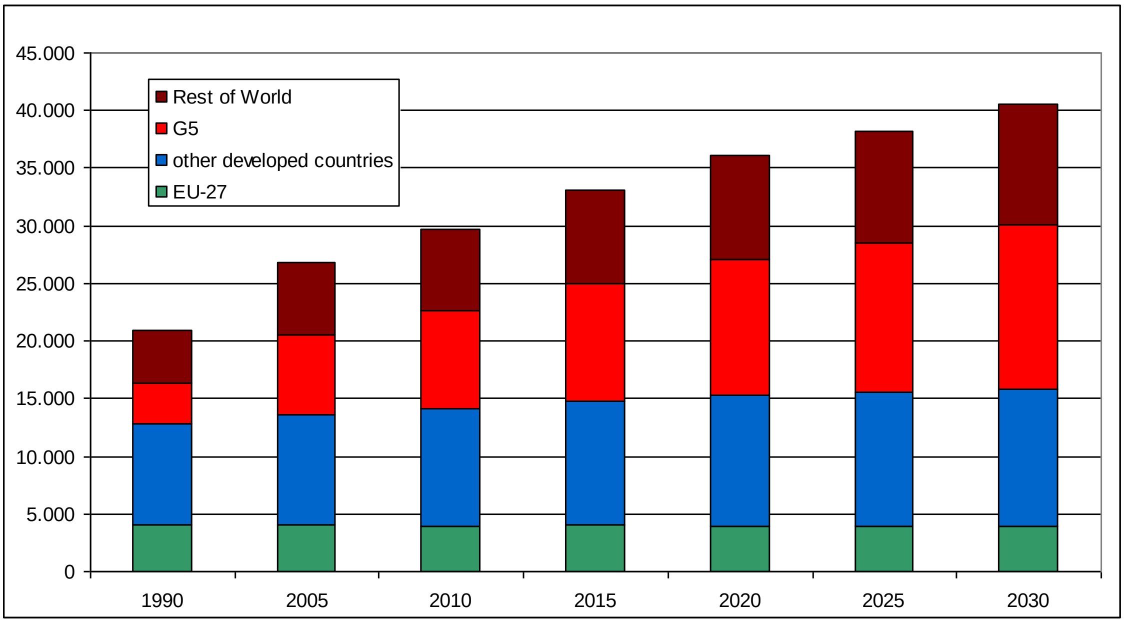

Figure 4.6 Energy-related CO_2 emissions, reference scenario in Mt CO_2.

Alternative Scenarios

The alternative scenario used for INDI-LINK is Scenario EU-1, a unilateral 20% reduction of GHG emissions until 2020, assuming that the rest of the world will not participate in a post-2012 framework. Such a unilateral commitment of the EU is not desired, but currently possible, if no international post-2012 agreement will be reached. At the same time it is necessary to consider, that the exact design of the GHG emission reductions and the EU internal burden sharing have just been decided in December 2008. Insofar quite a number of assumptions have been made. Costs of additional mitigation measures are expressed in deviation from the Gross Domestic Product (GDP) in the reference scenario. In doing so, all macroeconomic and inter-industry interdependencies, nationally and internationally, are embodied in the results.

The design of future regimes is important for model results: In this study it is assumed, that the EU aims for a fair burden sharing by uniform percentage reduction for EU-15 countries with respect to the Kyoto-targets (EU-15) respectively to the (expected) actual emissions in the period 2008-2012 (NMS-12). Under the EU emission trading system (ETS) the allowances of the energy sector are allocated by auctions. Energy intensive industries are not directly burdened, as long as they meet a required benchmark. The ETS will be extended to also include air traffic (EU-internal and 50% of international flights). To cover the impacts of diverse climate change policies on non-ETS sectors (business, trade, services, households, transport), a CO_2 tax (which is not a political recommendation) is used as a proxy for a variety of mitigation measures in the model. The tax revenues are recycled via tax reductions. The use of flexible mechanisms is not allowed in this scenario. The price of allowances will rise to 30 Euro2005/t CO_2 to meet the reduction target. This is approximately equal to 10 Cent per litre fuel oil. To achieve about the same percentage reduction in the non-ETS sectors an increase of the CO_2 price in form of a stylized CO_2 tax to 100 Euro2005 per ton (or 32 Cent per litre of diesel fuel) is needed in the EU15. In the remaining EU-27 countries, an increase of 50 Euro2005 per ton is sufficient due to high energy efficiency potentials.

4.3.2 SDIs in the reference scenario

We will now have a look at the outcomes of the simulation run of the reference, the "business-as-usual" scenario. For this, we refer to the following Figures, which display the changes in the indicators between 1995 and 2020. In the text we mainly consider this time period, while the graphs below in most cases also show the historic development since 1990 or 1995 depending on data availability. The 19 countries included in this analysis are EU-15, Czech Republic, Hungary, Poland and Slovakia. The remaining EU-27 countries could in many cases not be explicitly considered here due to a lack of data.

Socio-economic development (Theme 1)

The growth rates of GDP per inhabitant (L101) between 1995 and 2020 are highest in eastern European countries (Hungary, Poland, Slovakia and Czech Republic) and countries that lagged behind in their economic development before the 1990s as Ireland and Greece. The strong increase in the new member states is partly due to exogenous population decrease (based on UN projections) and strong GDP growth. The lowest increase in GDP per capita is experienced in Denmark, followed by Italy and Germany. The other central, north and western European countries have about the same GDP per capita increase in the respective time period (percentage wise). Two countries that need to be mentioned explicitly are Finland, which has by far the highest GDP per capita increase in central and northern Europe and Luxembourg, which was already ahead of all other countries and still has high growth rates.

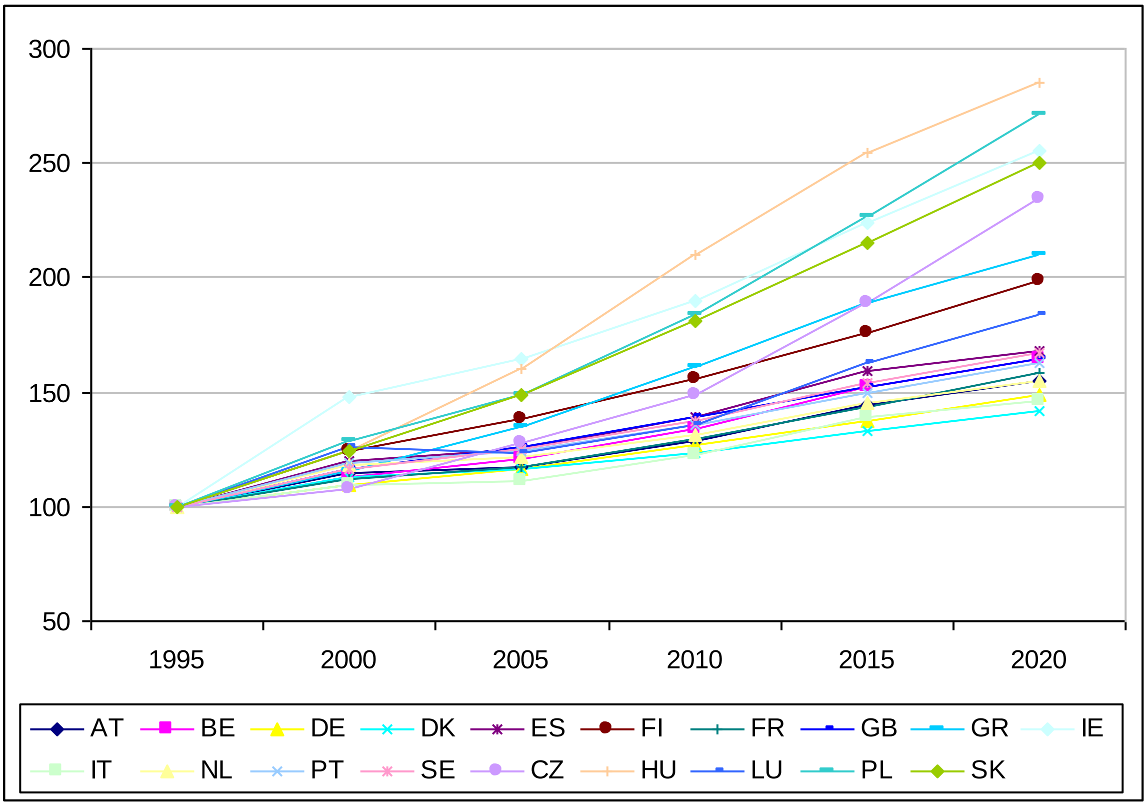

Figure 4.7 Growth rate of GDP per inhabitant.

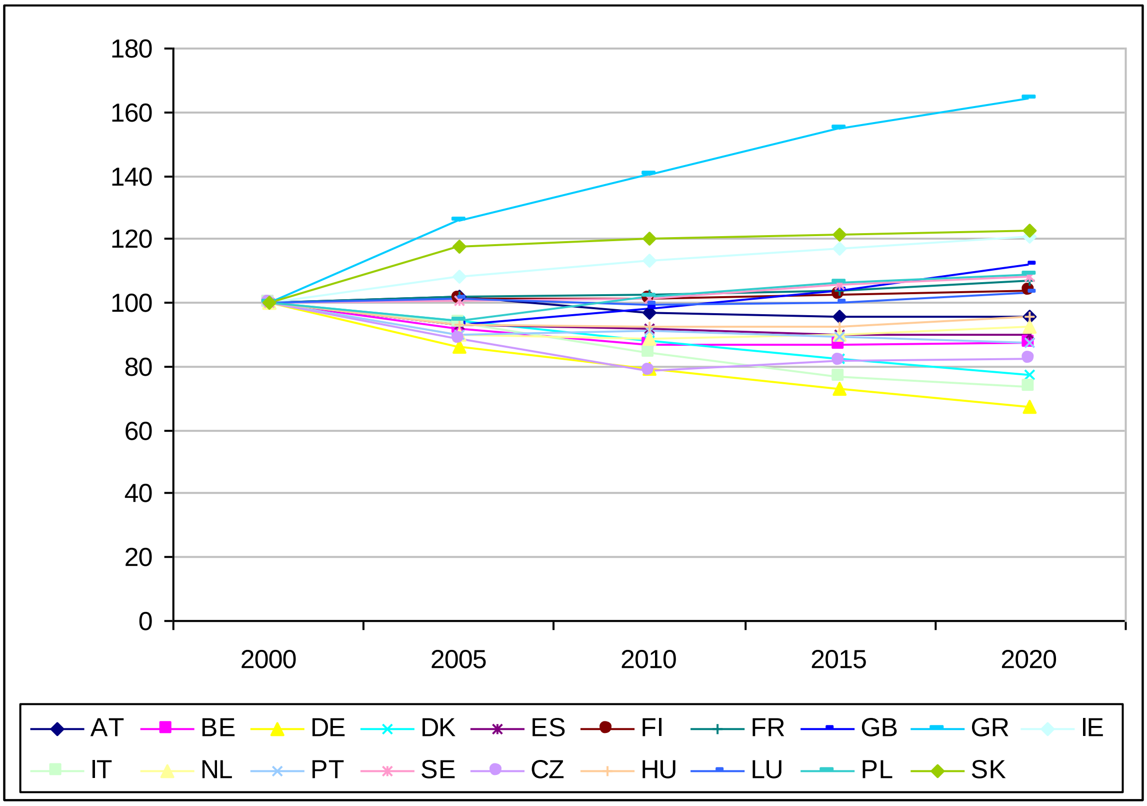

Figure 4.8 Total investment ratio.

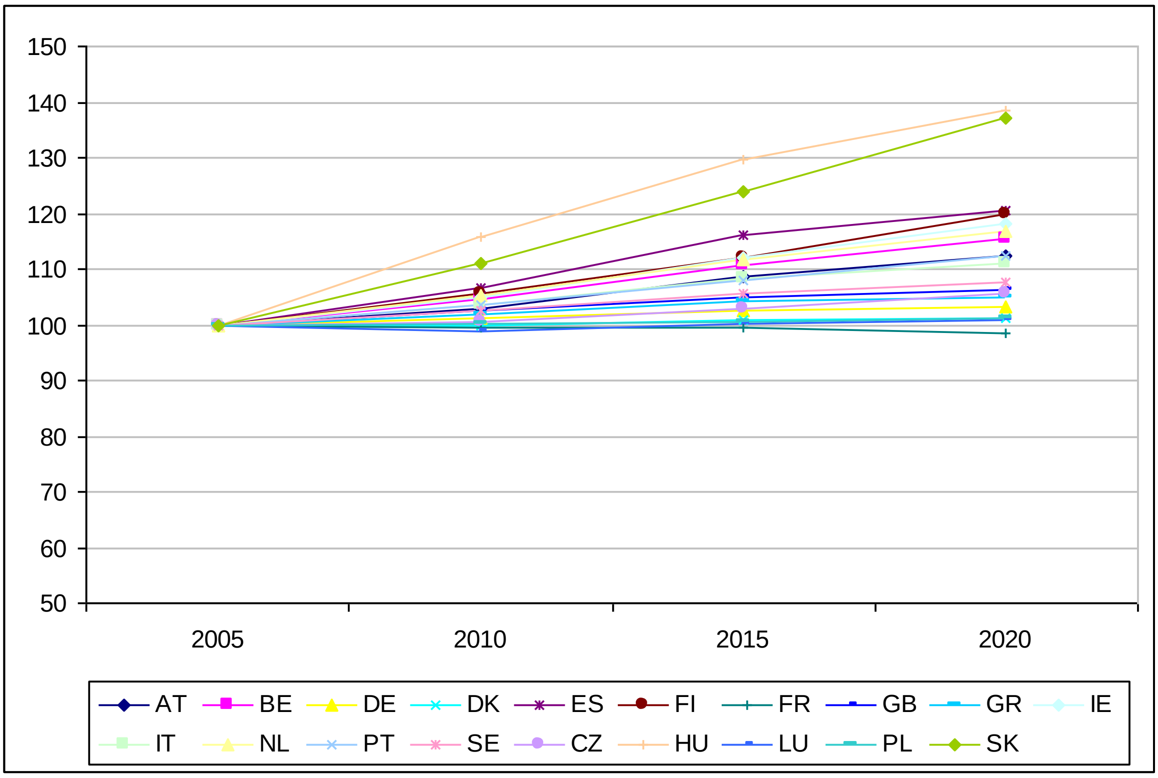

Figure 4.9 Total employment rate.

The level 2 indicator total investment ratio (L102) will decrease in eight (Austria, Belgium, Germany, Denmark, Spain, Italy, Portugal, Czech Republic) of the 19 countries between 2005 and 2020. The remaining countries will invest more compared to GDP in 2020, while "more" is between 2% and 30% (see Figure 4.8).

The development of the total employment rate (L114) differs greatly across the countries even though it increased in all countries after 2005 (see Figure 4.9). While some countries experience hardly any change in their employment rates (e.g. Denmark, France, Luxembourg, Poland), others can increase their employment rates by more than a third (Hungary, Slovakia). The increase in most countries is between 5% and 15%, which can already be considered as a favourable development.

Sustainable consumption and production (Theme 2)

For theme 2, the level 1 indicator resource productivity (L201), which is calculated as resource extraction in relation to GDP in GINFORS, develops quite favourably as well. It has to be stated that the calculated indicator is quite different from the Eurostat indicator that contains domestic material consumption (DMC). All observed countries can improve their resource productivity until 2020. The strongest increases take place in Greece.

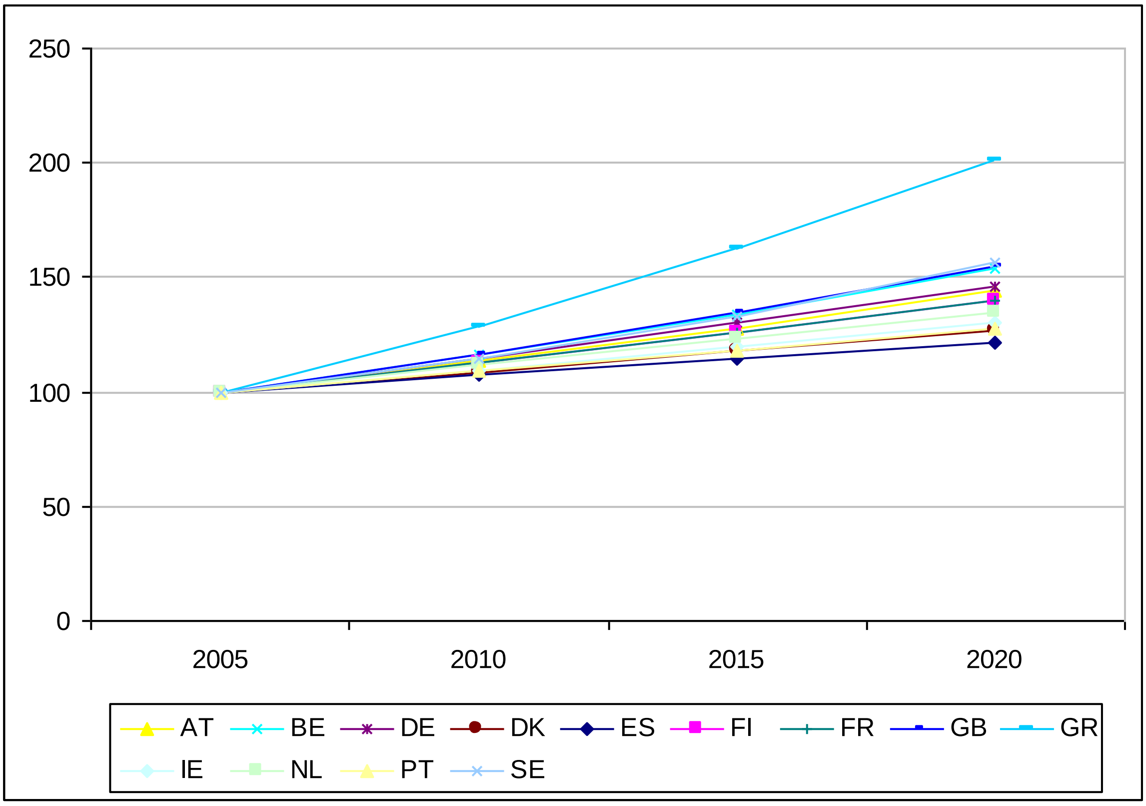

Figure 4.10 Resource productivity (as extraction to GDP).

Electricity consumption by households (L210) does not increase as much as in the past in almost all countries after 2005. Many countries will even be able decrease their electricity consumption by private households (see Figure 4.11).

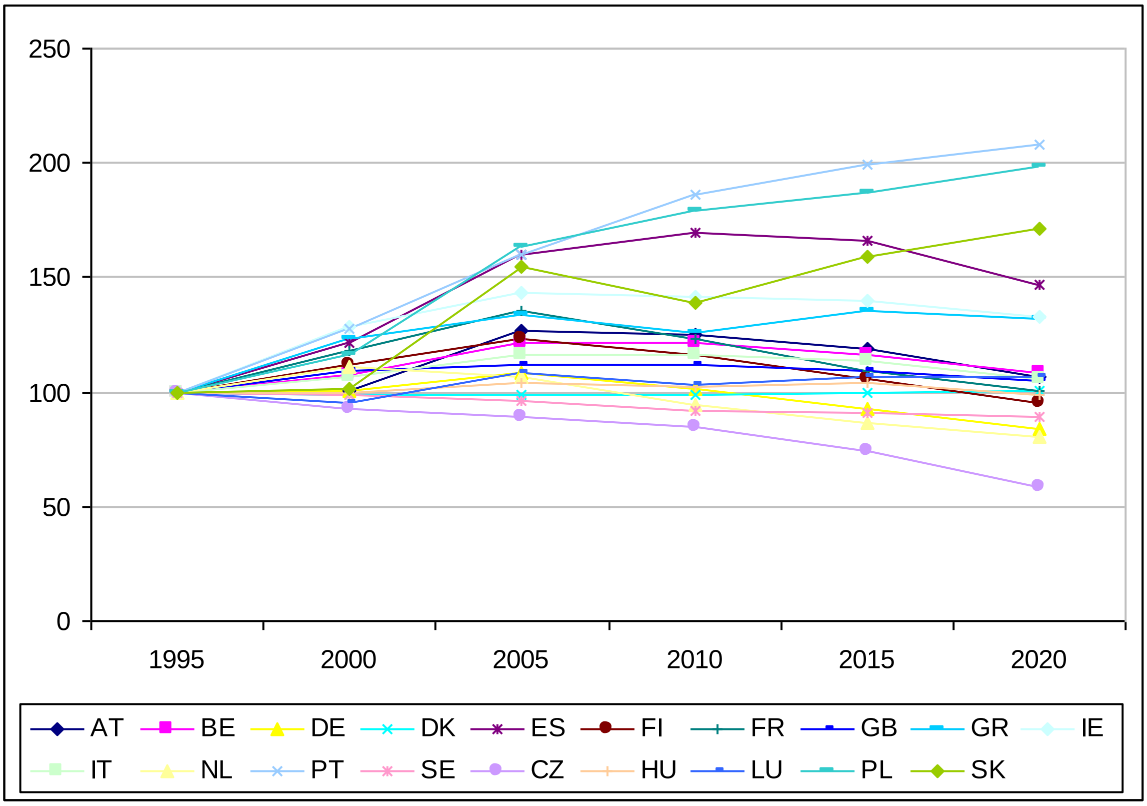

Figure 4.11 Electricity consumption by households.

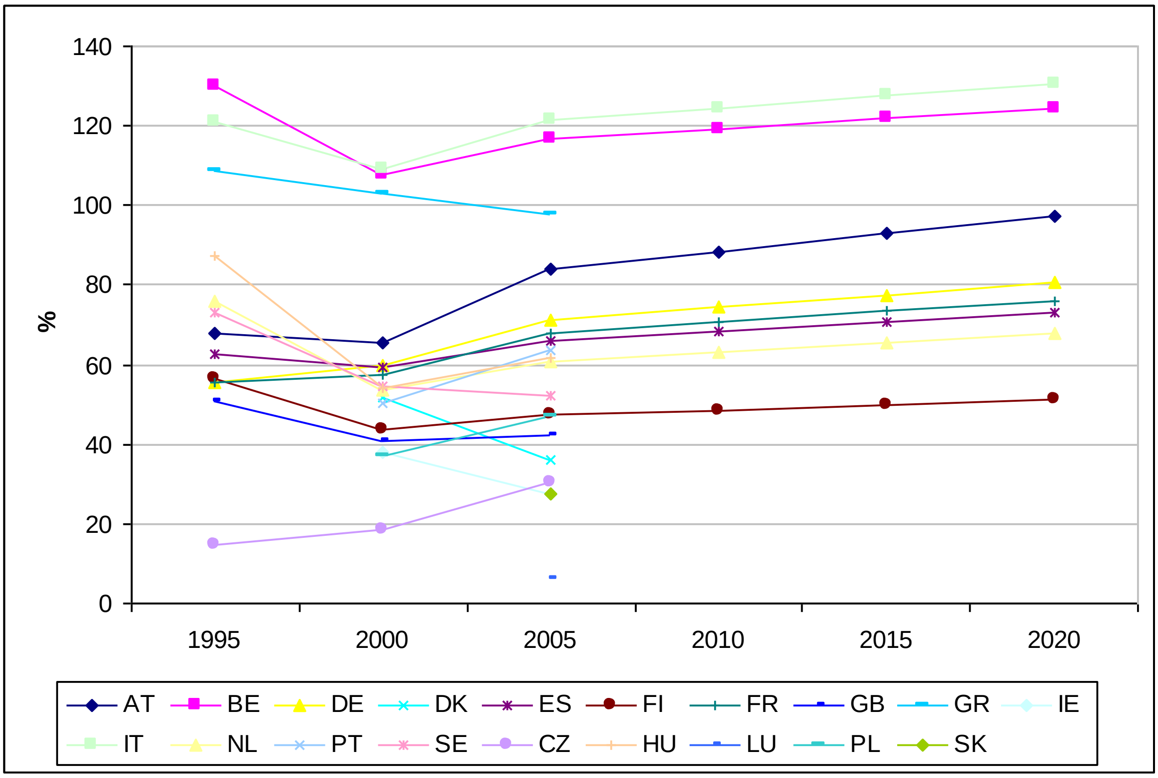

Figure 4.12 General government consolidated gross debt.

Demographic changes (Theme 4)

The EU countries for which GINFORS is able to extrapolate general government consolidated gross debt (L407) data are Austria, Belgium, Germany, Spain, Finland, France, Italy and the Netherlands (see Figure 4.11 *Electricity consumption by households.*

). It slightly increases in all of these countries after 2005.

Climate change and energy (Theme 6)

As most economy-energy-environment models, GINFORS is focussed on energy-related emissions that are partly driven by economic variables. Therefore only energy related CO_2 emissions are explicitly modelled. Its development differs widely among the European economies. Two countries (Czech Republic, Slovakia) are able to decrease their energy related CO_2 emissions in 2020 by more than 20% compared to 1990-levels. Another three countries (Germany, Denmark and Hungary) almost manage to do this with a decrease of more than 15%. Twelve out of the 18 countries under consideration not only fail to achieve a 20% reduction, they actually increase their energy related CO_2 emissions compared to 1990-levels. Comparing 2020-levels to 2005-levels does not change the picture to a great extend, only five out of the twelve “increasing” countries manage to keep their 2005-levels. The remaining seven countries still increase their emission activities.

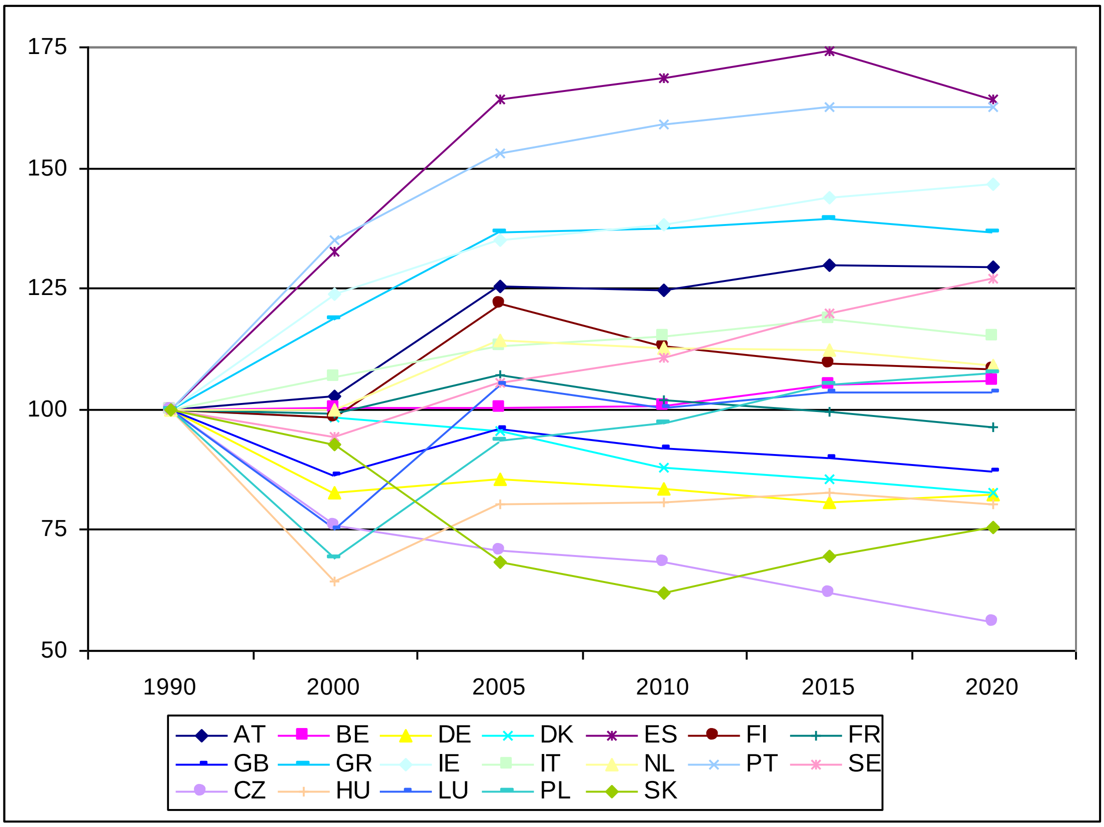

Figure 4.13 Energy-related CO_2 emissions, reference scenario (1990 = 100).

All countries but Austria will be able to increase the share of renewables in gross inland energy consumption (L602). Austria already has the third highest share, mainly hydro power, with more than 20% in all years since 1990. Additional policy measures adopted in 2008 are not included in the reference. Only Sweden and Finland have higher shares. These two countries will still increase their shares between 2005 and 2020 to more than 40% or 35%, respectively. Even though the growth rates of the shares are rather high, the shares of renewables in Luxembourg, Great Britain, Belgium, Hungary, Ireland, Czech Republic and Netherlands still remain below 10% in 2020 due to very low initial shares. Only four countries will be able to meet the 2020-target of the EU-25 of 20% (Sweden, Finland, Austria and Slovak Republic). Portugal and Greece come close to this target in 2020 (about 18%), but all other countries will fail by far.

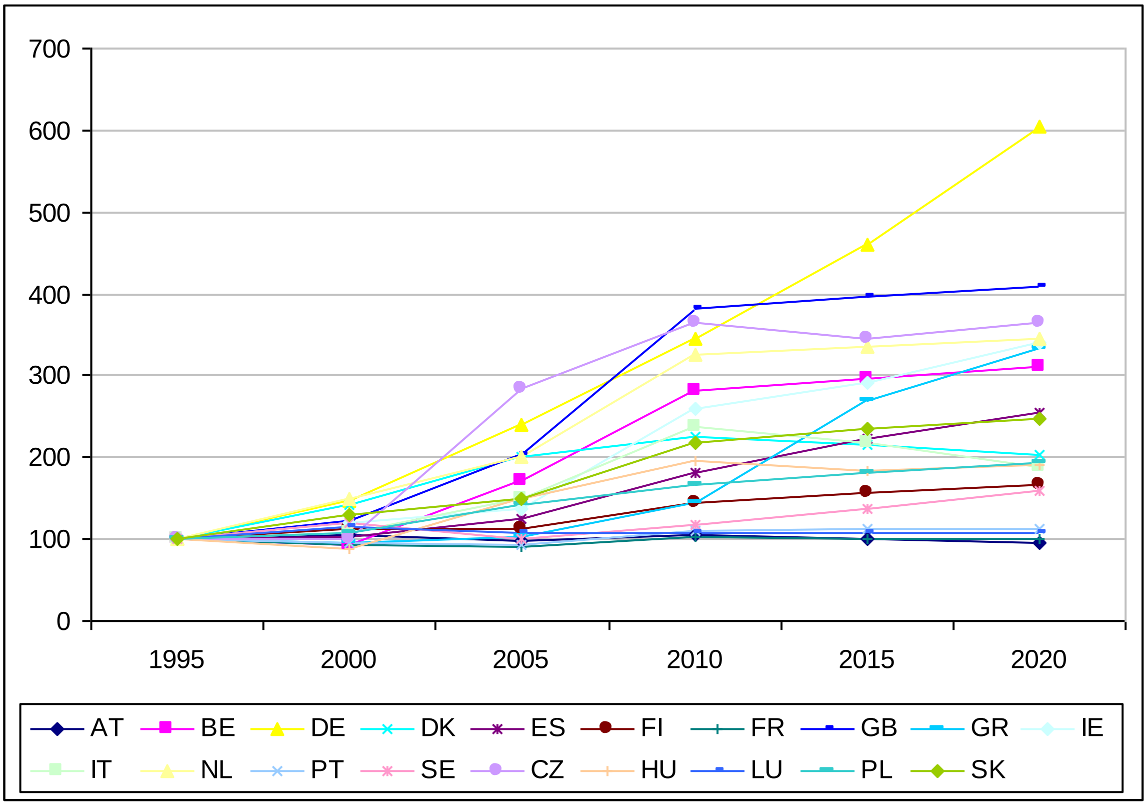

Figure 4.14 Renewables in gross inland energy consumption.

Energy dependency (L607) is the ratio of imported energy to domestically produced energy. While most European countries produce some energy domestically (between 20% and 80%), Luxembourg has to import more than 98% of the energy it consumes. Poland, which was a net energy exporter in 1995, will have to import 30% of its energy in 2020. Energy dependence will grow strongly from a still low level. Denmark increases its (renewable) energy exports, while Britain decreases it (gas and oil). For the United Kingdom the index development shown is problematic and may be misleading. The absolute number is -12.8 in 2005, i.e. the UK is exporting more than it consumes itself, and reaches 0 in 2020, i.e. the UK is still independent of energy imports (see Figure 4.16). Between 2005 and 2020 only five countries will be able to decrease their energy dependency (Finland, Greece, Italy, Portugal and Slovakia). Austria, Belgium, Ireland and Sweden do not experience a large change in their energy dependency, while the remaining seven countries (Germany, Spain, France, Netherlands, Czech Republic, Hungary and Poland) all have to import an increasing fraction of their energy consumption.

As can be seen in Figure 4.16, those countries with a relatively high share of renewable energies have a relatively lower energy dependency. While one would expect, that energy dependency decreases over time as the share of renewables increases, this is not true for all countries, e.g. Germany. Domestic energy demand increases faster than the use of renewable energies.

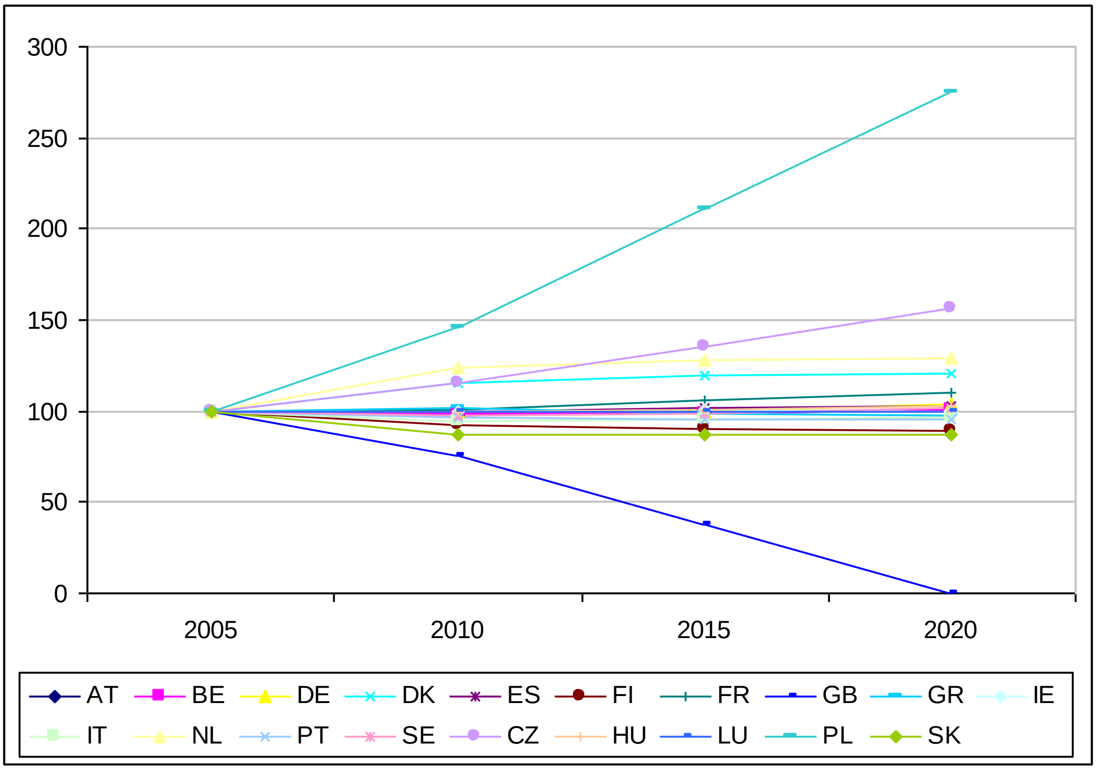

Figure 4.15 Energy dependency.

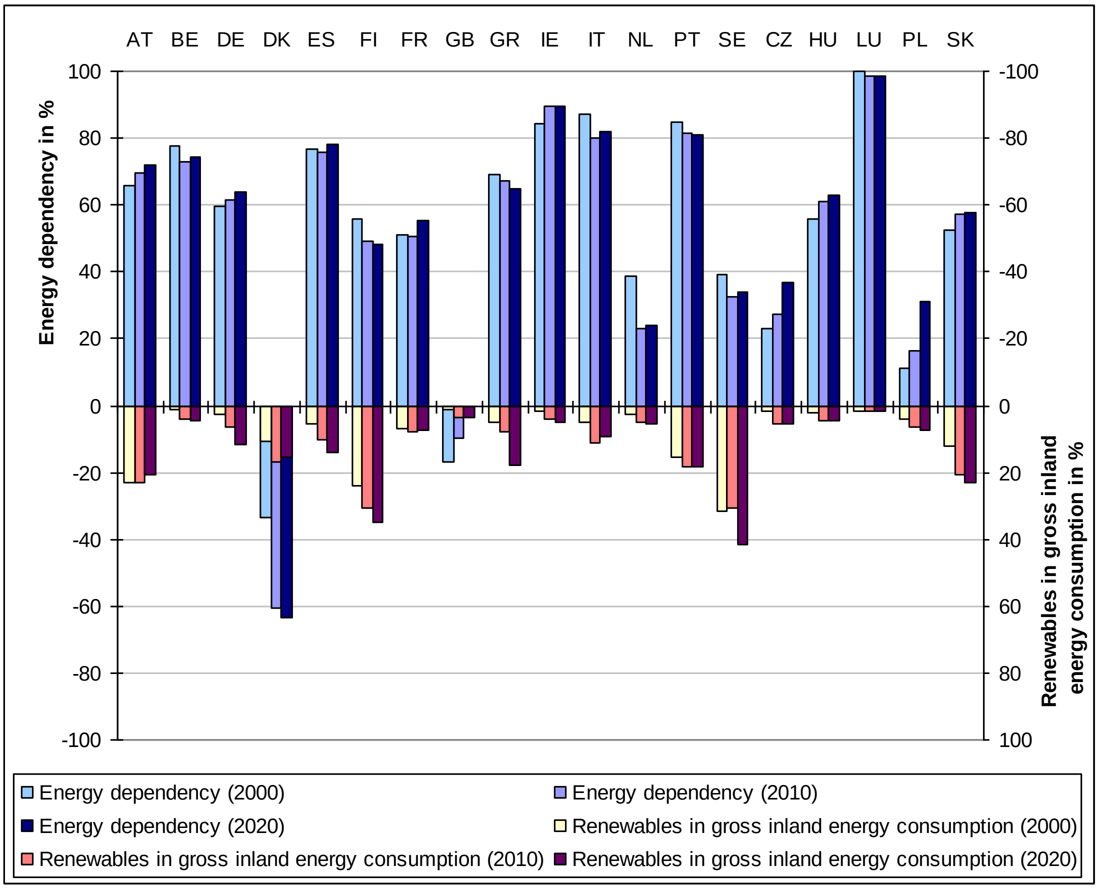

Figure 4.16 Energy dependence and renewables share in the reference.

Sustainable transport (Theme 7)

Despite rising fuel prices in all countries, the energy demand of the transport sector increases in most countries between 1995 and 2020. Sweden, Germany, Denmark, Finland and Luxembourg's transport sectors have about the same level of energy demand in 2020 as they had in 2005. The amount of energy demanded by the transport sector increases most in Ireland, the four eastern European countries, Spain and Belgium. Given the rising fuel prices it is interesting to have a closer look which of the four transport modes is most responsible for the increasing energy demand. Looking at the four new member states, which have a high increase in road fuel prices, shows that demand of the transport mode "road" still increases more than the energy demand of the total sector. The difference in the increase in fuel prices mainly depends on the difference in fuel taxes between the countries.

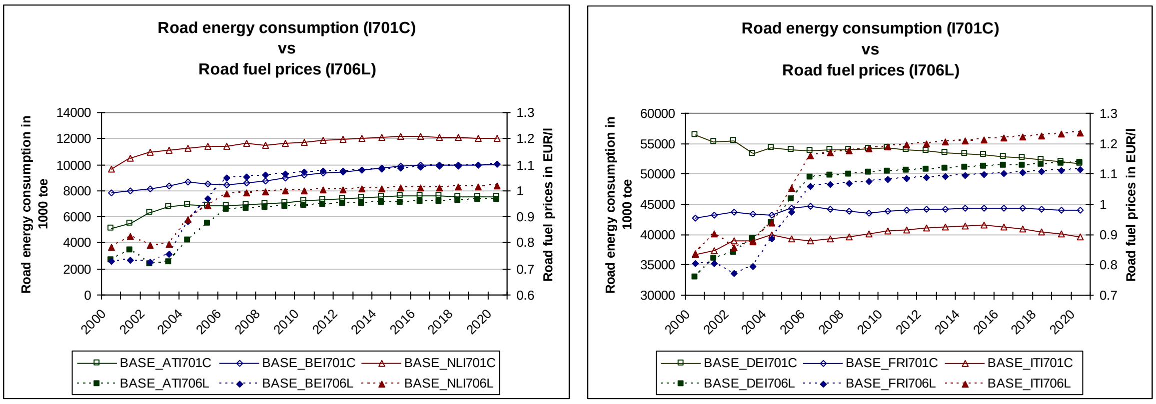

Figure 4.17 Road energy consumption vs. road fuel prices.

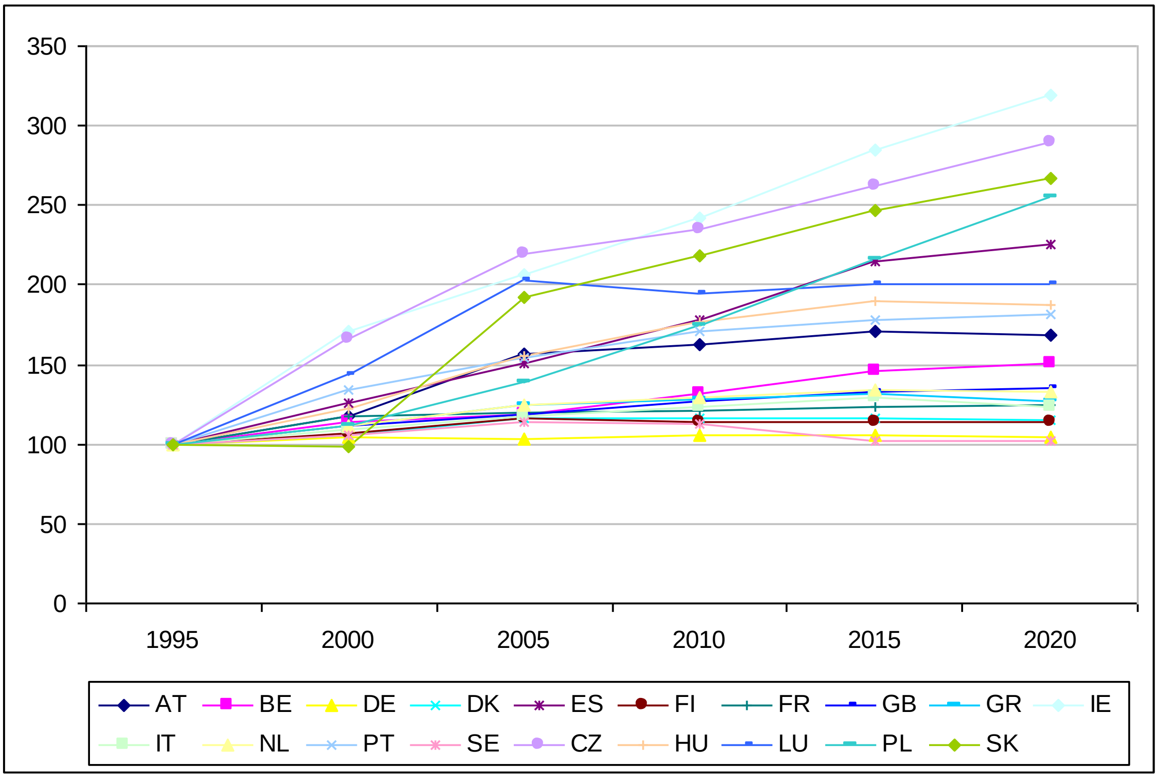

Figure 4.18 Energy demand of transport (L701).

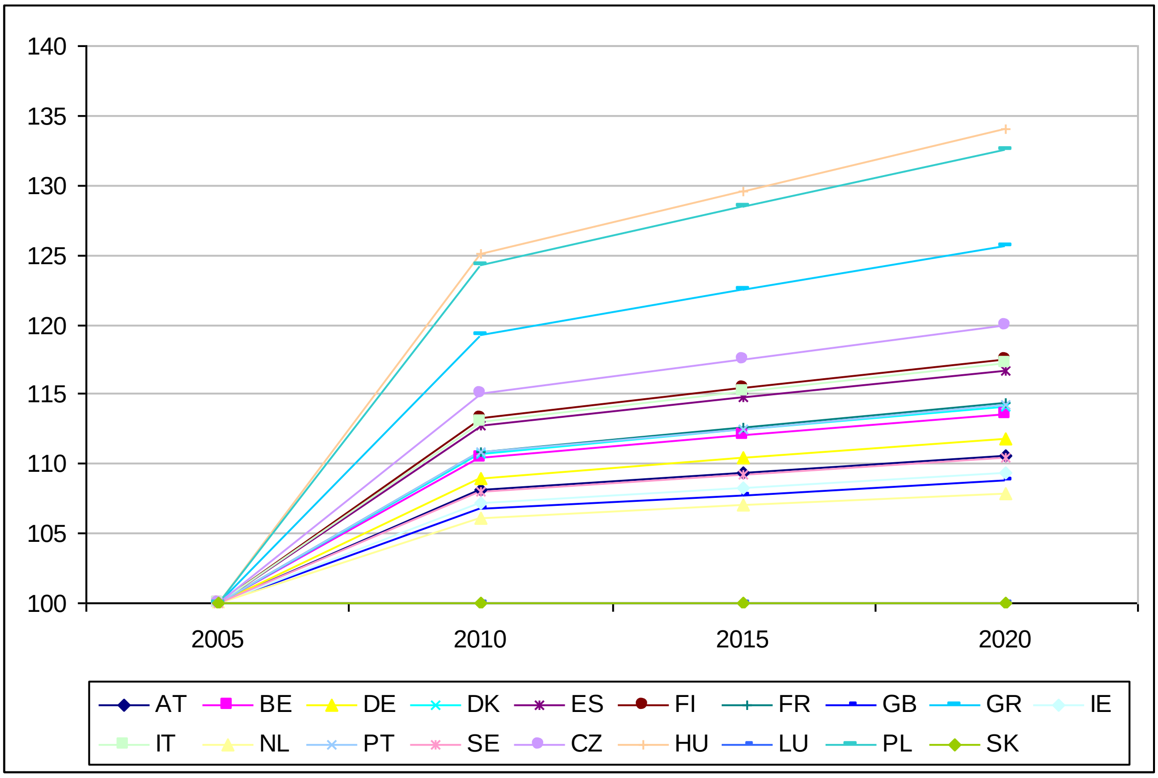

Figure 4.19 Road fuel prices (here: automotive diesel) (L706).

Global partnership (Theme 9)

About half of the countries are able to decrease their per capita CO_2 emissions between 1995 and 2020 (see Figure 4.20). After 2005 only seven countries (Belgium, Italy, Portugal, Sweden, Hungary, Poland and Slovakia) remain to increase their per capita emissions. Even though Luxembourg is second in reduction rates after 2005, its per capita emissions are still more than twice as high than that of the average European country. In comparison to emerging economies, EU (German) per capita emissions will still be extremely high in 2020, though much lower compared to the US.

Summary

While some indicators develop unfavourable (government consolidated gross debt, energy dependency, energy consumption by transport and emissions), all non-environmental indicators show a promising development in most countries in this “business-as-usual” scenario (reference scenario). There are too many countries though, that increase not only total but also per capita CO_2 emissions (Belgium, Italy, Portugal, Sweden, Hungary, Poland, Slovakia) and almost no country decreases emissions by more than 20% compared to 1990 levels in this setting without a post-Kyoto framework. Looking at the effect of a policy requiring this 20% emission reduction therefore seems to be a good idea to be able to analyze effects on those indicators which develop favourable in the business-as-usual setting.

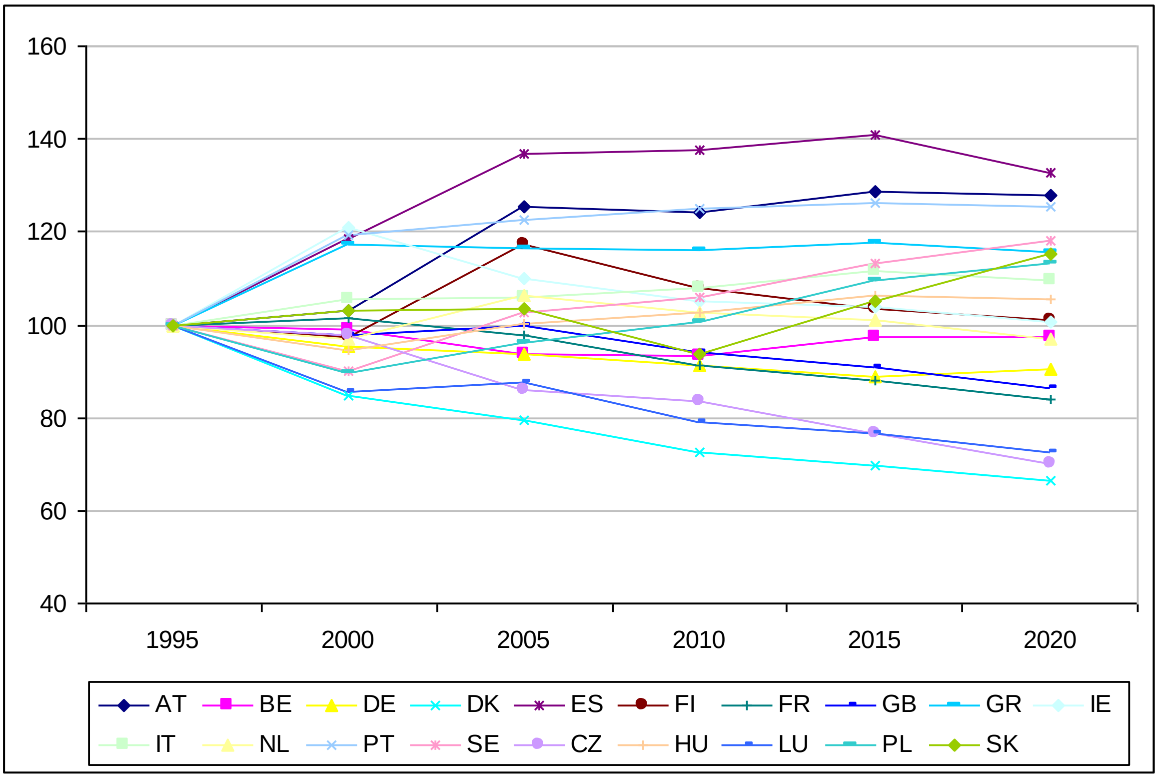

Figure 4.20 *Per capita CO_2 emissions.*

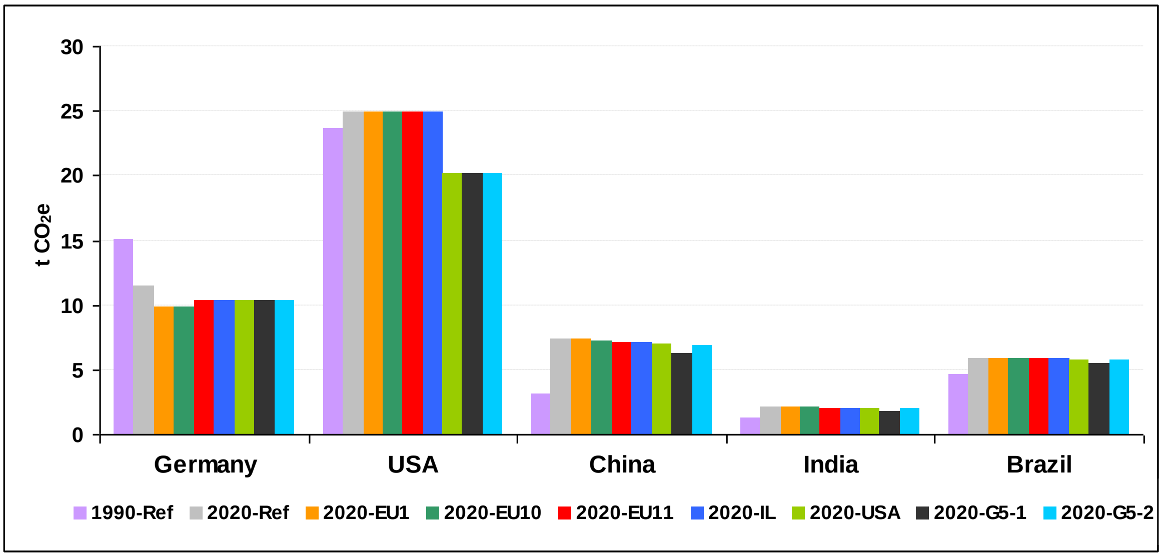

Figure 4.21 *Per capita CO_2 emissions in different scenarios (from GWS/Prognos 2007).*

4.3.3 Interlinkages

Table 4.9 shows the changes in the different indicators between 2005 and 2020 in the reference, i.e. the business-as-usual, scenario. While there is an improvement in the economic indicators, the data shows a substantial worsening of part of the environment-related indicators.

Using Table 4.8 we are able to compare the developments of the SDIs for the two scenarios described above, the reference scenario and scenario EU-1 (unilateral 20% GHG reduction until 2020).

The main differences between the two scenarios are obviously found in the indicators for total GHG emissions and per capita CO_2 emission. While in the reference scenario only seven out of 19 countries reduce their total GHG emissions compared to 2005, all countries but Sweden do so when the unilateral 20% reduction policy in the EU is adopted. On a per capita level also Sweden lowers its CO_2 emissions in this scenario, while in the reference scenario only eleven countries have lower CO_2 per capita emissions in 2020 than in 2005.

In 2020 in the reference scenario GDP per capita will be at levels that are 20% to 80% higher than in 2005, the highest increases being in the eastern European countries. A 20% higher GDP per capita corresponds to an annual growth rate of about 1.2%, while an 80% increase results from an annual growth rate of almost 4%. Growth rate of GDP per inhabitant is lower in the CO_2 reduction scenario EU-1 than in the reference in all countries except France (+1.0%). For the other countries effects range between close to zero for Finland (-0.29%) and the Netherlands (-0.29%) to -9.0% for Portugal. Interpretation has to take into account that the percentage difference of growth rates strongly depends on the value of the reference scenario. For Portugal the average growth rate between 2011 and 2020 is 1.82 in the reference and 1.66 in the reduction scenario, for the Netherlands growth rates are 1.70 and 1.69 in the two scenarios. It should be noted that normally GDP changes (of the level in 2020) and not changes of GDP growth rates are compared (see Figure 4.22). Overall the positive development described in the business-as-usual scenario above is not hampered to a great extend, though a negative link from CO_2 reduction to GDP per capita growth exists.

The direction of GDP impacts is in line with other results as the EU Commission (2008) impact assessment on the climate and energy package. But it is clearly stated in the impact assessment as well as in an overview of Dannenberg et al. (2008) on macroeconomic studies and is also the result of other still ongoing research with GINFORS that the specific policy design and especially the revenue recycling mechanism is very important and can even change the sign of the results, i.e. a trade-off between CO_2 reduction and GDP growth could become a synergy, if the same policy target is reached in the same model with another (better) policy design.

Investment ratios are more likely to rise in countries with a cumulative GDP per capita increase of significantly more than 30% in that period. Those countries with an increase of about 30% only, seem to have lower total investments in 2020 compared to 2005. An exception is the Czech Republic which has highest per capita income growth and third lowest investment ratio development compared to 2005 levels. Comparing the two scenarios, the impact on investment ratios is similar to the one of per capita income growth for most countries, but the scope is significantly lower. For a number of countries as Germany, Spain and the United Kingdom no trade-off between GHG emission reduction and total investment ratios can be observed.

Total employment rate slightly increases in most countries over time. This might be one reason for the higher per capita incomes, but when looking at the different countries, we cannot conclude that those countries with higher employment increases also have higher per capita growth rates or vice versa. On the labour market there is no clear pattern of impacts from the CO_2 reduction either. Total employment rate is higher in the reduction scenario in Belgium, Spain, Finland, France and Italy with the highest increase for Greece (0.74%). Trade-offs can be observed for Ireland, Portugal, Hungary and Slovakia (-1.28%, see Table 4.8).

Results for resource productivity are mixed. For 6 out of 13 countries including among others Germany, Greece and the UK a clear synergy between a reduction of GHG emissions and an increase in resource productivity is observed. For the others resource productivity, as GDP per unit of resource extraction, does not change significantly. It did increase in the business-as-usual scenario between 2005 and 2020 already substantially though, so that the effect of the GHG reduction seems to be only marginal.

Electricity consumption by households already reduces in the reference scenario with the exception of France and the Netherlands, but even more so in the reduction scenario. It is significantly reduced in scenario EU-1 in almost all EU countries compared to the reference. The highest synergies can be observed for Poland (-30.3%). But in Denmark, France and the Netherlands, where electricity is particularly important for heating, the share of electricity in heating can increase as electricity gains price competitiveness compared to fossil fuels. This holds especially for Denmark (+14.0%) with a high share of renewables and France (+13.8%) with most electricity stemming from nuclear power plants. Hence, the link here seems to be rather strong.

Impacts on general government consolidated gross debt are very small, partly as a result of the scenario design, as additional revenues are recycled via tax reductions.

Between 2005 and 2020 only five countries will be able to decrease their energy dependency (Finland, Greece, Italy, Portugal and Slovakia). Austria, Belgium, Ireland and Sweden do not experience a large change in their energy dependency, while the remaining seven countries (Germany, Spain, France, Netherlands, Czech Republic, Hungary and Poland) all have to import an increasing fraction of their energy consumption. Now, comparing the two scenarios, substitution from domestically extracted energy carriers to imported energy carriers can also be the reason for an increase in energy dependence of countries. The numbers for the change in energy dependency for Denmark and the UK have to be considered with care, since both countries have a negative energy dependency, meaning both countries are energy net exporters. Most EU-15 countries are able to decrease their energy dependence due to GHG emission reduction. For the new member states lower CO_2 emissions are connected to lower coal use which can increase dependence from Russian natural gas at the same time.

The increase in the share of renewables is already substantial in the reference scenario, but this increase is even higher in the emission reduction scenario, highlighting a significant linkage.

For the other indicators from themes 6 and 7 most results are straightforward. Road fuel prices strongly increase, even more than in the reference scenario, whereas the increase in energy consumption of the reference scenario is lowered by GHG reduction policies. Rail transport relatively profits from higher road fuel prices, but only for a few countries absolute increases are observed. A few anergies for rail transport in Denmark, Britain, Italy, the Netherlands and Slovakia indicate, that in the past rail transport in these countries neither related to energy price changes nor to changes of production or consumption levels.

In a more traditional view on the scenarios, Figure 4.22 shows changes of annual average growth rates of GDP between 2011 and 2020. Impacts are almost below perception. CO_2 emissions are reduced, but many countries will be far from the overall reduction target in 2020 mainly due to enormous increases between 1990 and today.

In a business as usual scenario, most economic indicators are positively linked (synergy), whereas environmental indicators will partly worsen, if economic performance improves (trade-off). Without going into detail the comparison of Table 4.8 and Table 4.9 shows that different perspectives of looking for synergies and trade-offs may deliver different results.

Table 4.8. Percentage changes in the unilateral 20% GHG reduction scenario against the reference scenario in 2020.

THEME/SUBTHEME	Level		Variable	AT	BE	DE	DK	ES	FI	FR	GB	GR	IE	IT	NL	PT	SE	CZ	HU	LU	PL	SK
SOCIO-ECONOMIC DEVELOPMENT	1	**Growth rate of GDP per inhabitant**	**I101L**	-2,88	-0,90	-5,36	-2,11	-0,82	-0,29	1,00	-4,83	-0,69	-4,24	-1,13	-0,29	-9,01	-1,37	-3,31	-2,83	-4,58	-4,21	-3,68
ECONOMIC DEVELOPMENT	2	Total investment	I102L	-0,37	-0,76	-0,05	-0,60	0,07	-0,42	-0,51	0,06	0,02	-0,05	-0,46	-0,77	0,34	-0,86	-3,87	-1,71	-0,02	-0,03	-0,01
	2	Public investment																				
	2	Business investment																				
INNOVATION, COMPETITIVENESS	2	Labour productivity per hour worked	I108L																			
EMPLOYMENT	2	Total employment rate	I114L	0,07	0,29	-0,09	0,04	0,42	0,22	0,23	-0,09	0,74	-0,56	0,63	0,18	-0,81	-0,01	-0,05	-0,75	-0,01	0,08	-1,26
SUSTAINABLE CONSUMPTION AN	1	**Resource Productivity**	**I201L**	0,16	-0,08	4,14	2,74	0,69	-0,05	-0,17	2,35	7,67	-0,09		1,83	-0,02	-0,17					
RESOURCE USE AND WASTE	2	Municipal waste generated																				
CONSUMPTION PATTERNS	2	Electricity consumption by households	I210L	-6,49	-4,77	-12,62	14,04	-10,57	-6,10	13,84	-11,20	-1,52	-1,42	-6,08	5,01	-6,18	-9,07	-13,52	-10,52	-13,56	-30,27	-12,82
PRODUCTION PATTERNS	2	Enterprises with an environmental management system																				
SOCIAL INCLUSION	1	**At-risk-of-poverty rate after social transfers, by gend**																				
MONETARY POVERTY AND LIVING	2	At-persistent-risk-of-poverty rate																				
ACCESS TO LABOUR MARKET	2	People living in jobless households, by age group																				
EDUCATION	2	Early school leavers																				
DEMOGRAPHIC CHANGES	1	**Employment rate of older workers**																				
DEMOGRAPHY	2	Life expectancy at age 65, by gender																				
OLD-AGE INCOME ADEQUACY	2	Aggregated replacement ratio																				
PUBLIC FINANCE SUSTAINABILITY	2	General government consolidated gross debt	I407L	-0,02	-0,02	0,03		-0,05	0,06	0,00				-0,03	-0,29							
PUBLIC HEALTH	1	**Healthy life years at birth, by gender**																				
	1	**Life expectancy at birth, by gender**																				
HEALTH AND HEALTH INEQUALITIE	2	Death rate due to chronic diseases, by age group																				
DETERMINANTS OF HEALTH	2	Salmonellosis incident rate in human beings																				
	2	Index of production of toxic chemicals, by toxicity class																				
CLIMATE CHANGE AND ENERGY	1	**Total greenhouse gas emissions**	**I601L**	-11,30	-9,12	-15,80	-24,02	-13,69	-16,02	-10,13	-13,12	-12,62	-9,64	-12,16	-9,90	-10,17	-16,30	-21,24	-10,11	-13,56	-23,78	-20,44
	1	**Renewables in gross inland energy consumption**	**I602L**	15,66	93,92	59,12	69,48	18,48	18,75	87,52	102,25	31,79	18,74	51,97	49,51	5,24	14,10	72,96	88,09		6,69	2,38
CLIMATE CHANGE	2	Greenhouse gas emissions by sector (including sinks)																				
ENERGY	2	Energy dependency	I607L	-3,94	-0,47	-5,18	11,39	-1,32	-7,84	-5,09	3596	-4,92	-0,88	-3,62	-13,11	-0,51	-1,67	8,89	-0,92		1,27	3,5
SUSTAINABLE TRANSPORT	1	**Energy consumption by transport mode**	**I701L**	-7,13	-11,80	-11,50	-11,12	-13,33	-13,15	-9,20	-12,01	-7,03	-9,06	-8,93	-7,46	-7,34	-20,74	-14,19	-9,60	-13,56	-13,44	-11,01
		- Rail	I701B	-0,98	-11,74	-1,19	0,00	-19,81	-4,72	0,23	-0,08	-1,70	8,96	-0,09	-0,05	-1,58	-2,77	-7,47	-0,60	-13,56	-2,97	0,04
		- Road	I701C	-6,80	-11,81	-12,07	-12,30	-13,05	-13,31	-8,92	-11,81	-7,14	-8,89	-9,29	-7,46	-7,19	-21,64	-14,60	-10,17	-13,56	-14,17	-11,25
		- Air	I701D	-13,74	-11,79	-10,45	-7,26	-13,57	-13,23	-11,96	-13,14	-6,52	-12,18	-7,23	-7,84	-8,94	-22,49	-10,25	-6,68	-13,56	-7,48	-15,29
		- Inland Navigation	I701E	-6,80	-11,81	-12,07	-12,30	-13,05	-13,31	-8,92	-11,81	-7,14	-8,89	-9,29	-7,46	-7,19	-21,64	-14,60	-10,17		-14,17	
TRANSPORT GROWTH	2	Modal split of passenger transport	I702L																			
	2	Modal split of freight transport																				
TRANSPORT PRICES	2	Road fuel prices	I706L	38,38	30,39	28,36	30,32	36,44	29,23	31,29	22,01	35,15	34,44	29,87	27,12	35,43	29,55	24,06	20,39		20,08	21,06
SOCIAL AND ENVIRONMENTAL IMF	2	Greenhouse gas emissions by transport, by mode																				
	2	People killed in road accidents																				
NATURAL RESOURCES	1	**Common Bird Index**																				
	1	**Fish catches taken from stocks outside safe biologic**																				
BIODIVERSITY	2	Sufficiency of sites designated under the EU Habitats dir																				
FRESH WATER RESOURCES	2	Surface and ground water abstraction																				
MARINE ECOSYSTEMS	2	Concentration of mercury in fish and shell fish																				
LAND USE	2	Built-up area	I810L																			
	2	Forest increment and fellings																				
GLOBAL PARTNERSHIP	1	**Official Development Assistance**	**I901L**																			
GLOBALISATION OF TRADE	2	EU imports from developing countries, (NOT) by income	I902L																			
FINANCING FOR SUSTAINABLE DE	2	Total EU financing for developing countries, by type																				
GLOBAL RESOURCE MANAGEMEN	2	CO_2 emissions per inhabitant in the EU and in developing	I911L	-11,30	-9,12	-15,80	-24,02	-13,69	-16,02	-10,13	-13,12	-12,62	-9,64	-12,16	-9,90	-10,17	-16,30	-21,24	-10,11	-13,56	-23,78	-20,44
GOOD GOVERNANCE																						
POLICY COHERENCE AND EFFECT	2	New infringement cases, by policy area																				
OPENNESS AND PARTICIPATION	2	Voter turnout in national and EU parliamentary elections																				
ECONOMIC INSTRUMENTS	2	Shares of environmental and labour taxes in total tax rev	I006L																			

Synergy
Anergy
Trade-off

Table 4.9 Index developments in the reference scenario for 2020 compared to 2005 (= 100).

THEME/SUBTHEME	Level		Variable		AT	BE	DE	DK	ES	FI	FR	GB	GR	IE	IT	NL	PT	SE	CZ	HU	LU	PL	SK
SOCIO-ECONOMIC DEVELOPMENT	1	**Growth rate of GDP per inhabitant**	**I101L**		132.24	136.16	127.50	121.54	134.27	143.60	135.35	130.33	155.38	154.81	130.65	128.09	130.82	133.53	182.93	178.57	149.33	182.19	168.51
ECONOMIC DEVELOPMENT	2	Total investment	I102L		93.69	95.07	78.25	82.51	96.41	102.52	105.14	120.25	130.61	111.22	78.45	102.66	97.07	107.88	92.46	102.39	102.05	115.27	104.27
	2	Public investment																					
	2	Business investment																					
INNOVATION, COMPETITIVENESS /	2	Labour productivity per hour worked	I108L																				
EMPLOYMENT	2	Total employment rate	I114L		112.25	115.51	103.06	101.35	120.46	119.71	98.64	106.40	104.80	118.14	111.09	116.63	112.25	107.62	105.75	138.42	100.70	101.27	137.21
SUSTAINABLE CONSUMPTION ANI	1	**Resource Productivity**	**I201L**		144.05	153.70	145.78	126.49	121.63	139.62	139.98	155.13	200.98	130.01		134.44	127.48	156.56					
RESOURCE USE AND WASTE	2	Municipal waste generated																					
CONSUMPTION PATTERNS	2	Electricity consumption by households	I210L		83.73	89.70	77.41	36.62	91.84	76.85	74.03	93.23	98.77	93.10	91.14	75.44	129.78	92.46	66.25	95.59	98.54	170.76	110.75
PRODUCTION PATTERNS	2	Enterprises with an environmental management system																					
SOCIAL INCLUSION	1	**At-risk-of-poverty rate after social transfers, by gend**																					
MONETARY POVERTY AND LIVING	2	At-persistent-risk-of-poverty rate																					
ACCESS TO LABOUR MARKET	2	People living in jobless households, by age group																					
EDUCATION	2	Early school leavers																					
DEMOGRAPHIC CHANGES	1	**Employment rate of older workers**																					
DEMOGRAPHY	2	Life expectancy at age 65, by gender																					
OLD-AGE INCOME ADEQUACY	2	Aggregated replacement ratio																					
PUBLIC FINANCE SUSTAINABILITY	2	General government consolidated gross debt	I407L		177.61	135.16	168.16		142.45	146.21	163.52				138.03	144.20							
PUBLIC HEALTH	1	**Healthy life years at birth, by gender**																					
	1	**Life expectancy at birth, by gender**																					
HEALTH AND HEALTH INEQUALITIE	2	Death rate due to chronic diseases, by age group																					
DETERMINANTS OF HEALTH	2	Salmonellosis incident rate in human beings																					
	2	Index of production of toxic chemicals, by toxicity class																					
CLIMATE CHANGE AND ENERGY	1	**Total greenhouse gas emissions**	**I601L**		103.35	105.56	96.16	86.74	100.06	88.71	89.70	90.80	99.93	108.29	101.91	95.45	106.23	120.38	79.14	100.08	98.54	114.95	110.36
	1	**Renewables in gross inland energy consumption**	**I602L**		95.40	181.57	251.97	101.57	203.53	146.99	111.37	200.67	325.12	248.17	125.72	171.04	119.18	160.23	128.89	127.86	100.00	134.82	560.06
CLIMATE CHANGE	2	Greenhouse gas emissions by sector (including sinks)																					
ENERGY	2	Energy dependency	I607L		100.95	100.63	103.70	120.57	103.04	89.41	110.20	0	97.71	100.08	96.85	128.73	95.89	101.50	156.34	102.76	100.00	274.91	87.6
SUSTAINABLE TRANSPORT	1	**Energy consumption by transport mode**	**I701L**		107.91	126.56	101.60	98.55	149.90	98.19	103.33	114.44	102.31	155.31	105.09	106.79	117.08	76.60	131.93	120.66	98.54	184.16	138.43
		- Rail	I701B		94.03	68.87	87.32	100.00	193.68	95.13	121.28	103.23	104.18	325.40	112.83	110.65	135.20	128.34	142.86	138.29	98.54	194.80	147.97
		- Road	I701C		109.99	117.75	95.69	96.52	147.28	99.25	99.09	108.64	106.24	152.92	100.85	105.75	115.67	73.85	133.73	122.20	98.54	185.21	139.27
		- Air	I701D		88.65	190.21	142.73	108.14	158.78	91.09	127.95	133.82	79.13	156.08	149.00	109.95	126.56	83.83	96.23	82.65	98.54	129.31	58.29
		- Inland Navigation	I701E		109.99	117.75	95.69	96.52	147.28	99.25	99.09	108.64	106.24	152.92	100.85	105.75	115.67	73.85	133.73	122.20		185.21	
TRANSPORT GROWTH	2	Modal split of passenger transport	I702L																				
	2	Modal split of freight transport																					
TRANSPORT PRICES	2	Road fuel prices	I706L		110.63	113.62	111.82	114.10	116.72	117.49	114.38	108.79	125.68	109.35	117.24	107.92	114.18	110.40	119.90	134.01	100.00	132.58	100.00
SOCIAL AND ENVIRONMENTAL IMF	2	Greenhouse gas emissions by transport, by mode																					
	2	People killed in road accidents																					
NATURAL RESOURCES	1	**Common Bird Index**																					
	1	**Fish catches taken from stocks outside safe biologic**																					
BIODIVERSITY	2	Sufficiency of sites designated under the EU Habitats dire																					
FRESH WATER RESOURCES	2	Surface and ground water abstraction																					
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FINANCING FOR SUSTAINABLE DE	2	Total EU financing for developing countries, by type																					
GLOBAL RESOURCE MANAGEMEN	2	CO_2 emissions per inhabitant in the EU and in developinç	I911L		101.72	104.02	96.63	83.76	97.01	86.09	86.20	86.70	99.07	91.80	103.62	91.48	102.26	114.71	81.43	104.97	83.01	117.44	111.41
GOOD GOVERNANCE																							
POLICY COHERENCE AND EFFECT	2	New infringement cases, by policy area																					
OPENNESS AND PARTICIPATION	2	Voter turnout in national and EU parliamentary elections																					
ECONOMIC INSTRUMENTS	2	Shares of environmental and labour taxes in total tax reve	I006L																				

🟩 Synergy
🟨 Anergy
🟥 Trade-off

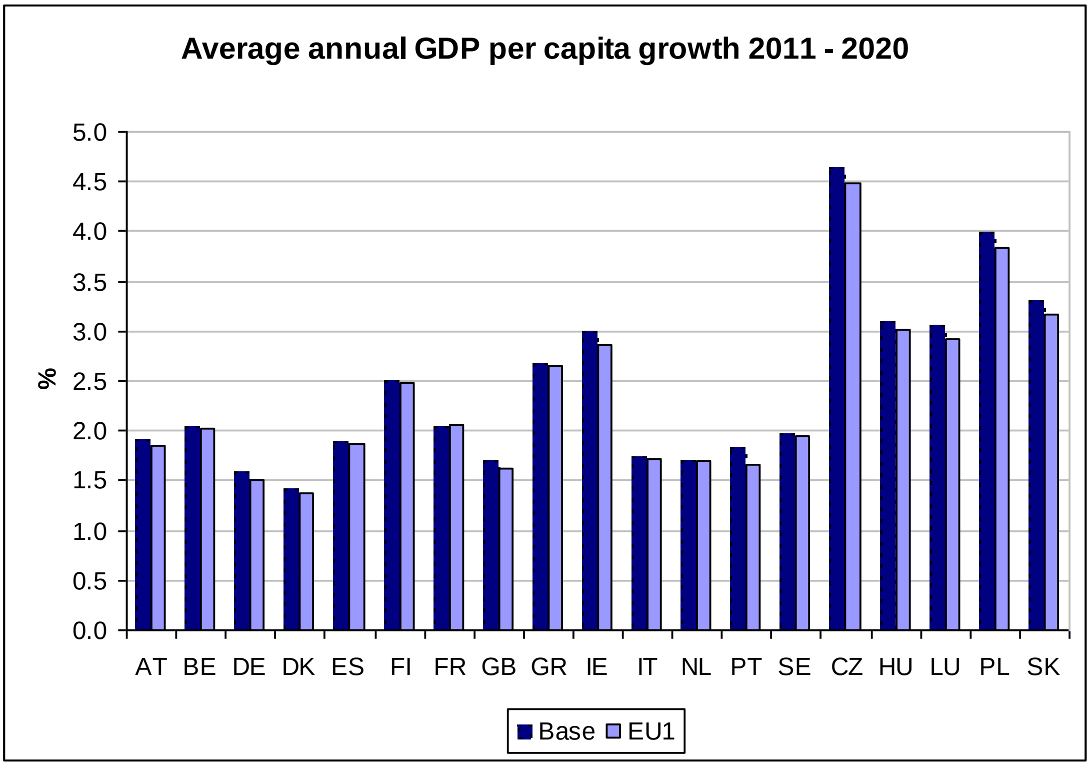

Figure 4.22 GDP per capita growth in the two simulations for EU-19.

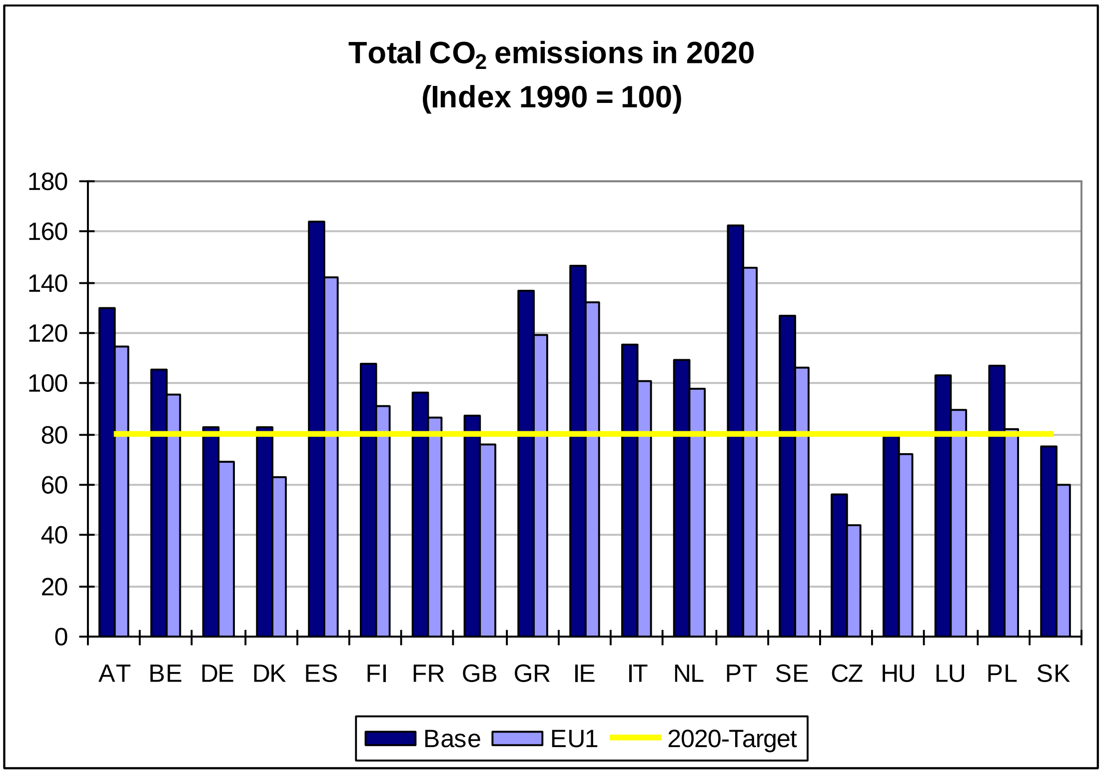

Figure 4.23 Total CO_2 emissions in the two simulations for EU-19 (1990 = 100).

4.4 Conclusions and outlook

GINFORS is capable of providing scientifically sound, policy relevant insights into the links between economic growth, economic activity at a sector level and environmental themes including climate change and material consumption. Some social aspects as unemployment and gross debt are also included. The model is among others used for EU policy simulations (GWS/Prognos 2007, Lutz et al. 2008) in a global context. The model is well suited for revealing interlinkages among different SDIs and to assess different policy strategies to overcome possible trade-offs.

GINFORS is based on publicly available data sets from international organisations. Due to the interdependence of the modelling system all input data is also output. Only some exogenous variables such as population forecasts will not change.

GINFORS is used for forecasts and scenario analysis. Different SDIs with a focus on the economic and environmental pillar are explicitly modelled. Due to the full interdependency of the system, variations in exogenous variables such as policy instruments in model simulations deliver a consistent picture of the changes in the different SDIs. Intra-pillar and extra-pillar interlinkages are covered. All linkages are quantitative.

The inclusion of SDIs in the model proved to be very helpful for evaluating policy measures. Other models used for impact assessment should take the indicators specifically into account to enable policy makers to compare their plans to impacts on SDIs. Once integrated in the models, the SDIs will be calculated in every model simulation. Ongoing modeling in other projects hint that the policy design of CO_2 emissions reductions can change the sign of changes in different SDIs compared to the scenarios above. Policy should try to turn as many trade-offs into anergies or even synergies as possible. Further modeling work with GINFORS might focus on the impacts of the renewable and energy efficiency part of the EU climate and energy package and on strategies to improve resource efficiency.

Concerning the further development of the additional indicators, GINFORS is able to contribute to

- environmentally weighted indicator of material consumption,
- external costs of transport activities, and
- total material consumption and GDP at constant prices.

A weakness of the approach (the general data availability) is the poor coverage of the social pillar. However, applications in Germany show that it is possible to enlarge the model in the social dimension. Another potential weakness is the complex model structure and the large datasets needed for the model.

SDIs are linked indirectly via a complex modeling system. Therefore the linkages depend on the set of policy measures taken into account in scenarios. Synergies or trade-offs strongly depend on the covered policy measures. In a business as usual scenario, most economic indicators are positively linked (synergy), whereas environmental indicators will worsen, if economic performance improves (trade-off).

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5. DEAN

5.1 Introduction

In task 2.3.2, extrapolations and modelling of future interlinkages, of the INDI-LINK project we apply the multi-sectoral dynamic applied general equilibrium model DEAN, to analyse future (scenario-driven) interlinkages between sustainable development indicators (SDIs).

This report is structured as follows. A brief description of the DEAN model is given in Section 5.2.1. Section 5.2.2 describes how a number of variables in DEAN are related to SDIs. Section 5.3 explains how DEAN is used to assess the interlinkages between SDIs. In a first step, the future development of the SDIs is projected in a benchmark projection in Section 5.3.1. Section 5.3.2 then describes some policy scenarios. Key economic and environmental results of the policy scenarios are presented in Section 5.3.3. Section 5.4 further reflects on the interlinkages in DEAN. Finally, Section 5.5 concludes and makes recommendations for further research.

5.2 The DEAN Model

5.2.1 General description of the model

The DEAN model[8] is a multi-sectoral dynamic applied general equilibrium (AGE) model for a small open economy with special attention to the specification of pollution and abatement for several major environmental themes simultaneously. The framework for the model is a Ramsey-type economic growth model with perfect foresight. A detailed description of the model, the treatment of environmental issues and data sources can be found in Dellink (2005); below, the main model characteristics are briefly sketched.

The AGE model describes the relationships between economic agents. These economic agents can be households (consumers), firms (producers), other countries and the government. Firms are grouped together into production sectors. Producers operate under full competition and maximise profits subject to their production technology, for given prices. Under constant returns to scale, this leads to the first of the three basic conditions: the *zero profit condition*. Households are grouped into household groups. As the model assumes all households to behave identically, they can be aggregated into one representative consumer. Households maximise their utility subject to a budget constraint, for given prices and given initial endowments. This is the second basic condition: the *income condition*. The economy is said to be in equilibrium if every agent can satisfy his/her demand or supply for each good, given a set of (relative) market prices that is common to all agents. In other words, total demand must equal total supply on all markets. This is referred to as *market clearance*, the third class of basic AGE conditions. Equilibrium is attained through adjusting the relative prices. The resulting prices are called equilibrium prices.

The environment is treated as necessary input to production. An intuitive way of looking at this is to think of environmental services as input for production, for which emission permits are required. These environmental services can be regarded as the allowance to emit polluting sub-

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[8] DEAN stands for *D*ynamic applied general *E*quilibrium model with pollution and *A*batement for The *N*etherlands.

stances to the environment. The costs associated with this input concern the payments for the emission permits that are required to use the environmental resource, *i.e.* a transaction between the polluter and the government. A similar approach is used in AGE modelling by, amongst others, Bergman (1990; 1991), Conrad and Schröder (1991; 1993), Robinson *et al.* (1994) and Welsch (1996).

The model contains seven environmental themes: climate change, acidification, eutrophication, smog formation, dispersion of fine dust, desiccation, and soil contamination. The main rationale for using these environmental themes is that they form the basis for environmental policy in The Netherlands. Moreover, combining different related polluting substances in an environmental theme ensures that the interactions between the substances involved are properly taken into account. The emissions of different substances that contribute to a certain environmental theme are converted to theme-equivalents to be able to add them up. For climate change, all major greenhouse gases (GHGs), including carbon dioxide, methane, nitrous oxide, CFCs, HCFCs, HFC and halons, are combined using their long-term global warming potentials. Desiccation and soil contamination concern cleaning up past pollution and are represented in the model by a fixed governmental expenditure on abatement, rather than emissions.

Abatement is itself an economic activity and should be modelled as such. Many models ignore the interactions between abatement activities and the rest of the economy, even though these interactions may be significant. In DEAN, essential bottom-up information on abatement measures is integrated in a top-down framework, thereby allowing a detailed analysis of the direct and indirect costs of environmental policy. Key information included in the model is (i) the abatement costs at different levels of abatement (the abatement cost curves), (ii) the technical potential of emission reduction that can be achieved by implementing technical abatement measures and (iii) the cost components of these technical abatement measures. These cost components describe the inputs used in the abatement process and include labour costs, capital costs and energy costs. Note that the abatement cost curves contain all known available technical options to reduce pollution, both end-of-pipe as well as process-integrated options, including substitution among different inputs (e.g. fuel switch). All these elements are specified in a dynamic manner. Polluters have the endogenous choice between paying for pollution permits or increasing their expenditures on abatement. The extent to which this substitution is possible and the characteristics of producing abatement are derived from empirically estimated abatement cost curves.

Emissions are related to the output levels of producers and consumption levels of consumers. This implies that GHG emissions are not directly linked to fuel use (as an input). Though this specification matches the set-up of the abatement cost curves (as changes in fuel mix and their impacts on emissions are incorporated there), it denies the indirect effects of abatement on the demand for fuels.[9] The advantage of this approach over the common approach in integrated climate-energy-economy models is that all possible options, including end-of-pipe measures, are taken into account.

The climate module that is needed to calibrate the GHG stock addition of The Netherlands is kept very simple. Based on the DICE model (Nordhaus, 1994), first an annual decay factor for the existing stock of GHGs is specified. This decay factor is assumed to apply to all contributions of The Netherlands to the stock of greenhouse gases and is used to calculate how much of the GHG stock addition in a period carries over to the next period. Secondly, a marginal reten-

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[9] The impact of this approximation remains limited, as shown in Verbruggen et al. (2000).

tion rate determines how much emissions contribute to the stock addition. Since not all emitted GHGs remain in the atmosphere, this retention rate is smaller than unity. These two items imply that the addition to the stock caused by one unit of emissions is lower than unity and varies over time.

It should be noted that the DEAN model does not aim at providing an optimal climate policy. For that purpose, global energy-economy models are better suited. The strength of the DEAN model lies in its ability to embed climate policy in a wider environmental policy plan. In terms of the IndiLink project, the strength of the DEAN model is to describe and quantify future interlinkages between indicators from different SD pillars (economic, environmental).

5.2.2 SDIs included in the DEAN model

The DEAN model includes a number of variables that are related to SDIs. Table 5.1 presents a selection of these variables.

Table 5.1 Variables in DEAN related to SDIs.

Theme	Subtheme (Level)	Variable in DEAN	Description
Socio-economic development	Growth rate of GDP per inhabitant (L1)	GDP	Gross Domestic Product in Euro billion (1990 prices)
	Net national income (L3)	NNI	Net National Income in Euro billion (1990 prices)
	Gross household saving (L3)	S	Savings in Euro billion (1990 prices)
Sustainable production and consumption	Emissions of acidifying substances by source sector (L3)	ACID	Acid equivalents (million)
	Emissions of ozone precursors by source sector (L3)	SMOG	Volatile organic compounds, excluding methane (million kilograms)
	Emissions of particulate matter by source sector (L3)	PM10	“Fine dust (PM10)”, (million kilograms)
Climate change and energy	Greenhouse gas emissions (L1)	CLIM	CO_2-equivalents (billion)

Socio-economic development (Theme 1)

The Level 1 indicator of theme 1 “Socio-economic development“ is defined as the growth rate of gross domestic product (GDP) per inhabitant at constant prices (1995) (referred to as real GDP per capita), expressed as percentage change on previous year. The indicator is defined for all EU member states.[10] The DEAN model computes a policy-dependent GDP for the Nether-

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[10] Eurostat, Sustainable Development Indicators.

lands in five year steps from 1990 to 2095. GDP is in constant 1990 prices and it can be reported in billions of Euros or as a percentage change from benchmark (no policy) GDP. To match GDP from DEAN to the SDI, its price base should be adjusted from 1990 to 1995 and its annual growth rate should be computed. In the DEAN model, the benchmark growth of GDP is 2 percent per year. Note again that the geographical domain of DEAN is restricted to the Netherlands.

The Level 3 Indicator "Net national income" is defined as GDP minus primary income payable by resident units to non-resident units, plus primary income receivable by resident units from the rest of the world, minus the consumption of fixed capital. Net national income is also calculated by DEAN; its benchmark growth is also 2 percent per year. The same technical comments as to GDP apply.

The Level 3 Indicator "Gross household saving" is defined as the portion of disposable income that is not used by the household for final consumption. It is measured by gross saving divided by gross disposable income adjusted for the change in the net equity in pension fund reserves. The savings rate in the DEAN model is an endogenous variable that maximizes the present value of the utility of the representative consumer in a forward looking framework.[11]

Sustainable consumption and production (Theme 2)

The Level 3 Indicator "Emissions of acidifying substances by source sector" is an aggregate of acidifying substance emissions (sulphur dioxide, nitrogen oxides and ammonia) in terms of their acidifying effects, and expressed in acid equivalents. The indicator reports emissions for eight source sectors. DEAN includes acidifying substance emissions ("ACID") in the same metric (acid equivalents).

The Level 3 Indicator "Emissions of ozone precursors by source sector" reports on emissions of ozone precursors (nitrogen oxides, carbon monoxide, methane and non-methane volatile organic compounds), by source sector. Ozone precursor emissions are combined in terms of their tropospheric ozone-forming potential, and expressed in NMVOC equivalents. DEAN includes a "SMOG" variable in terms of non-methane volatile organic compounds only.

The Level 3 Indicator "Emissions of particulate matter by source sector" reports on emissions of primary particles, and secondary particulate precursors (sulphur dioxide, nitrogen oxides and ammonia). Particulates and particulate precursor emissions are combined in terms of their particulate-forming potential and expressed in terms of particulate-forming equivalents. DEAN includes a "PM10" variable in terms of primary particles (PM10) only.

The DEAN model also includes an indicator of eutrophication (EUTRO) that has no direct SDI counterpart but that does play a role in the subsequent scenario analyses in this paper. The eutrophication indicator is composed of a weighted combination of the emissions of nitrogen and phosphorus. In the Dutch circumstances, it is an important environmental theme that has direct consequences for sustainable consumption and production. DEAN furthermore accounts for defensive environmental expenditures on dessication and soil contamination. While these do not reflect ongoing emissions, the restoration of a good environment by cleaning up past pollution is an essential step in the transition towards Sustainable Development.

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[11] The endogenous savings rate is a characterizing feature of Ramsey-type growth models (see Section 5.2.1)

Climate change and energy (Theme 6)

The Level 1 Indicator “Greenhouse gas emissions” is an index of non-fluorinated gases (CO_2, CH_4 and N_2O), and fluorinated gases (HFC, PFC and SF_6), weighted by their global warming potentials (GWPs), with base year = 100. In general, the base year is 1990 for the non- fluorinated gases and 1995 for the fluorinated gases. DEAN includes a “CLIMATE” variable that is a GWP-weighted sum of non-fluorinated and fluorinated gases in CO_2-equivalents.

5.3 Assessment of future interlinkages

5.3.1 Benchmark projection

The Dutch economy is projected to grow at a balanced growth rate of 2% per year. The growth is fuelled by an autonomous increase in effective labour supply. Growth in effective labour supply combines demographic developments, i.e., increases in the number of workers, and developments in labour productivity, i.e. increases in the production per worker. The rate of growth of effective labour supply is calibrated on Dutch data from the period 1990-2000 (Dellink, 2005). Along the balanced-growth path, all economic variables grow at the speed of the balanced growth rate. Figure 5.1 presents the benchmark projections for GDP, NNI and savings (S).

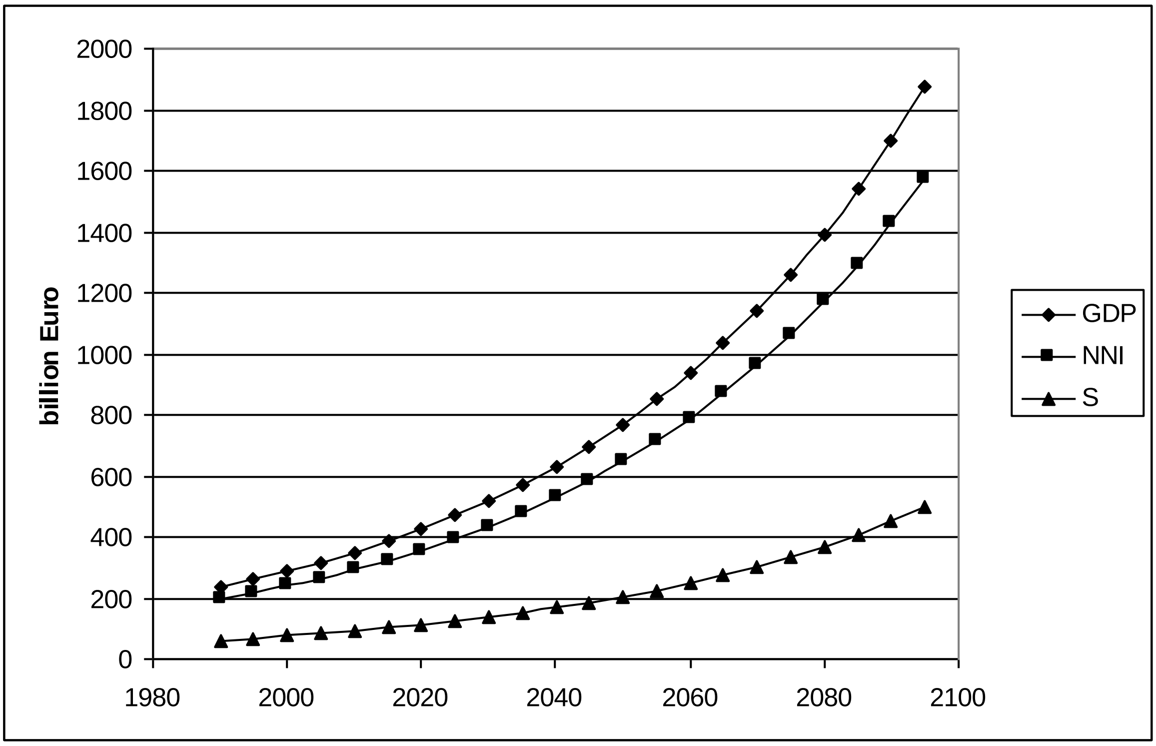

Figure 5.1 Benchmark growth of GDP, NNI and Savings

The difference between the growth rate of the economy and the growth rate of emissions in the benchmark projection is described by the autonomous pollution efficiency improvement (APEI) parameter. This difference may be the result of free efficiency improvements as some sort of ‘manna from heaven’, but also captures the impacts of any abatement activities in the benchmark projection. The autonomous pollution efficiency improvements are calibrated for each environmental theme separately using the realised development of emission levels between 1990 and 2000. As it is unrealistic to assume that high autonomous pollution efficiency improvements can be sustained in a growing economy without additional abatement efforts, the ad-hoc assumption is made that the efficiency improvements gradually change over time to the common benchmark growth rate of 2%, such that benchmark emissions are stabilised in 2030 and beyond. (cf. Dellink and Van Ierland, 2006). Figure 5.2 presents benchmark projections of the environmental themes.

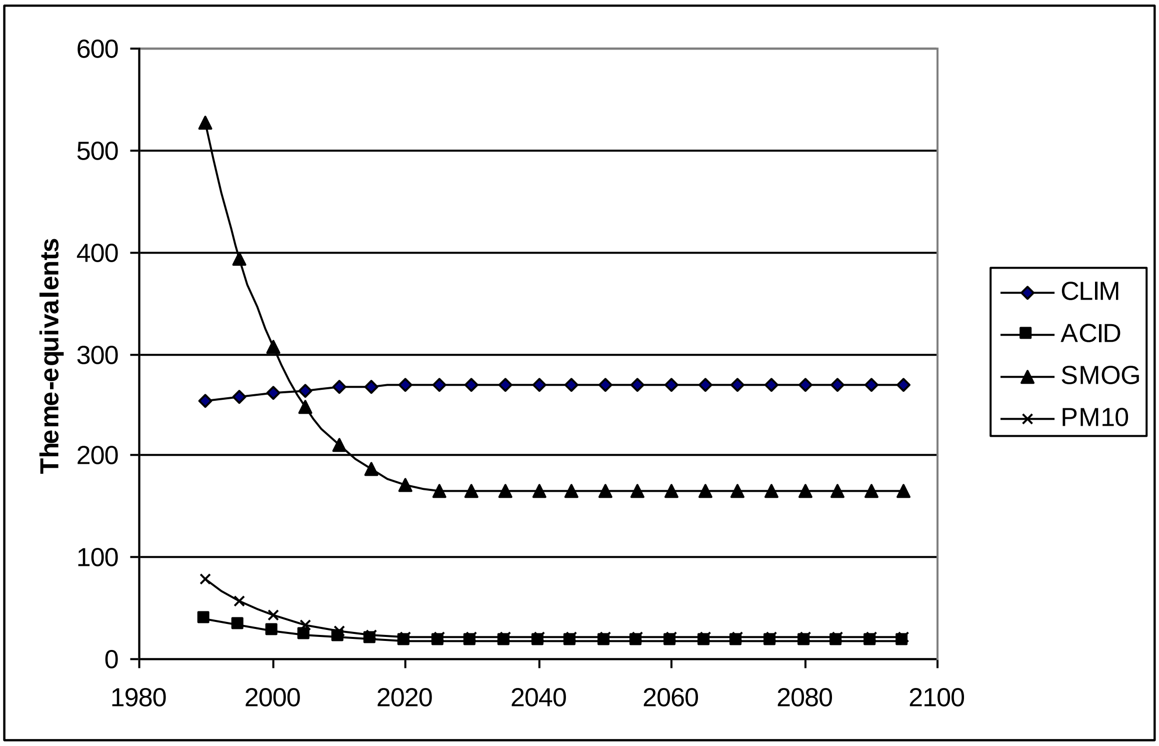

Figure 5.2 Benchmark growth of environmental themes

5.3.2 Policy Scenarios

Next to the benchmark scenario, three policy scenarios are constructed and analysed: the *Integrated Stock Policy* scenario, the *Integrated Emission Policy* scenario, and the *Stand-Alone Policy* scenario. The environmental policy targets for the year 2030 used in these scenarios are based on the Dutch Fourth National Environmental Policy Plan (VROM, 2001).

Table 5.2 Policy targets for environmental themes in the Netherlands for 2030

Environmental theme[1)]	Reduction target 2030 (%-change compared to 1990)
Climate change –CLIM	– 50%
Acidification –ACID	– 85%

Eutrophication –EUTRO	– 75%
Smog formation –SMOG	– 85%
Dispersion of fine dust –PM10	– 90%

[1)] For explanation of the environmental themes and comparison to SDIs, see Section 5.2.2

For the themes acidification, eutrophication, smog formation and dispersion of fine dust, the policy targets act as a restriction on the maximum allowable emissions in the target year 2030. For the policy simulations with DEAN, these targets have to be translated into maximum allowable emission paths. In other words, an exogenous supply of pollution permits has to be imposed for all periods in the model horizon. Since no explicit goals exist for periods before or after the policy target year, the *ad hoc* assumptions are made that (i) in periods 1 to 3 (until 2004) emissions can follow the benchmark projection[12]; (ii) from period 4 (2005), a reduction path towards the target is imposed, that is linear in terms of reduction percentages, as this allows for a gradual adjustment process, and (iii) after the policy target is reached, emissions cannot increase.

In the *Integrated Stock Policy* scenario, the government aims at controlling the concentrations of greenhouse gases in the target year 2030 and beyond, while for the other environmental themes the government auctions tradable emission permits. To reflect the stock pollutant property of greenhouse gasses, the government does not auction emission permits for climate change, but ‘GHG stock addition permits’. The government sets a policy target on the total stock addition of the Netherlands, *i.e.* restricts the number of permits to be auctioned over the entire model horizon, and polluters have to buy the GHG stock addition permits to be able to emit GHGs. Hence polluters have annual expenses on GHG permits, even if the target for the total stock addition is not yet met. Note that only domestic emissions and stock additions are controlled in this manner.

For climate change, the emission target as laid down in the environmental policy plans is specified in terms of emission reductions. This target is translated into a target for total allowable addition to the stock of greenhouse gasses (GHGs) over the model horizon, to allow flexibility in timing of emission reductions. The emission reduction target for the target year gives insufficient information to calculate the stock addition target, as the emissions in other years are in principle unrestricted. Therefore, a two-step approach is used. Firstly, a proposed path of GHG emissions is formulated that is consistent with the actual emission policy target for 2030, analogue to the maximum allowable emission paths for the other environmental themes (*i.e.* a linear reduction path between 2005 and 2030 and constant emissions thereafter). Secondly, the stock addition over the model horizon that would result from this emission path is calculated. This calculated stock addition is then taken as the maximum allowable stock addition in the *Integrated Stock Policy* scenario. It should be stressed that the proposed emission path is not imposed in this scenario: emissions can fluctuate over time, as long as the stock addition target is not exceeded.

In the *Integrated Emission Policy* scenario, climate change is specified as a flow pollutant, just as the other environmental themes. That is, the *proposed path* of emission reductions is imposed, and the government issues emission permits instead of stock addition permits. Note that environmental pressure, as measured by total addition to the stock of GHGs, is identical for both specifications.

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[12] Remember that one period spans over 5 years. Period 3 starts in 2000, period 4 in 2005.

Finally, the *Stand-Alone Policy* scenario mimics the *Integrated Stock Policy* scenario for climate change, but no stringent policies are formulated for the other environmental themes.

The total addition to the stock of greenhouse gases is identical across the scenarios. There may be a slight difference in environmental quality, as earlier emission reductions imply smaller radiative forcing.

The three policy scenarios are compared to the benchmark projection that was described in Section 5.3.1.

5.3.3 Results

Macroeconomic results

All policy scenarios show that enforcement of the environmental policy targets lead to a reduction of economic activity as measured by GDP. The change in GDP in comparison to the benchmark projection over the periods is shown in Figure 5.3.

In the *Integrated Stock Policy* scenario, GDP levels drop in the long run to around 10 to 11 percent below the benchmark projections. This does not mean that absolute levels of GDP are declining; the annual growth rate of GDP stays well above zero for all periods. Clearly, these numerical results have to be interpreted with care, given the shortcomings in the model specification. These macro-economic costs of environmental policy cannot be disregarded, but in light of the significant reductions in environmental pressure for several environmental themes simultaneously, they can be characterised as modest. In comparison, current environmental costs in the Netherlands amount to more than 3 percent of GDP (RIVM, 2002), though this figure includes the costs of waste management, a theme that is not present in the DEAN model.

Though the private households have perfect foresight on the future level of environmental policy, and know the future prices of environmental permits, the paths of GDP is not completely smooth. The extent to which consumers switch between current and future consumption is driven by the constant intertemporal elasticity of substitution (this elasticity equals 0.5 for the private households). The properties of the intertemporal utility function imply that the further the consumers shift their consumption away from the original equilibrium, the less they can fulfil their preferences and the larger the disutility is that is associated with this shift. Therefore, the costs, in terms of a decrease in utility, increase more than proportionately if more consumption is shifted intertemporally. In effect, the development of GDP and NNI over time reflects a combination of the required emission reductions and a temporary slowdown of economic growth.

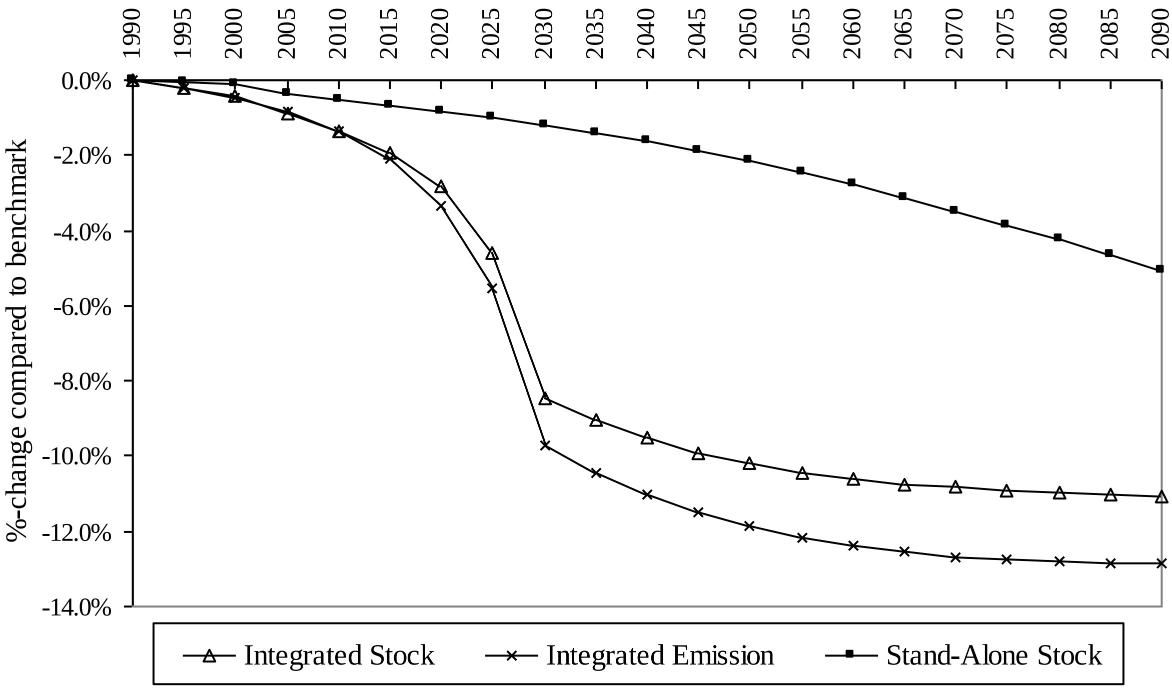

Figure 5.3 Results of the environmental policies on the development of GDP

As noted before, the drop in GDP growth does not mean that absolute GDP levels are declining. Whereas in the benchmark the growth rate of GDP equals 2 percent, the economic growth rate remains in all scenarios above 1 percent throughout the model horizon. In fact, the growth rate of the economy comes very close to the benchmark level in the second half of the century, implying that the environmental policy, which has constant emission reduction percentages in the long run, has only a temporary effect on the growth rate of the economy. The decrease in the absolute level of GDP is, however, lasting. From Figure 5.3 we may conclude that a structural reduction of emissions of at least 50 percent for all environmental themes in the DEAN model will lead to a GDP that is structurally around 10 to 11 percent below what it would have been without the environmental policy.

For the *Integrated Emission Policy* scenario, the GDP-losses are roughly 2 percent-point larger, while the growth rate of GDP is hardly affected by the alternative policy assumption. As there is less flexibility on the market for climate change permits, it is not surprising that the economic costs are larger than in the stock-oriented policy. In this scenario, the constant reduction targets for all environmental themes after 2030 imply that the *undiscounted* marginal costs are equal over time, as there are no possibilities to shift part of the burden to other periods.

For the *Stand-Alone Policy* scenario, the macro-economic costs of the policy are purely determined by the costs of greenhouse gas emission reductions and these are minimised by equalising *discounted* marginal costs. Until 2020, the costs are below 1 percent compared to the benchmark, but in the long they increase to 2.2 percent in 2050 and around 5 percent at the end of the century. The impact on GDP of the *Stand-Alone* scenario cannot be compared with the impact on GDP of the other policy scenarios because these other policy scenarios cover more environmental themes. A direct comparison is possible by comparing permit prices, as is done in Section 0.0.0 below.

Since the monetarised benefits of environmental policy are not analysed in this paper, it is impossible to say whether these costs are justified. It is up to policy makers to decide whether the environmental benefits outweigh the economic costs or not. The DEAN model can play a role in assessing the economic costs and show relevant mechanisms that influence the interactions between economic and environmental indicators of sustainable development.

Environmental results

Figure 5.4 shows the development of greenhouse gas emissions over time according to the three scenarios. These differ solely in the timing of emission reductions; the total contribution of the Netherlands to the global stock of greenhouse gases is identical across the scenarios.

In the stock-oriented scenarios, *Integrated Stock Policy* and *Stand-Alone Policy*, some GHG emissions are reduced in 1990, even though the assumption is made that between 1990 and 2000 no technical abatement measures are available. The 1 percent reduction in GHG emissions is therefore fully achieved via a restructuring of the economy, *i.e.* via the reduction of agricultural and industrial production.

The flexibility in the timing of GHG emission reduction is used by the polluters to place some more emphasis on reductions in the later periods, allowing for higher emissions in the early periods (compare the *Integrated Stock Policy* and *Integrated Emission Policy* scenarios). The path of emission reductions that emerges for the stock policies is based on an equalisation of the discounted costs over time.

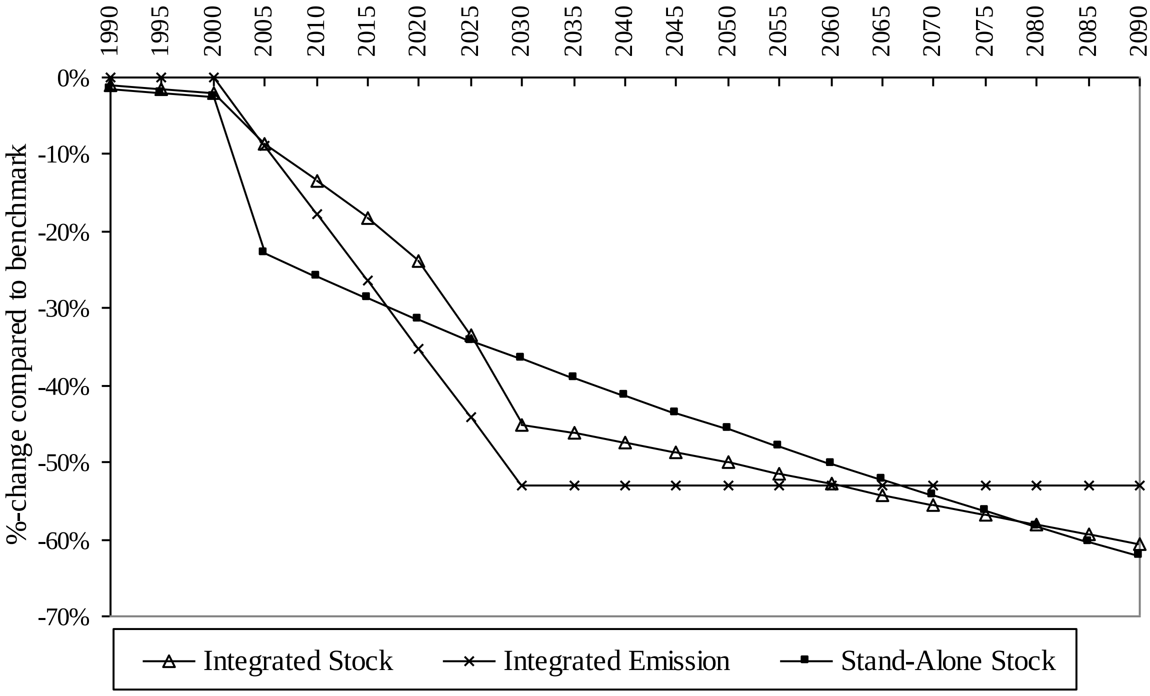

Figure 5.4. Results of the environmental policies on the development of GHG emissions

One mechanism that drives the timing is the positive discount rate, which implies that late emission reductions are relatively cheap in net present value terms. A second mechanism is the increasing marginal abatement costs with increasing abatement levels. This leads to a smooth path of emission reductions over time, avoiding peaks in any period. The third mechanism is given by the interaction with other environmental policies. *Ceteris paribus*, it is efficient to time GHG emission reductions to coincide with the reductions of emissions for the other environmental themes, as these induce changes in the economic structure that also influence GHG emissions (compare the *Integrated Stock Policy* and *Stand-Alone Policy* scenarios). This also explains the kink in the lines for the scenarios *Integrated Stock Policy* and *Integrated Emission Policy* around 2030: until 2030 the required reduction percentages of the other environmental themes increase, while from 2030 onwards they are stable (*cf.* Section 5.3.2). A relatively smooth path of GHG emission reductions emerges, avoiding peaks in any period and with additional emphasis on late reductions. This means that emission reductions can be limited for the first few decades.

Emissions per unit production or consumption are declining for each theme, indicating a decrease in environmental intensity of production and consumption. Moreover, in absolute terms, emissions are declining, while economic growth remains positive. Therefore, the conclusion can be drawn that both a relative and absolute decoupling of economic growth and environmental pressure is possible, given the availability of the abatement measures.

The permit prices for climate change can be reported either as the price of one kilogram of stock addition or as the price of one kilogram of emissions. These two prices differ as one kilogram of CO_2-equivalent emissions leads to less than one additional kilogram stock of CO_2-equivalents, given the calibrated marginal retention rate that is smaller than unity. In Figure 5.5 the climate change permit prices are given in Euro per ton of emissions in CO_2-equivalents. Total expenditures on climate change permits do not depend on the way the permit prices are represented. The reported permit prices are comparable to those found in the literature, especially in the more elaborated global energy-economy models (Kuik et al., 2009; Weyant et al., 2006).

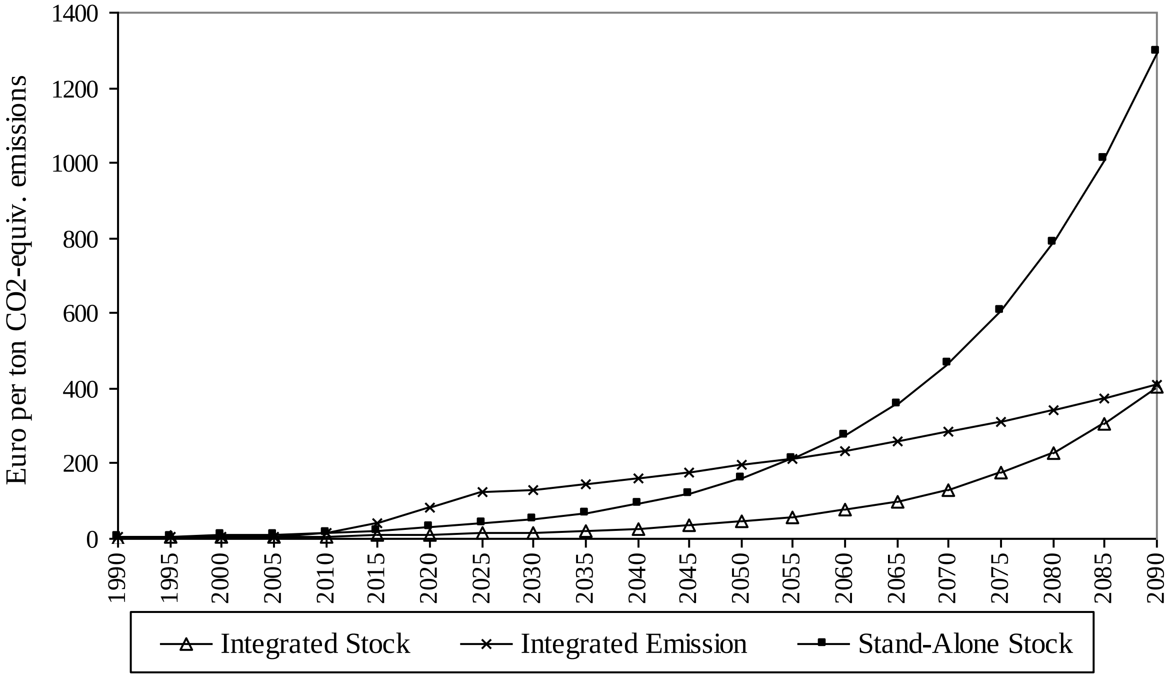

Figure 5.5. Results of the environmental policies on the development of GHG permit prices

For the stock-oriented policies, the price of climate change permits and hence the costs of climate change policy increase steadily over time, as abatement efforts increase. The undiscounted price of climate change permits increases exponentially over time, reflecting an equalisation of discounted costs for climate change permits, in line with the Hotelling rule.

The price of emission permits for climate change ranges from around 45 to 195 Euro per ton in 2050, depending on the scenario. The conclusion that can be drawn from this is that the costs of environmental policy can be reduced substantially by (i) allowing flexibility in the timing of GHG emission reductions; and/or (ii) integrating climate change policy with other environmental policies.

Note that the analysed climate change policy implicitly assumes that all emission reductions are realised domestically. If flexible mechanisms, as mentioned in the Kyoto Protocol (Joint Implementation and Clean Development Mechanism), are allowed, the economic costs of climate change policy could be lower.

It is not likely that policy makers are able to predict the optimal path of emissions in the highly complex surroundings of simultaneous policies for different environmental themes, since they do not have all information that individual polluters have. Fixing a path of emission reductions by government by implementing a system of emission permits may then lead to substantially higher economic costs than implementing a system of stock addition permits. The emission policy may lead to a somewhat higher environmental quality, as polluters have an incentive to delay their reduction efforts when timing is flexible. Early emission reductions will lead to less radiative forcing, less temperature rise and hence less damages. However, this environmental difference turns out to be less than 0.1 percent of global radiative forcing over the model horizon. Therefore, if policy makers have arguments to prefer an emission-oriented policy to a stock-oriented policy, *e.g.* more security that the target will be met, they have to weigh these arguments against the additional economic costs of an emission policy.

The economic costs of the integrated environmental policies can be attributed to the policies for the different environmental themes using the permit prices. From 2030 onwards, the economic costs of the policy on smog formation are very high and this theme dominates the other themes. Given the limited potential to reduce the associated Volatile Organic Compounds (VOC) emissions via technical abatement measures (estimated to be around one third of emissions), a strict policy target induces large decreases in the production of those sectors emitting VOCs. Secondly, a relatively large part of VOC emissions is attributed to consumers. There are several reasons why this result is not realistic; most importantly, polluters will react on the high permit price for smog formation by investigating new technologies to reduce their VOC emissions and thus avoid paying for expensive permits. The DEAN model does not capture such endogenous innovation effects. The results do, however, show the potential threat for the economy stemming from current smog formation policy if no additional effort is placed on researching VOC-reducing technologies.

Sectoral results

The impacts of environmental policy on individual sectors are much more diverse than the macro-economic results suggest, *cf.* Figure 5.6. The impacts of environmental policy differ substantially among sectors. While some emission-intensive sectors are severely affected by environmental policy, this does not hold for all production sectors. In fact, it is very likely that some production sectors can even benefit from stricter environmental targets. These include the sector that provides the abatement technology (not represented in Figure 5.6), but also sectors that produce relatively clean services. Environmental policy will generate not only losers, but also winners. The shift from dirty to clean sectors is relatively important in the DEAN model, as the possibilities to reduce emissions via technical abatement measures are limited.

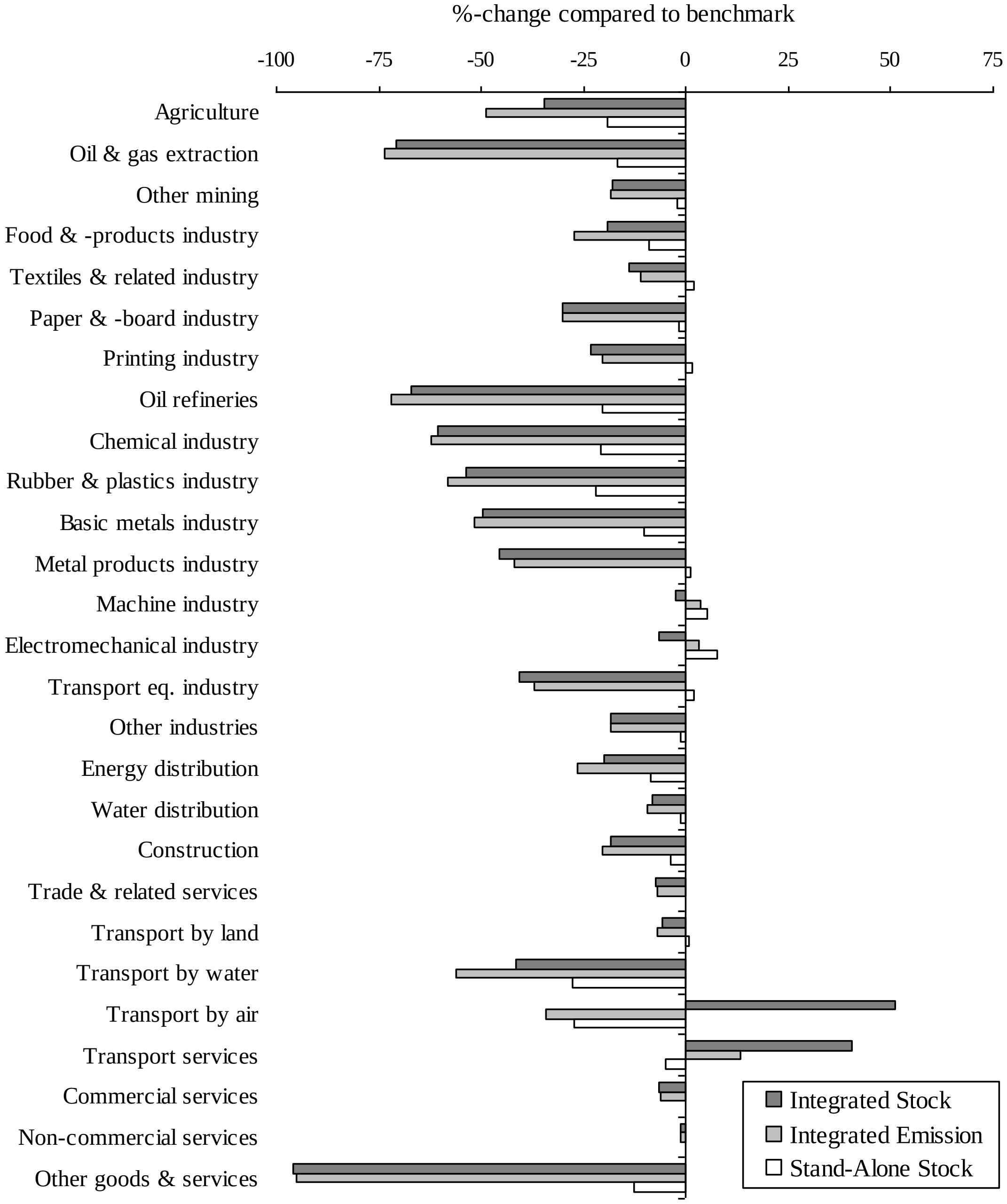

Figure 5.6. Results of the environmental policies on production (year 2050)

Some sectors that will have to reduce their production substantially are oil and gas extraction, oil refineries, the rubber and plastics industry and other goods and services (a heterogeneous set of small subsectors, some of which have high VOC-emissions). At the other end, there are the abatement services and non-commercial services: the abatement services sector increases its production value considerably, while the non-commercial services are hardly affected by environmental policy. The machine and electromechanical industries can also benefit from the environmental policy, especially if only a stringent climate change policy is implemented; this result is related to the substitution from heavy polluters towards these relatively more environmentally friendly sectors, both domestically and via exports.

Policy makers should pay attention to the economic opportunities induced by a stringent environmental policy. Analysis of environmental policy mostly focuses on the economic threats of these policies, *i.e.* on sectors that are affected by the policy. The opportunities that environmental policy creates for other production sectors, including the abatement sector and potentially also some services sectors, are often ignored. The implementation of environmental policy boils down to a reallocation of resources in the economy, not just a shrink of economic activity. Consequently, the macro-economic impact of stringent environmental policies is relatively modest, though certainly not negligible, and the growth rate of the economy is only temporarily affected.

Moreover, changes in sectoral structure of the economy (economic restructuring) are as important for reaching the environmental policy targets at minimum costs as the implementation of technical abatement measures. Both sources of emission reductions are vital in terms of their contribution to achieving the policy targets as well as in terms of the associated costs. More stringent environmental policies imply more emphasis on economic restructuring as a means to achieve the targets. If policy makers impose restrictions on the changes in sectoral structure, *e.g.* by providing additional support to specific sectors or exempting some economic activities from the policy, they have to realise that the macro-economic costs of the policy will increase substantially and/or that the policy target may not be reached.

5.4 Reflections on interlinkages

The DEAN model describes and quantifies interlinkages between indicators from the economic pillar and the environmental pillar of sustainable development, such as, for example, between GDP and GHG. It does so in a theoretically consistent way and it respects key national accounting principles such as the GDP identity from the income and expenditure side. The interlinkages between GDP and GHG in DEAN are complex, as they depend in principle on the simultaneous solution of all equations in the model for all time periods. The quantitative dynamic relationship between GDP and GHG and other environmental indicators is consistent given the assumptions of the model (on market behaviour and technologies), but in principle they differ for each ‘policy scenario’ that is evaluated.

It is important to note that DEAN is not meant to produce ‘forecasts’ in the sense of predictions about the likely evolution of key economic and environmental variables over time. On the contrary, in its benchmark projection the model assumes that the Dutch economy is on a balanced-growth path and that it will remain there over the course of the next century (recall Figure 5.1). In the benchmark projection, the growth of environmental pressures is superimposed on the model by the condition that historical rates of rates of ‘autonomous pollution efficiency improvements’ (1990-2000) converge to the common benchmark balanced-growth rate in 2030 (recall Figure 5.2 and accompanying text). Hence, the ‘benchmark’ interlinkages between GDP and environmental variables such as GHG are constructed by the modeller. These interlinkages are, of course, consistent from theoretical and accounting principles,[13] but they are not ‘unique’ and necessarily superior to any other set of consistent interlinkages.

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[13] This consistency is assured because of the overall internal consistency of the DEAN model.

The strength of DEAN lies in its ability to predict how the introduction of certain policy variables (e.g., taxes) leads to deviations from the benchmark. Hence, the interlinkages between indicators in the DEAN model are:

1) specific to a certain 'policy scenario'; and
2) can best be interpreted as relative deviations from a somewhat arbitrary benchmark.

In the '*Stand-Alone Policy*' scenario, GHG emissions over the 21th century are restricted according to the environmental objectives of the Fourth National Policy Plan of the Netherlands. The 'interlinkage' between GDP and the emissions of GHG in this policy scenario is shown in Figure 5.7 below. Figure 5.7 is a combination of Figure 5.3 (GDP in Stand-Alone) and Figure 5.4 (GHG in Stand-Alone). In this policy scenario, a reduction of the emissions of GHG by 45% relative to the benchmark in 2030 reduces GDP by 1% relative to the benchmark. Over the course of the century, the reduction of the emissions of GHG increases to 60% relative to the benchmark, associated with a reduction of GDP of 4% relative to the benchmark.

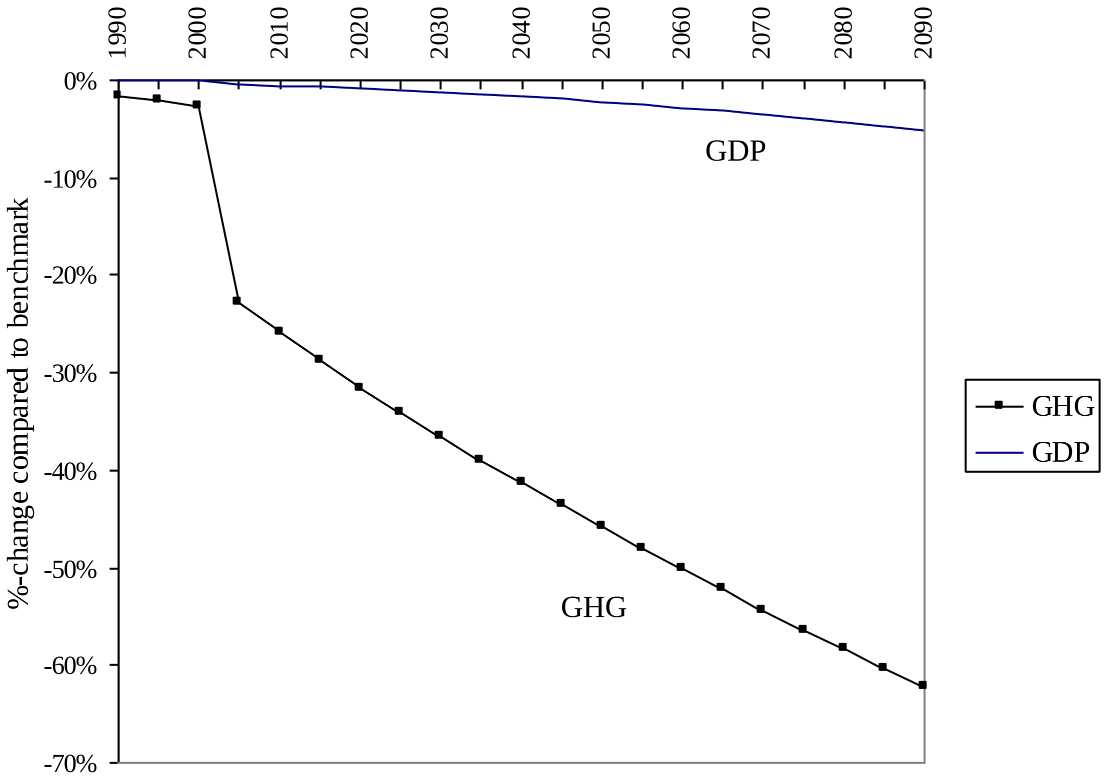

Figure 5.7 The interlinkage between GDP and GHG emissions in the 'Stand-Alone Policy' scenario.

The interlinkage between GDP and the emissions of GHG in the other policy scenarios is more difficult to show because in these policy scenarios GDP is associated with a basket of different pollutants (GHG and conventional air pollutants). We did show, however, that the optimal path of GHG emissions (and reductions) differed across the policy scenarios, indicating that there are interactions between GHG and air pollution policies. In general, therefore, the interlinkage between GDP and GHG emissions is dependent on the specific policy context.

5.5 Conclusion and outlook

The DEAN model is a multi-sectoral dynamic AGE model for a small open economy with special attention to the specification of pollution and abatement for several major environmental themes simultaneously. The DEAN model includes variables that are closely related to a number of Eurostat's SDIs, both within the economic as well as the environmental pillar of sustainable development. The DEAN model can therefore examine future interlinkages among SDIs within and between those pillars in (policy) scenarios.

The DEAN model suggests that it may be possible for the Netherlands to decouple environmental pressure and economic growth, given the availability of technical abatement measures and substitution possibilities within the economy. The impacts of environmental policy differ across economic sectors. There is a substantial shift in production from the relatively dirty agricultural and industrial sectors to the relatively clean services sectors. Consumption is adjusting much less than production because part of the environmental problem can be "transferred abroad" by importing more dirty goods and exporting more clean goods. Domestic emissions can be reduced substantially through this leakage effect, but in the case of transboundary environmental problems this may not be desirable from an environmental point of view.

We have also noted, however, that DEAN is not meant to produce 'forecasts' in the sense of predictions about the likely evolution of key economic and environmental variables over time. Interlinkages between indicators in the DEAN model can best be interpreted as relative deviations of the indicators from their benchmark levels and are always specific to a certain 'policy scenario'. The benchmark projection of the indicators is internally consistent, but not unique and not necessarily superior to any other consistent benchmark.

The analysis in this paper suggests that the precise form of the future interlinkages depends on three major aspects: (i) the assumptions made with respect to the model specification and parameterization, (ii) the benchmark projection, and (iii) key characteristics of the underlying environmental policies, with respect to its efficiency per theme (*e.g.* intertemporal flexibility with respect to climate change) as well as with respect to its integration across different environmental themes (air pollution). In general, the analysis in this paper suggests that decoupling between economic and environmental SDIs will be greater, the more flexible and integrated the environmental policies are.

It should be noted, however, that the present analysis has missed two big elephants in the room. The first elephant is technological progress. In the DEAN model technological development is specified in an exogenous manner and based on current knowledge. Recent literature indicates that high permit prices are likely to induce innovation of new abatement technologies (*cf.* Löschel, 2002). It was, for example noted above that the high permit price that is predicted for smog formation would induce polluters to investigate new technologies to reduce their VOC emissions. Future interlinkages between SDIs will be affected by future technological possibilities and options that are currently unknown. Hence, any prediction on future interlinkages will always be conditional upon fundamentally unknown future technological (and institutional) progress.

The second big elephant is the benefits of environmental policy or the damage due to a lack thereof. The model does not capture the feedback effect of the environment on the economy and on the utility of consumers. Because of the absence of a feedback link from the environment to the economy potentially important interlinkage between SDIs is ignored. Further research is needed in order to identify and quantify the key feedback interlinkages.

These caveats notwithstanding, the current analysis clearly shows how the future developments of the SDIs are quantitatively interlinked, and that targeted policies can influence the size or even the sign of these interlinkages.

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6. ASA

Onno Kuik

6.1 Introduction

The Advanced Sustainability Analysis (ASA) method was developed for the DECOIN project. Vhemas et al. (2008) illustrated how the ASA method could be used for the purpose of forecasting and for the analysis of interlinkages among sustainable development indicators. In this chapter we review the ASA method with a view on its usefulness for assessing future linkages.

6.2 The ASA method

6.2.1 General description of the ASA method

The Advanced Sustainability Analysis (ASA) method is a mathematical information system developed by Finland Futures Research Centre. It is basically a decomposition method that can analyse relationships between changes in environmental, economic and social variables that can be measured by any quantitative indicator or index. ASA decomposes an observed change in any sustainability indicator into contributing factors. The main features of ASA include applying the decomposition technique into environmental stress (ES) or social welfare (WF) indicators and interpreting the decomposed factors as indicators either advancing or threatening sustainability. One advantage of the ASA approach is that it can be used to interpret and quantify many often used but sometimes poorly defined concepts such as dematerialization of production, eco-efficiency, or the rebound effect. ASA can also be used to develop new theoretical concepts such as immaterialization of consumption, welfare productivity (of GDP), sustainable economic growth, or required technological development for sustainability.

ASA can also be applied to scenario construction by setting either a trend (forward) or a target (backward) as drivers of the future development. The drivers can be freely chosen among the identified factors that contribute to the observed change.

The general mathematical structure of ASA is as follows. A level variable (V) can always be *identically* expressed as the product of an intensity factor V/X and the level variable X. In fact, the identity holds for n intensity factors and one level variable in the form:

$$V \equiv \frac{V}{X_1} \times \frac{X_1}{X_2} \times \frac{X_2}{X_3} \times \ldots \times \frac{X_{n-1}}{X_n} \times X_n \tag{6.1}$$

For convenience, let us decompose the level variable V into two intensity factors and one level variable:

$$V \equiv \frac{V}{X_1} \times \frac{X_1}{X_2} \times X_2 \tag{6.2}$$

Denote the intensity factors ($V/X1$) and ($X1/X2$) by α and φ respectively. Substituting α and φ in Equation (6.2) and totally differentiating yields:

$$dV = X_2\varphi\, d\alpha + \alpha X_2 d\varphi + \alpha\varphi\, dX_2 \tag{6.3}$$

Where an infinitesimal change in V is explained by infinitesimal changes in α, φ, and X_2. Dividing both sides of Equation (6.3) by V yields an equation in percentage change:

$$\dot{V} = \dot{\alpha} + \dot{\varphi} + \dot{X}_2 \tag{6.4}$$

Where a dot above a variable ($\dot{X}$) signifies percentage change ($\frac{dX}{X}$). The formula in Equation (6.4) decomposes an infinitesimal or marginal change in the variable V into infinitesimal or marginal changes in its contributing factors (α, φ, and X_2).

If we want to decompose a non-marginal change of the variable V, we have to take account of second-order, interaction effects. Equation (6.3) becomes:

$$\begin{aligned}\Delta V = {} & X_2\varphi\ \Delta\alpha + \alpha X_2\Delta\varphi + \alpha\varphi\ \Delta X_2 + \\ & \underbrace{+\alpha\Delta X_2\Delta\varphi + \varphi\Delta\alpha\Delta X_2 + X_2\Delta\alpha\Delta\varphi + \Delta\alpha\Delta\varphi\Delta X_2}_{R},\end{aligned} \tag{6.5}$$

where the last four interaction terms of the decomposition are commonly known as the residual (R) of the decomposition. Several authors have developed practical decomposition methods whereby the residual terms ‘vanish’. Methods to make the residual vanish are called ‘perfect’ decomposition methods. They provide a ‘complete’ decomposition by applying a procedure to distribute the residual factors across the main contributing factors. Authors that have proposed such procedures include Sun (1998) and Albrecht et al. (2002). The method of Sun (1998) is fairly simple: it distributes the residual terms equally across the contributing factors. The method of Albrecht et al. (2002) is slightly more complex and is based on the so-called Shapley value from co-operative game theory. Ang et al (2004) have shown that the ‘perfect’ decomposition methods of Sun and Albrecht et al. are basically the same. Hence, they are now called the Sun/Shapley method of decomposition.

The ASA method uses the Sun/Shaply method for ‘perfect’ decomposition to decompose the change in an indicator of sustainable development into a number of contributing factors, including, perhaps, other indicators of sustainable development. We will call the former indicator (the one that is to be decomposed) the *Target indicator* and the latter indicators its *Contributing Factors*.

6.2.2 SDIs included in ASA

The ASA method can deal with social, economic and environmental dimensions of sustainable development. Technically it is possible to link all the pillars of SD and any given SD indicator as long as data is available. Whether the linking makes sense is another issue. Identification of the contributing factors and driving forces is a fully case-specific issue, and the construction of a relevant identity with a reasonable meaning for each factor in the identity can be challenging, especially when the number of explaining factors is high. Furthermore, sufficient knowledge on what affects the change in the phenomena under investigation is needed in order to construct plausible causal chains and interpretations.

A number of difficulties have been encountered in using indicators from the EU SDI set for ASA analysis. Some difficulties are of a practical nature and relate to formatting requirements, etc. Other difficulties are more fundamental, such as indicators in the wrong dimensions (rates instead of levels), short time series, the absence of data at the sub-national level, and the absence of indicators that play a role as explanatory factors in specific decomposition analyses. In this respect it is regrettable that the SDI set was not developed on the basis of the driver-pressure-state-impact-response (DPSIR) framework that was developed to define and select related indicators within one theme. The DPSIR framework could have been used for each theme, instead of the three-level hierarchy of lead objectives, SDS priorities and actions (explanatory variables), which misses important aspects of sustainable development.

6.3 Assessment of future linkages

In this section, ASA's approach to the assessment of future linkages is illustrated with two examples from different dimensions of sustainability, namely *Climate Change and Energy* and *Poverty and Social Exclusion*. For a full illustration of the approach, Section 6.3.1 starts with the assessment of historic interlinkages, whereas Section 6.3.2 subsequently illustrates how the approach can be used to assess future interlinkages.

6.3.1 Historic linkages

For the analysis of *Climate Change and Energy*, the following decomposition of the target indicator "carbon-dioxide (CO_2) emissions" in the EU15 over the period 1973-2005 is made:

$$CO_2 = \frac{CO_2}{TPES} \times \frac{TPES}{GDP} \times \frac{GDP}{POP} \times POP\,, \tag{6.6}$$

Where:

- CO_2 is carbon dioxide emissions from fuel combustion;
- TPES is total primary energy supply
- GDP is gross domestic product in real prices;
- POP is the country's population;
- CO_2/TPES is the CO_2 intensity of primary energy use;
- TPES/GDP is the energy intensity of the economy;
- GDP/POP is gross domestic product per capita.

CO_2 emissions over the period 1973-2005 have been decomposed in four contributing factors. The factors are the CO_2 intensity of primary energy use (CO_2/TPES), the energy intensity of the economy (TPES/GDP), GDP per capita as a measure of the productivity of the economy (GDP/POP), and the size of the population (POP). All factors are calculated as a percentage of the base year (1973) value. Figure 6.1 shows the relative values of the contributing factors and the percentage changes in CO_2 emissions over the period 1973-2005 and in three sub-periods. Each bar describes the amount of corresponding factor contributing to the change in CO_2 emissions during the studied time period.

The ASA analysis shows that over the periods considered, CO_2 emissions rise with economic growth (GDP/POP) and population, but fall with the decreasing CO_2 intensity of primary energy use (CO_2/TPES) and the decreasing energy-intensity of the economy (TPES/GDP). On balance, CO_2 emissions decreased over the period 1973-2005 and over all sub-periods except for 1973-1980.

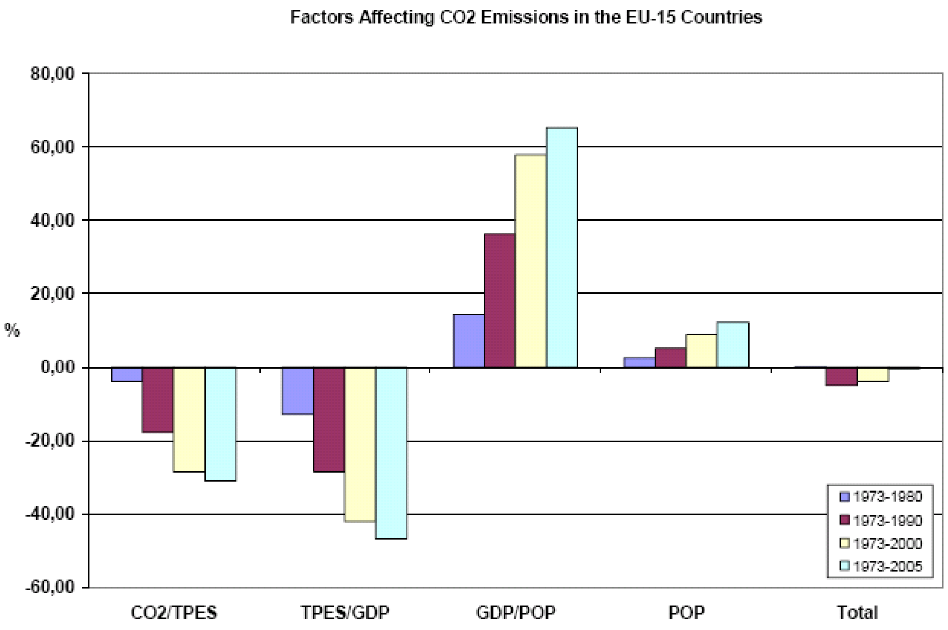


Figure 6.1 The factors affecting CO_2 emissions in the European Union (EU15) over the period 1973-2005 and over three sub-periods. (Source: Vhemas et al., 2008)

The developments can also be expressed in annual growth rates. Over the period 1973-2005, the annual per capita growth of GDP (GDP/POP) of 1.6% and the annual population growth of 0.4% would have resulted in an annual increase in CO_2 emissions of 2%, had not the energy intensity of the economy decreased by 1.9% per year and had not the CO_2 intensity of energy use decreased by 1.1% per year.

For the analysis of *Poverty and Social Exclusion* the following decomposition of the target indicator Poverty and Social Exclusion (PS) in the EU15 over the period 1995-2005 is made:

$$PS = \frac{PS}{AS} \times \frac{AS}{GDP} \times \frac{GDP}{EMP} \times \frac{EMP}{POP} \times POP \,, \tag{6.7}$$

where:

- PS is an indicator of poverty and social exclusion, i.e. the at-risk-of poverty rate after social transfers defined as the share of persons with an equivalised disposable income below the risk-of-poverty threshold, which is set at 60 % of the national median equivalised disposable income (after social transfers).
- AS is an indicator of ageing society, i.e., the old-age-dependency ratio defined as the ratio between the total number of elderly persons of an age when they are generally economically inactive (aged 65 and over) and the number of persons of working age (from 15 to 64);
- GDP is gross domestic product;
- EMP is employment (total number of employed people);
- POP is population;
- PS/AS is at-risk-of poverty intensity of ageing society;

- AS/GDP is ageing society intensity of GDP;
- GDP/EMP is employment productivity (Gross Domestic Product per employed person)
- EMP/POP is participation rate (employed fraction of population)

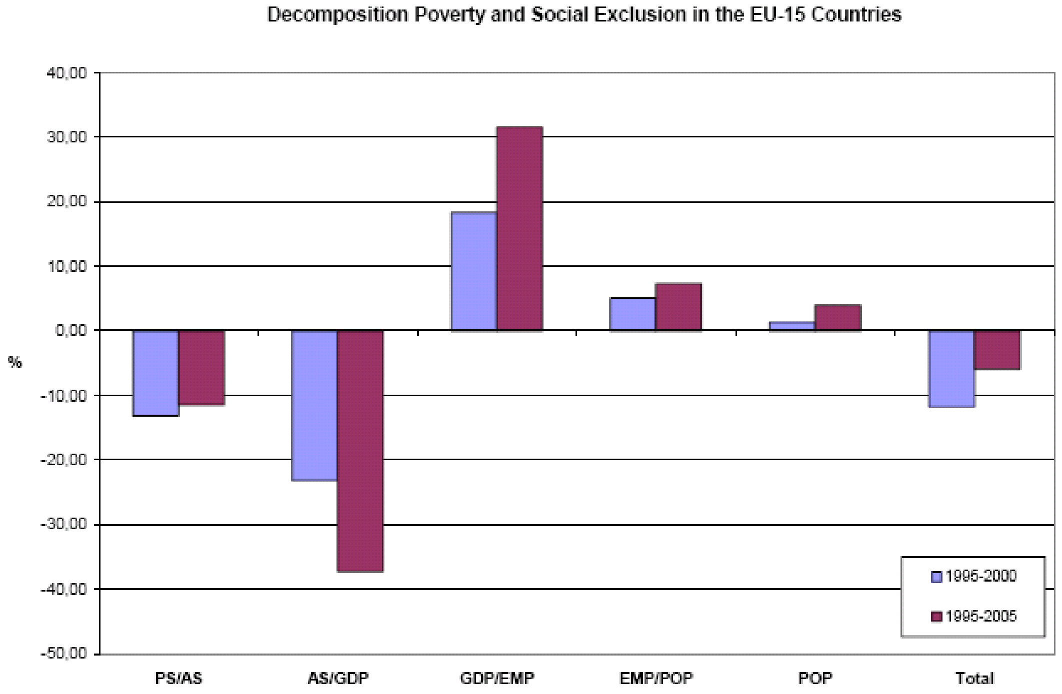


Figure 6.2 The factors affecting Poverty and Social Exclusion in the European Union (EU15) over the period 1995-2000 and 1995-2005. (Source: Vhemas et al., 2008)

Figure 6.2 shows that the target indicator Poverty and Social Exclusion has decreased in EU15 over the period 1995-2005. The factors that contributed to this decrease were the risk-of-poverty intensity of ageing society (PS/AS) and the ageing society intensity of GDP (AS/GDP). Factors that would *increase* Poverty and Exclusion are employment productivity (GDP/EMP), participation rate (EMP/POP) and the size of the population (POP).

The ageing society intensity of GDP is the most important factor in a quantitative sense. This factor basically expresses that, over the period considered, the rate of growth of GDP was higher than the rate of growth of the old-age-dependency ratio. The risk-of-poverty intensity of ageing society has decreased, suggesting that old-age pensioners have become relatively less poor over the period considered.

These positive effects are counteracted by the increase in employment productivity that would, by itself, widen the gap between the employed and the unemployed, and by increases in the participation rate and the size of the population. It is somewhat puzzling and counterintuitive that an increasing participation rate would, by itself, increase poverty and social exclusion. The effect of population size on poverty and social exclusion is also not directly clear.

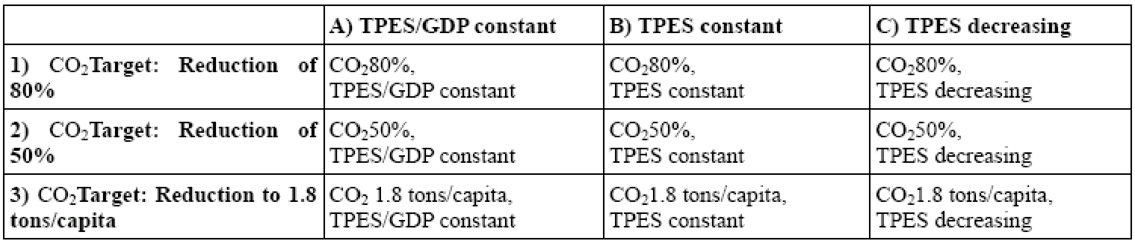
6.3.2 Future linkages (scenario-analysis)

How can we use these decomposition analyses for the assessment of *future* linkages between SD indicators? The ASA method can be used to analyse and forecast trends. The ASA method can be applied for scenario construction by selecting either a trend (forward) or a target (backward) as drivers of the future change. The drivers can be chosen from the set of contributing factors that is used in the decomposition analysis or the driver can be the target indicator of the decomposition (the indicator that is being decomposed) itself. This gives possibilities to provide answers to different kinds of "what if" questions relating to future trends and linkages. In this section, we will illustrate this use of the ASA method by exploring future trends and linkages in the *Climate Change and Energy* and *Poverty and Social Exclusion* examples that were introduced in Section 6.3.1 above.

In the *Climate Change and Energy* example, the change in emissions of CO_2 in the EU15 was decomposed in changes in the CO_2 intensity of energy use, the energy intensity of the economy, economic growth per capita, and population. If we set a target for CO_2 emissions in the future, we can explore how one of the factors – in our example: the CO_2 intensity of energy use – should adjust given assumptions on the changes of the other factors.

The future scenarios cover the period 2005-2050 in five-year steps. Three different targets for CO_2 emissions in 2050 were selected: 1) total emissions in 2050 will be 80% lower than in 2005; 2) total emissions in 2050 will be 50% lower than in 2005; and 3) per capita emissions in 2050 do not exceed 1.8 tons of CO_2. For the energy intensity of the economy (TPES/GDP) also three assumptions were made: A) the intensity remains constant; B) energy use (TPES) remains constant, resulting in a decreasing intensity; C) energy use decreases by 5% every five years, also resulting in a decreasing intensity. GDP is assumed to increase by 10% every five years (is approximately 1.9% per year), and the change in population (POP) follows a projection by EUROSTAT (increasing until 2030 and decreasing thereafter). Table 6.1 presents a summary overview of the main assumptions of the 3 x 3 = 9 scenario options.

Table 6.1 Overview of the nine future scenarios of Climate Change and Energy (Source:Vehmas et al., 2008).



	A) TPES/GDP constant	**B) TPES constant**	**C) TPES decreasing**
1) CO_2Target: Reduction of 80%	$CO_2$80%, TPES/GDP constant	$CO_2$80%, TPES constant	$CO_2$80%, TPES decreasing
2) CO_2Target: Reduction of 50%	$CO_2$50%, TPES/GDP constant	$CO_2$50%, TPES constant	$CO_2$50%, TPES decreasing
3) CO_2Target: Reduction to 1.8 tons/capita	CO_2 1.8 tons/capita, TPES/GDP constant	$CO_2$1.8 tons/capita, TPES constant	$CO_2$1.8 tons/capita, TPES decreasing

The ASA decomposition is done for the periods 2005-2025 and 2005-2050. Figure 6.3 below present the results of the decomposition of the nine scenario options in graphical form. GDP and POP (and therefore also the ratio GDP/POP) are fixed over the scenario options. Differences are in CO_2 targets, the CO_2 intensity and the energy intensity. The decomposition analysis suggests that the CO_2 target of 1.8 tons of CO_2 per capita is very similar to the target of 80% reduction (first and third rows of Figure 6.3).

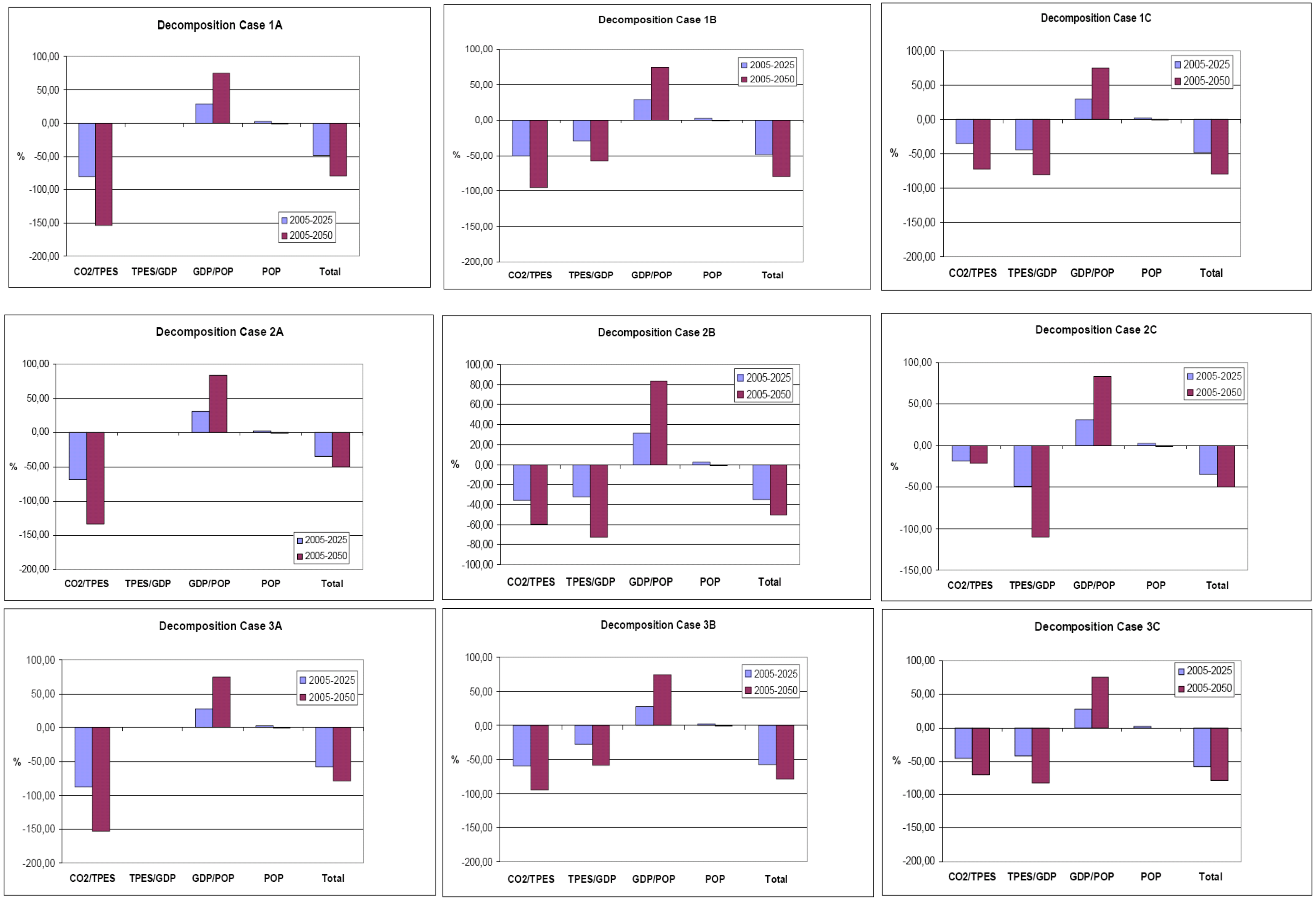
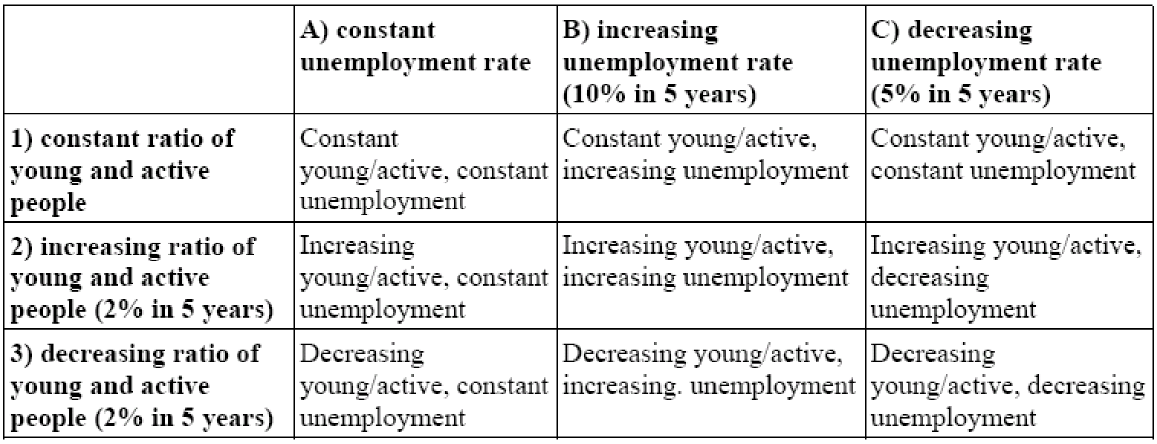


Figure 6.3 Future linkages of Climate Change and Energy (Source: Vhemas et al., 2008)

In the DECOIN report (Vehmas et al., 2008), the general conclusion from the analysis is that CO_2 reduction targets can be reached through different routes. In all scenarios, economic growth tends to increase emissions, which has to be offset by a decrease in the CO_2 intensity of energy use, and, possibly, a decrease in the energy intensity of the economy. The required decrease in CO_2 intensity of energy use is evaluated at three different rates of change of energy intensity. The larger the decrease in energy intensity, the less the required decrease in CO_2 intensity.

In the *Poverty and Social Exclusion* example, the change in the share of people-at-risk-of-poverty in the total population of the EU15 was decomposed in changes of a large number of factors, including the poverty intensity of old age, the ratio between the growth rates of old-age dependency and GDP, employment productivity, participation rate and size of population. Figure 6.2 showed how the target variable and its contributing factors changed in the period 1995-2005. To examine future linkages between the target indicator and its contributing factors, again a quantitative target for the target indicator was set: the share of people-at-risk-of-poverty should decline from 16% currently to 10% in 2050. The growth in old-age-dependency was taken from EUROSTAT. For GDP and population, the same projections were used as in the Climate Change and Energy example above. Scenario assumptions were made for the variable employment that affects the factors employment productivity (GDP/EMP) and participation rate (EMP/POP). Given the assumed growth of old-age-dependency, employment is affected by the participation rate of young people and by unemployment of the potentially active population. Table 6.2 gives an overview of the scenario assumptions on participation rate of young people and on unemployment.

Table 6.2 Overview of the nine future scenarios of Poverty and Social Exclusion (Source:Vehmas et al., 2008).



	A) constant unemployment rate	**B) increasing unemployment rate (10% in 5 years)**	**C) decreasing unemployment rate (5% in 5 years)**
1) constant ratio of young and active people	Constant young/active, constant unemployment	Constant young/active, increasing unemployment	Constant young/active, constant unemployment
2) increasing ratio of young and active people (2% in 5 years)	Increasing young/active, constant unemployment	Increasing young/active, increasing unemployment	Increasing young/active, decreasing unemployment
3) decreasing ratio of young and active people (2% in 5 years)	Decreasing young/active, constant unemployment	Decreasing young/active, increasing. unemployment	Decreasing young/active, decreasing unemployment

Instead of presenting all the decompositions as we did for the example of Climate Change and Energy, we just show a summary graph of the future linkages between the factors employment productivity (GDP/EMP) and participation rate (EMP/POP) and the target indicator Poverty and Social Exclusion, where this latter indicator is assumed to decrease by 37.5% (from a share of people at-risk-of poverty of 16% in 2005 to a share of 10% in 2050).

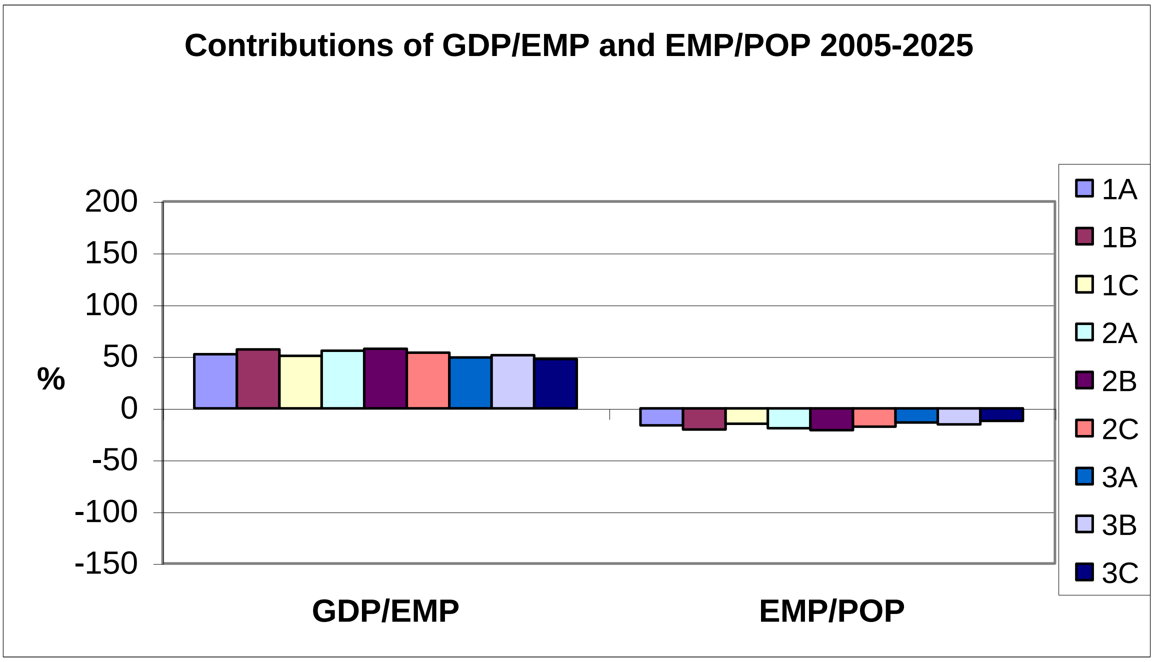


Figure 6.4 Future linkages between the factors employment productivity (GDP/EMP) and participation rate (EMP/POP) and the target indicator Poverty and Social Exclusion for the EU15 in the period 2005-2050. (Source: Vhemas et al,. 2008)

Figure 6.4 shows that an increase in employment productivity tends to increase Poverty and Social Exclusion (as in the historic decomposition in Section 6.3.1 above), and that a decreasing participation rate tends to decrease Poverty and Social Exclusion. This is a somewhat puzzling conclusion.

6.4 Reflection on future interlinkages

Decomposition analysis is a very useful tool for understanding historic trends in economic, social or environmental variables over time. The ASA decomposition technique is a very useful tool for better understanding trends in Sustainable Development Indicators. The Climate Change and Energy example shows the relative contributions of the contributing factors to the energy-related emissions of carbon dioxide. The Climate Change and Energy example is based on a conceptual “model” of the driving forces of energy-related CO_2 emissions that is well established in the literature. Given this “model”, the decomposition tool can relatively easily be used for the examination of future linkages in a “what-if” mode. The example in Section 6.3.2 above examined “what-if” scenario options for the CO_2 intensity of energy use and the energy intensity of the economy. The analysis suggested that CO_2 intensity and energy intensity are to some extent substitute factors.

The quantitative interpretation of the results is somewhat unclear, however. In Scenario 1A, CO_2 intensity (CO_2/TPES) decreases by 154%. This makes little sense: it means negative emissions. If CO_2 intensity would really decrease by more than 100%, total emissions would become negative, whatever the other factors. If we take a close look at the decomposition, we see that the change in CO_2 intensity is comprised of two parts: the “real” change in CO_2 intensity and the share of the residual of the decomposition (R in Equation (6.5)) that is attributed to this factor. In this scenario, the residual of the decomposition is very large. In fact, it is the single largest contributing factor to the change in CO_2 emissions in a decomposition with residual. Figure 6.5 compares the ASA method with a method of decomposition with residual. This latter method (with residual), correctly reports the percentage changes of the contributing factors. The change in CO_2 intensity in scenario 1A is – 91%. A simple sum of the changes in contributing factors does not lead to the postulated overall change in CO_2 emissions, however. Interaction effects among the factors[14] lead to a residual of – 126%, the single largest factor of the decomposition. Distributing the residual across the explanatory variables, as in the Sun/Shapley method of "perfect" decomposition that is applied in the ASA method, adds a (negative) share of the residual to the contributing factors. Figure 6.5 shows that CO_2/TPES decreases from – 91% to – 154% and GDP/POP decreases from 135% to 75%.[15] The large residual has a major effect on the numerical values of the factors of the decomposition, rendering their quantitative interpretation difficult if not impossible.

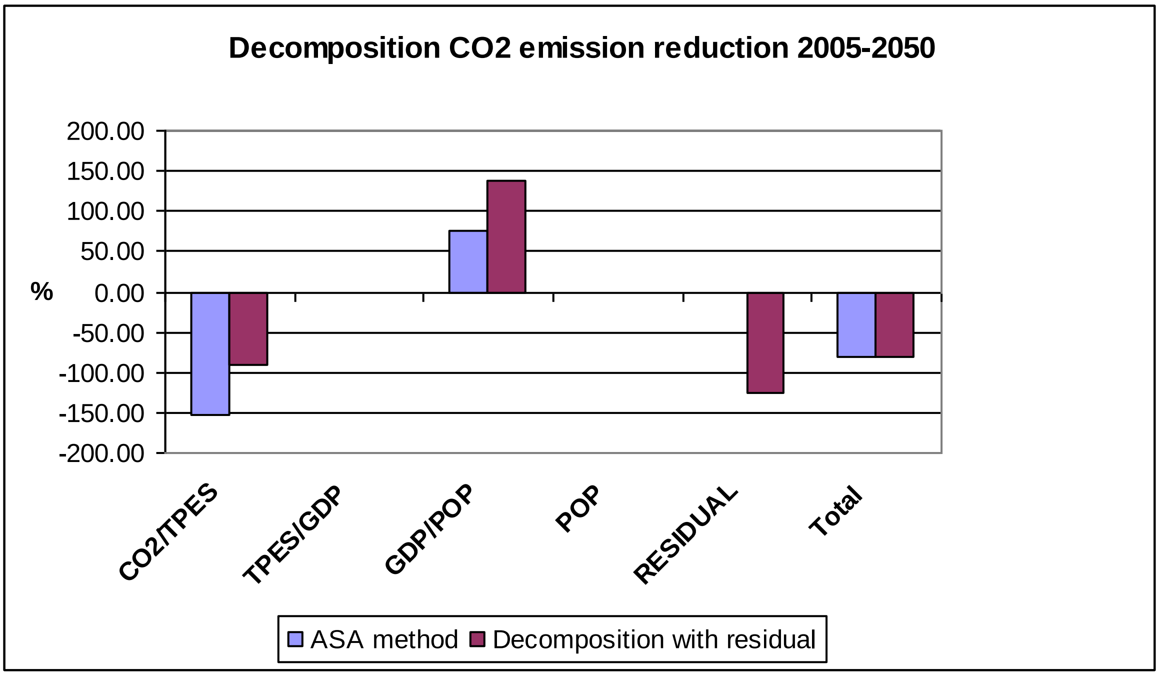


Figure 6.5 Comparison of ASA method and decomposition with residual for Scenario 1A. (Source: own calculations)

The Poverty and Social Exclusion example share the same difficulties as the Climate Change and Energy example. An additional difficulty is that the decomposition is not based on a well-established conceptual model. Therefore, apart from the numerical difficulties due to the existence of a residual, some of the factors themselves are hard to interpret. What do "at-risk-of poverty intensity of ageing society" (PS/AS) or "ageing society intensity of GDP" (AS/GDP) mean, apart from being technically convenient ratios for the decomposition? The usefulness of the ASA methods seems somewhat diminished if the rates of change of indicator variables are

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[14] In this case, predominantly the interaction between CO_2 intensity and GDP per capita.

[15] GDP/POP of 135% is the true scenario value: GDP grows by 1.9% per year by 45 years is 136% (continuously compounded) and population falls by 1%.

"explained" by *ad hoc* factors that not exist beyond the realm of the decomposition for which they are applied (and created).

6.5 Conclusions and outlook

The ASA method is a useful tool for understanding historic trends in economic, social or environmental variables over time. It can be used for "what-if" kinds of scenario analysis. There are some problems, however, in the interpretation of the results of these scenario analyses if the residual of the decomposition is large relative to the contributing factors and if the decomposition is not based on some well-established underlying model so that the meaning of some of the factors is unclear. These problems require some further study before the method can be routinely applied to assess future linkages between SD indicators.

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7. Conclusions

In this report we examined how five selected methodologies, methods and tools (MMT) approached the problem of projecting future paths of sustainable development indicators and the interlinkages among them. The five MMT's were previously selected from a larger set of MMT's because of their quantitative nature (Van Drunen et al. 2008). Van Drunen et al. (2008) also discussed the MMT's general approach towards addressing (future) interlinkages among sustainable development indicators. In this report we elaborate on the analysis of Van Drunen et al. (2008) by illustrating how the selected MMT's perform in the examination of actual policy scenarios. In this section we discuss the overall results of the policy scenarios that were examined and we give recommendations for further research.

The multi-criteria analysis (MCA) method was used to rank four future electricity production alternatives for the Netherlands with the help of a set of criteria that are closely related to a number of sustainable development indicators from the economic and environmental pillars, the costs of electricity generation, the depletion of natural gas stocks, the emissions of the conventional air pollutants SO_x, NO_x, and PM_{10}, and the emissions of the greenhouse gas CO_2. An interesting side product from the multi-criteria analysis is the correlation matrix of the criteria that is derived from the effects table. The correlation matrix shows trade-offs and synergies between the criteria of the decision-making problem. Because the criteria were closely related to sustainable development indicators, the correlation matrix suggests the nature of the interlinkages among sustainability indicators, but only, of course, within the context of the specific decision-making problem investigated. In that decision-making problem, there appeared to be high positive correlations between natural gas depletion and the reduction of SO_2 and PM_{10} emissions (which seems to point at a trade-off) and high negative correlations between the reductions of CO_2 and NO_x (trade-off), and a high negative correlation between the costs of electricity generation and PM_{10} emissions (synergy). These synergies and trade-offs are specific for this decision-making context, however, and cannot be easily generalized to other contexts. For example, in this case there appears to be no clear trade-off between generation costs and CO_2 emissions reduction. A generalization of this result to a broader policy context would seem to be inappropriate.

The GVAR model can be used to explore statistical relationships among sets of sustainability indicators. The model has been successfully applied to forecasting purposes in the area of financial and economic analysis, and could in principle be applied to explore future interlinkages among a broad array of sustainable development indicators. In the case study, GVAR examined interlinkages between (the growth rates of) GDP per capita, CO_2 emissions per capita, energy use per capita, life expectancy at birth, and the unemployment rate. The analysis was first done with Eurostat's SDI data for EU15, but the time series of the data (1992-2004) was not long enough to derive robust results due to the presence of multicollinearity. The model was therefore re-estimation with data from the UN World Development Indicators for EU15 for the period 1980-2005. The latter model performed much better. The case study briefly presented statistical relationships between the variables for Germany. It should be noted, however, that these relationships describe short-term rather than long-term interlinkages. The case study discusses what steps need to be taken to identify long-run relationships. The GVAR model clearly looks like a promising tool to find significant statistical relationships among diverse indicators of sustainable development, but there is still much work to be done, both with respect to expanding the empirical database and with respect to providing “a theoretically coherent framework for modelling the [..] interactions [between SDI indicators]”.

GINFORS is a large-scale, global, economy-energy-environment simulation model, encompassing various dimensions of sustainable development. GINFORS’ coverage of sustainable development indicators from the economic and environmental pillars is relatively large. Currently the model includes twelve sustainable development indicators, including the headline indicators of the themes: socio-economic development; sustainable consumption and production; climate change and energy; and sustainable transport. Another thirteen indicators (among which the headline indicator for demographic changes) could be included in a relatively easy way. Detailed information on the sustainable development indicators is presently available for 19 EU countries (EU15 + Czech Republic, Hungary, Poland and Slovakia). Two environmental policy scenarios were evaluated with GINFORS: a reference scenario and a scenario in which the EU would unilaterally reduce its emissions of greenhouse gases by 20% by 2020. A comparison between the scenarios reveals trade-offs between the economic and environmental indicators (especially greenhouse gas emissions), but there are differences across countries. Because of the many indicators and countries, the results of the simulations provide a rich set of quantitative interlinkages among the indicators.

The DEAN model is a dynamic applied general equilibrium model for the Netherlands – a small open economy. DEAN covers detailed information on the emissions of greenhouse gases and a number of environmental pollutants and on the abatement options to mitigate these emissions. It contains seven variables that are closely connected to sustainable development indicators from the economic and environmental pillars. DEAN evaluated four policy scenarios – a reference (benchmark) scenario and three policy scenarios that are all based on the achievement of national environmental policy targets. The benchmark scenario of DEAN itself is somewhat arbitrary – DEAN *assumes* a balanced-growth path in which all economic variables grow at the same rate. The growth rate of emissions is governed by exogenous changes in pollution per unit of economic activity (pollution efficiency rates). Of interest in the policy scenarios are the relative deviations of the variables and indicators from the benchmark path. The analysis with DEAN suggests that the precise form of the future interlinkages depends on three major aspects: (i) the assumptions made with respect to the model specification and parameterization, (ii) the benchmark projection, and (iii) key characteristics of the underlying environmental policies, with respect to its efficiency per theme as well as with respect to its integration across different environmental themes. In general, the analysis suggests that synergies between economic and environmental sustainable development indicators will be greater, the more flexible and integrated the environmental policies are.

The ASA method is a decomposition method that can be applied to a wide variety of sustainable development indicators. The ASA method is a useful tool for understanding historic trends in sustainable development indicators over time. It ‘decomposes’ these trends of the target indicator in relative contributions of explanatory factors. One or more of these explanatory factors can themselves be sustainable development indicators, so that interlinkages between the target indicator and the explanatory indicators can be established. The ASA method can be used for *what-if* kinds of scenario analysis. There are some technical problems, however, in the interpretation of the results of these scenario analyses if ‘large’ changes are evaluated (and interaction among the explanatory factors is strong). The results may also be difficult to interpret if the decomposition is not based on some well-established underlying model so that the meaning of some of the explanatory factors remains unclear.

The above observations illustrates that the identification of future interlinkages between sustainable development indicators requires additional analysis, such as statistical analysis of modelling results. The nature of the interlinkages is not automatically revealed by the tested models. If one has an idea (a theory) about the nature of the interlinkages, cause-effect relationships between the trends of different indicators can be established. This idea can be simple – a simple correlation between two SDI's (MCA) – or complex – embodied in a large simulation model (GINFORS). Some ideas can be tested on historic data (GVAR), but this is always subject to methodological difficulties and data constraints. Moreover, interlinkages that held in the past, may not automatically hold in the future. Future interlinkages are dependent on future policy scenarios (including no-policy scenarios); this interdependence can be represented in relatively simple models (ASA) or complex applied general equilibrium models (DEAN). All potential future interlinkages are therefore conditional and uncertain, but – in relative terms – we have better 'ideas' or 'theories' on future interlinkages between indicators within and between the economic and environmental pillars of sustainable development than between the social pillar and the other pillars.

The challenge of future research in this area is to develop better 'ideas' on interlinkages, especially related to indicators from the social pillar, to test these ideas against historical data, and to include them in applied assessment models. Given the uncertainty that surrounds sustainable development policies and sustainable development itself, it would also be a challenge to better integrate uncertainty analysis and risk-based approaches in the assessment of future linkages.

Appendix I. Definition of indicators by EUROSTAT (2008)

Growth rate of real GDP per capita Gross domestic product (GDP) is a measure for the economic activity, defined as the value of all goods and services produced less the value of any goods or services used in their creation. The calculation of the annual growth rate of GDP per capita at constant prices is intended to allow comparisons of the dynamics of economic development both over time and between economies of different sizes. The growth rate is calculated from figures at constant prices since these give volume movements only, i.e. price movements will not inflate the growth rate.

Employment rate The employment rate is calculated by dividing the number of persons aged 15 to 64 in employment by the total population of the same age group. The indicator is based on the EU Labour Force Survey. The survey covers the entire population living in private households and excludes those in collective households such as boarding houses, halls of residence and hospitals. Employed population consists of those persons who during the reference week did any work for pay or profit for at least one hour, or were not working but had jobs from which they were temporarily absent.

Total R&D expenditure The indicator is defined as the percentage share of GERD (Gross domestic expenditure on R&D) in GDP. Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge.

Resource Productivity Resource productivity is GDP divided by domestic material consumption. Domestic material consumption (DMC) measures the total amount of materials directly used by an economy. It is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports. It is important to note that the term "consumption" as used in DMC denotes apparent consumption and not final consumption. DMC does not include upstream hidden flows related to imports and exports of raw materials and products.

Domestic Material Consumption The indicator Domestic Material Consumption (DMC) is defined as the total amount of material directly used in an economy. DMC equals Direct Material Input (DMI) minus exports. DMI measures the direct input of materials for the use in the economy. DMI equals Domestic Extraction (DE) plus imports.

Electricity consumption by households The indicator is defined as the quantity of electricity consumed by households. Household consumption covers all use of electricity for space and water heating and all electrical appliances.

Early school leavers Early school leavers refers to persons aged 18 to 24 in the following two conditions: the highest level of education or training attained is ISCED 0, 1 or 2 and respondents declared not having received any education or training in the four weeks preceding the survey (numerator). The denominator consists of the total population of the same age group, excluding no answers to the questions "highest level of education or training attained" and "participation to education and training". Both the numerators and the denominators come from the EU Labour Force Survey.

Public expenditure on education This indicator is defined as total public expenditure on education, expressed as a percentage of GDP. Generally, the public sector funds education either by bearing directly the current and capital expenses of educational institutions or by supporting students and their families with scholarships and public loans as well as by transferring public subsidies for educational activities to private firms or non-profit organisations. Both types of transactions together are reported as total public expenditure on education.

Life expectancy at birth Life expectancy at birth is defined as the mean number of years still to be lived by a person at birth, if subjected throughout the rest of his or her life to the current mortality conditions.

Total GHG emissions Under the Kyoto Protocol, the EU has agreed to an 8% reduction in its greenhouse gas emissions by 2008-2012, compared to the Kyoto base year. The reductions for each of the EU-15 countries have been agreed under the so-called EU Burden Sharing Agreement (Council Decision 2002/358/EC), which allows some countries to increase emissions, provided these are offset by reductions in other Member States. Eight of the ten new Member States have chosen other reduction targets and other base years, as allowed under the Kyoto Protocol. These and the 'Burden sharing' targets for 2008-2012 are shown in the table (no target for Cyprus and Malta). Emissions of the 6 greenhouse gases covered by the Protocol are weighted by their global warming potentials (GWPs) and aggregated to give total emissions in CO_2 equivalents. The total emissions are presented as indices, with the base year = 100. In general, the base year is 1990 for the non-fluorinated gases (CO_2, CH_4 and N_2O), and 1995 for the fluorinated gases (HFC, PFC and SF_6; exception see metadata). Data exclude emissions and removals due to land use, land use change and forestry (LULUCF).

Renewables in gross inland energy consumption This indicator is defined as the percentage share of renewables in gross inland energy consumption. It is split into the major energy sources.

Appendix II. Regression results

	AT	BE	DK	FI	FR	DE	GR	IE	IT	LU	NL	PT	ES	SE	UK
Δln(GDPC(t)): GDP per capita															
mR2	0.96	0.98	0.93	0.93	0.98	0.97	0.85	0.93	0.98	0.93	0.97	0.98	0.97	0.96	0.97
adjR2	0.87	0.93	0.76	0.78	0.94	0.91	0.51	0.77	0.94	0.78	0.90	0.92	0.90	0.86	0.89
Ljung-Box	0.02	2.52	0.15	0.05	3.73	1.97	5.06	1.36	0.16	0.05	0.02	0.01	0.00	0.13	1.11
p-value	0.00	0.00	0.01	0.01	0.00	0.00	0.11	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Δln(GDPC(t-1))	0.33	0.08	1.20 .	1.85 *	-0.22	1.62 **	-0.07	0.32	0.64 *	-0.37	0.61 *	0.87 **	0.23	0.14	0.09
Δln(CO2E(t-1))	0.17	-0.01	0.13	0.14	0.02	0.35 *	-0.28	0.08	-0.10	0.13	0.03	-0.02	-0.04	-0.05	0.03
Δln(EUPC(t-1))	-0.1	0	-0.1	-0.3	-0.06	-0.2	0.55	0.0	0.0	0.0	-0.3 *	0.12	-0.07	0.2 *	0.1
Δln(LIFE(t-1))	2.32	-0.7	-0.05	-0.61	0.11	-1.28	1.92	-4.0	-0.39	-2.05	0.59	-2.1 .	0.53	0.05	-1.22
Δln(UNEM(t-1))	-0.03	0.05 .	0.06	0.16 .	0.00	0.04	0.11	-0.04	-0.01	0.04	0.03	0.08 .	0.00	-0.05	0.00
coefficient	0.00	0.00	0.04	-0.02	0.00	-0.01	0.07 .	0.07	0.00	0.00	0.01	0.01	0.00	0.01	0.05 .
Δln(GDPCf(t))	1.05 **	1.09 **	0.72	1.16	0.91 **	2.03 ***	-1.25	-1.05	0.80 **	2.41	0.29	0.87 .	0.88 *	0.52	0.10
Δln(CO2Ef(t))	0.26	0.06	0.39	0.35	0.02	-0.09	0.43	-0.19	-0.28	-0.15	-0.28	-0.16	0.10	-0.23	-0.13
Δln(EUPCf(t))	-0.31	-0.08	-0.49	-0.41	-0.18	0.28	0.29	-0.43	0.32	-0.03	0.26	0.40	-0.09	0.26	0.50 .
Δln(LIFEf(t))	0.00	1.54	-6.09	-0.01	1.14	1.97	-0.77	-0.23	-0.49	-2.15	-0.57	-5.68 *	1.21	4.54	-2.24
Δln(UNEMf(t))	0.05	0.03	-0.06	-0.07	-0.05	0.05	-0.45 .	-0.21	-0.04	0.10	-0.06	-0.17 .	-0.03	-0.11	-0.21 .
Δln(GDPCf(t-1))	-0.80	-0.25	-0.56	-1.40	0.05	-1.55 *	-2.41 *	-0.34	-0.35	0.81	-0.12	-1.88 .	0.19	-1.16 .	-1.81 *
Δln(CO2Ef(t-1))	-0.50	0.1	0.03	0.18	-0.08	0.31	-0.31	-0.25	-0.1	-0.8	-0.01	-0.56	0.15	0.0	-0.26
Δln(EUPCf(t-1))	0.4	0	-0.01	0.00	0.03	-0.9 .	0.8	0.1	0.1	0.7	0.20	1.30 *	-0.2	-0.5	0.2
Δln(LIFEf(t-1))	-0.92	0.99	-6.42	5.48	0.84	0.81	-0.08	0.48	-0.32	-1.46	-2.01	3.4	-0.15	4.16	4.19
Δln(UNEMf(t-1))	-0.06	-0.1	0.10	0.05	-0.03	-0.09	-0.13	0.08	0.02	-0.15	0.05	-0.02	-0.02	0.04	-0.04
Δln(CO2E(t)): CO2-emissions per capita															
mR2	0.86	0.78	0.83	0.81	0.87	0.85	0.77	0.87	0.71	0.46	0.91	0.93	0.86	0.89	0.70
adjR2	0.52	0.29	0.44	0.38	0.58	0.51	0.23	0.58	0.04	-0.78	0.71	0.78	0.53	0.64	0.01
Ljung-Box	9.16	0.04	0.46	0.03	2.80	3.29	2.31	1.91	4.61	0.00	0.07	0.37	0.06	0.07	1.16
p-value	0.10	0.28	0.16	0.20	0.07	0.11	0.32	0.07	0.50	0.95	0.03	0.01	0.10	0.05	0.53
Δln(GDPC(t-1))	-1.06	3.65	-0.33	-1.41	-3.63	-1.49	0.33	-0.48	1.09	0.10	0.39	-0.01	1.09	3.14 .	0.45
Δln(CO2E(t-1))	-0.11	-0.01	0.34	-0.39	0.33	-1.21 *	0.03	-0.70 *	-0.60	0.97	-0.02	-1.02 *	-0.83 *	-0.97 **	-0.80 .
Δln(EUPC(t-1))	-0.17	-0.05	-1.29	-0.43	-1.48 .	2.58 *	-0.17	0.73 *	0.29	-0.80	0.06	0.46	0.06	0.81 .	1.13
Δln(LIFE(t-1))	0.25	-5.00	-7.23	5.38	-1.36	-0.37	8.52 .	-3.04	-3.25	-0.57	-4.48	2.13	12.84	-6.20	0.94
Δln(UNEM(t-1))	0.04	0.25	-0.12	-0.38	-0.12	-0.09	0.35 .	-0.16	-0.10	-0.07	0.63 **	-0.08	-0.18	0.08	-0.02
coefficient	0.07	0.07	0.15	0.33 *	-0.02	-0.01	0.01	-0.01	-0.03	-0.01	0.08	-0.05	0.04	0.24 *	-0.11
Δln(GDPCf(t))	-0.81	-2.01	-2.62	-9.02 .	-0.01	-2.03 .	-0.29	-0.32	0.07	3.65	-3.10 .	5.26 **	1.93	-6.39 *	1.50
Δln(CO2Ef(t))	-0.47	0.57	0.48	-1.23	1.04	-0.32	0.98	-0.33	0.25	0.98	-2.87 .	2.26 *	2.17 .	-0.18	0.55
Δln(EUPCf(t))	1.37	-0.36	3.34	3.61 .	0.38	0.65	-1.32	1.38 .	-0.27	-0.20	2.11	-6.38 **	-3.36 *	0.54	1.16
Δln(LIFEf(t))	-1.86	0.17	-15.03	7.64	-3.80	9.13	-3.10	8.47	-0.61	8.48	-25.92 *	-14.88	-11.57	-10.03	11.96
Δln(UNEMf(t))	-0.23	-0.25	0.31	-1.08 .	0.14	-0.18	-0.14	0.11	-0.04	0.33	-0.29	0.61 .	0.03	-0.68	0.36
Δln(GDPCf(t-1))	2.19	-0.94	-0.19	-6.82	4.86 .	2.72	-0.90	-0.18	1.54	-2.54	0.64	6.91 .	3.00	-6.66 *	0.27
Δln(CO2Ef(t-1))	2.24 .	0.77	0.99	-1.09	0.76	0.43	-1.45	-0.86	0.92	-0.03	-4.62 **	0.98	1.87 .	-0.75	0.57
Δln(EUPCf(t-1))	-2.65	-0.56	-0.21	3.38	-1.06	-2.04	2.83 .	1.87 *	-1.13	1.11	4.03 **	-1.75	-1.62	2.77	-0.98
Δln(LIFEf(t-1))	-12.98	-17.92	-15.83	-12.74	7.02	-0.39	-1.70	2.80	4.69	-10.10	-2.72	-8.54	-25.94	-17.41	5.45
Δln(UNEMf(t-1))	0.16	0.33	-0.02	0.02	-0.13	0.27	-0.19	-0.28	0.26	-0.48	-0.80 .	0.68 *	0.80	-0.21	-0.37
Δln(EUPC(t)): Energy use per capita															
mR2	0.92	0.87	0.87	0.82	0.98	0.86	0.84	0.87	0.85	0.55	0.82	0.90	0.97	0.69	0.75
adjR2	0.75	0.57	0.57	0.42	0.92	0.55	0.48	0.56	0.52	-0.48	0.42	0.68	0.91	-0.03	0.17
Ljung-Box	0.04	0.04	0.40	0.50	3.29	0.09	3.55	2.16	0.11	0.01	1.79	1.26	1.20	0.29	0.01
p-value	0.02	0.08	0.08	0.17	0.00	0.09	0.13	0.08	0.11	0.86	0.17	0.03	0.00	0.56	0.38
Δln(GDPC(t-1))	-0.10	1.81	-0.01	-1.35	0.45	-0.70	-0.08	-0.18	0.55	-0.27	0.16	1.19	1.63 *	-0.53	-0.96
Δln(CO2E(t-1))	0.23	-0.05	0.22	-0.09	0.04	-0.35	0.16	-0.33	0.05	0.81	0.04	-0.29	-0.19 .	-0.19	-0.05
Δln(EUPC(t-1))	-0.30	0.09	-0.47	-0.87	-0.29	0.75	-0.31	0.00	-0.62	-0.74	-0.10	-0.32	-0.70 *	-0.24	0.39
Δln(LIFE(t-1))	2.76	-5.82	-2.45	3.32	-2.17 *	-0.47	6.55 .	-6.66 *	-2.38	-6.06	-0.19	2.56	2.63	-1.91	-0.79
Δln(UNEM(t-1))	0.06	0.11	-0.05	-0.37 .	0.04	-0.03	0.22	-0.04	0.15	-0.07	0.10	0.06	0.02	-0.07	0.04
coefficient	0.02	0.00	0.09	0.21 *	-0.03 *	-0.01	-0.01	0.06	0.01	0.05	0.01	-0.02	0.01	0.00	0.01
Δln(GDPCf(t))	-0.60	0.60	-2.14	-5.99 *	-0.37	-1.07	0.68	-2.47 .	0.12	0.64	-0.20	3.45 *	1.49 *	0.06	0.84
Δln(CO2Ef(t))	-0.15	-0.63	0.10	-2.29 *	0.37 .	-0.40	1.56 .	-1.11 *	0.62	0.31	-0.60	1.15	1.24 **	0.32	0.49
Δln(EUPCf(t))	1.53 **	1.87 **	2.06 .	3.18 *	0.93 **	1.21 *	-1.41	1.37 .	-0.49	0.01	1.31	-4.20 *	-2.03 **	0.70	0.85
Δln(LIFEf(t))	0.42	0.90	-10.85	17.86	0.56	3.30	-0.10	8.32	1.93	5.32	-0.15	-10.65	-4.10	-3.48	-1.84
Δln(UNEMf(t))	0.02	0.08	-0.07	-0.85 *	0.22 **	-0.14	-0.03	-0.16	-0.11	-0.19	0.07	0.27	-0.02	-0.04	-0.06
Δln(GDPCf(t-1))	0.72	-1.72	0.76	-6.95 *	1.69 *	0.96	-0.26	-1.39	0.24	-0.41	0.01	4.47	1.86	-0.15	-0.68
Δln(CO2Ef(t-1))	0.91	-0.14	-0.06	-1.87 .	0.22	-0.05	-0.29	-1.71 *	0.41	-0.03	-0.34	0.66	0.58	0.52	0.21
Δln(EUPCf(t-1))	-1.13	0.81	0.30	3.29 *	-0.24	-0.28	1.06	2.51 **	-0.50	0.06	-0.14	-1.10	-0.73	0.13	-0.38
Δln(LIFEf(t-1))	-2.85	-3.51	-14.49	-0.76	4.37 .	1.43	2.73	1.44	2.79	-7.61	-0.94	-9.02	-10.64 .	9.84	6.52
Δln(UNEMf(t-1))	-0.04	-0.13	0.17	-0.25	-0.04	0.13	-0.17	-0.49 *	0.09	0.04	-0.20	0.54 *	0.46 *	0.25	-0.04
Δln(LIFE(t)): Life expectancy at birth															
mR2	0.92	0.94	0.81	0.89	0.90	0.93	0.90	0.90	0.87	0.83	0.84	0.91	0.97	0.83	0.90
adjR2	0.72	0.82	0.38	0.65	0.67	0.77	0.66	0.68	0.58	0.43	0.46	0.69	0.89	0.45	0.68
Ljung-Box	0.39	0.60	0.11	0.13	0.33	0.50	1.22	0.62	1.21	2.37	0.55	0.89	0.73	2.92	2.20
p-value	0.02	0.01	0.21	0.04	0.04	0.01	0.04	0.03	0.07	0.17	0.14	0.03	0.00	0.15	0.03
Δln(GDPC(t-1))	-0.13	0.24 .	-0.12	0.07	-0.03	0.07	0.07	0.00	-0.12	-0.01	0.01	-0.07	0.07	-0.11	0.08
Δln(CO2E(t-1))	-0.03	-0.02	0.00	0.03	-0.03	-0.01	0.06 *	0.04	-0.01	-0.07	0.00	-0.03	0.02 .	0.02	-0.01
Δln(EUPC(t-1))	0.03	-0.01	-0.04	-0.07	0.05	0.02	-0.10 *	-0.02	0.05	0.10	0.04	-0.02	-0.06 .	0.01	-0.07
Δln(LIFE(t-1))	-0.90	0.39	-0.08	-0.24	-0.71 *	-0.98 *	0.13	0.50	-0.69 *	-0.39	-0.05	0.40	-0.12	-0.49	-0.13
Δln(UNEM(t-1))	0.01	0.00	-0.02 .	0.01	-0.01	0.02	-0.01	0.00	0.02	0.01	-0.01	-0.01	0.00	0.00	0.00
coefficient	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
Δln(GDPCf(t))	0.00	-0.08	0.14	-0.08	0.13	0.06	0.26 .	-0.12	-0.02	0.11	0.22	0.05	-0.12 *	0.19	-0.06
Δln(CO2Ef(t))	0.00	-0.07 .	-0.01	-0.04	0.06	-0.10 *	-0.06	-0.01	0.04	-0.05	0.11	-0.04	0.11 *	0.05	-0.06
Δln(EUPCf(t))	0.01	0.13 *	0.03	0.06	-0.09	0.13 .	-0.02	0.05	-0.06	-0.06	-0.12	-0.08	-0.17 **	-0.05	-0.02
Δln(LIFEf(t))	0.72	0.61	1.00	0.50	0.96	-0.10	-0.59	0.29	0.37	0.31	1.37 .	0.19	1.10 **	0.83	1.06
Δln(UNEMf(t))	-0.01	0.00	0.03	-0.02	0.01	0.00	0.06 *	-0.01	-0.01	0.04	0.03	0.00	-0.01	0.01	0.01
Δln(GDPCf(t-1))	0.15	-0.26 .	0.05	-0.11	0.01	-0.02	0.05	0.00	0.04	0.34	-0.03	0.18	0.11	0.07	0.11
Δln(CO2Ef(t-1))	0.06	0.02	0.07	0.00	0.05	-0.05	0.01	0.17 *	-0.08	0.01	0.07	0.01	0.02	0.01	0.03
Δln(EUPCf(t-1))	-0.05	0.01	-0.02	-0.07	-0.05	0.04	0.12	-0.20 .	0.13	-0.02	-0.13	-0.11	0.01	-0.09	-0.03
Δln(LIFEf(t-1))	1.11	-0.52	-0.24	-0.46	1.24	0.20	-0.71	0.36	0.19	-0.10	1.11 .	-0.21	-0.14	0.51	-1.33
Δln(UNEMf(t-1))	0.00	-0.01	0.00	0.00	-0.01	-0.02	-0.02	0.00	0.00	0.01	-0.01	0.01	0.04 *	0.00	0.02
Δln(UNEM(t)): Unemployment rate															
mR2	0.82	0.83	0.70	0.89	0.92	0.89	0.65	0.91	0.75	0.88	0.94	0.92	0.91	0.95	0.82
adjR2	0.42	0.45	0.01	0.62	0.75	0.63	-0.15	0.70	0.18	0.60	0.79	0.74	0.71	0.84	0.41
Ljung-Box	0.68	0.32	2.89	2.30	0.56	2.63	1.00	0.41	0.18	2.86	1.75	0.33	0.20	0.26	0.01
p-value	0.17	0.15	0.53	0.05	0.02	0.05	0.66	0.03	0.37	0.06	0.01	0.02	0.03	0.00	0.18
Δln(GDPC(t-1))	-3.40	-5.30	-7.41	-14.26 *	-1.21	-1.27	0.21	-1.01	3.57	0.67	-8.46 **	-2.64	-0.93	3.50	-2.71
Δln(CO2E(t-1))	-0.93	-0.05	-1.47	-0.47	0.24	-0.67	0.06	0.37	-1.51	-0.57	0.34	-1.18	-0.27	-0.86	-0.31
Δln(EUPC(t-1))	4.75	-0.89	1.51	1.89	1.48	1.54	0.31	-0.43	0.65	1.75	-0.41	0.27	2.05	-1.13	0.31
Δln(LIFE(t-1))	-8.73	0.83	16.99	0.46	-5.68	-5.85	-7.19	7.88	0.91	7.24	-0.73	18.68 .	-2.32	-12.58	-2.36
Δln(UNEM(t-1))	-0.18	-0.25	-0.44	-1.00	-0.14	-0.11	-0.22	0.52	0.02	-0.75	0.41	0.02	-0.31	0.84 *	-0.21
coefficient	-0.17	0.17	-0.26	0.18	0.02	0.12	-0.06	0.02	-0.11	0.65 *	0.44 *	0.31 .	0.11	0.28	-0.25
Δln(GDPCf(t))	-2.89	-3.33	6.12	-5.06	-0.72	-4.44	2.33	3.23	3.73	-11.15	-4.23	-4.03	1.10	-10.79	2.44
Δln(CO2Ef(t))	0.86	-0.26	-1.32	-2.78	0.81	-0.69	-2.37	1.96	-0.65	0.06	-1.02	-0.33	-3.14	0.98	-1.73
Δln(EUPCf(t))	-0.31	0.80	1.64	3.87	-0.59	-0.08	2.82	0.21	0.63	1.48	2.37	-4.18	2.61	-2.96	1.11
Δln(LIFEf(t))	28.77	-8.84	9.44	21.84	-6.75	8.20	1.62	-17.96	5.88	-16.19	-37.86 .	-31.21	-38.54 *	-43.06	23.40
Δln(UNEMf(t))	0.56	-0.05	2.27	0.62	0.23	0.73	0.89	1.26 *	0.44	-0.45	-0.73	0.65	0.86	0.58	1.90 .
Δln(GDPCf(t-1))	5.64	-1.53	9.25	7.63	1.86	1.34	-1.01	-0.23	-2.53	-15.16	-3.73	8.31	-5.41	9.97 .	6.91
Δln(CO2Ef(t-1))	6.00	-0.21	0.63	-2.59	-0.76	-0.14	-2.06	0.70	0.55	4.22	-0.07	4.99	-4.75 *	6.01 .	-0.56
Δln(EUPCf(t-1))	-13.89 .	-0.38	-1.87	0.67	-0.96	-0.28	-0.74	0.34	-0.60	-5.40	-1.04	-7.78 .	5.64 *	-3.67	-0.24
Δln(LIFEf(t-1))	56.18 .	14.23	-4.18	-10.38	9.06	2.74	12.34	-8.41	-0.84	-23.72	-8.68	-44.82 *	-20.85	-36.66	2.73
Δln(UNEMf(t-1))	-0.26	0.22	-0.18	-1.00	0.81 *	-0.02	-0.45	-0.55	0.11	1.23	-0.32	0.75	0.33	0.38	-0.12
dof	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

*p-value 0.01 . 0.05 * 0.01 ** 0.00 ****

Appendix III. $G^{-1}H$ Model I

		AT					BE					DK					FI					FR				
		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
AT	1	0.17692	0.01283	0.01632	-1.52128	-0.00088	-0.02320	0.00066	0.00177	-0.09790	0.00012	-0.00229	0.00017	0.00037	-0.00890	0.00002	-0.00201	0.00010	0.00029	-0.00730	0.00001	-0.07680	0.00402	0.01069	-0.27057	0.00064
	2	-0.09054	-0.10972	-0.02865	0.12209	-0.00154	-0.01863	-0.00061	0.02096	0.92776	0.00025	-0.00244	0.00031	0.00294	0.07990	0.00004	-0.00241	0.00001	0.00259	0.05532	0.00003	-0.05311	-0.00342	0.07305	2.33735	0.00158
	3	-0.01568	-0.03348	-0.40018	4.52527	-0.00119	-0.01357	0.00003	0.01489	0.51888	0.00001	-0.00144	0.00034	0.00206	0.04047	0.00000	-0.00157	0.00006	0.00171	0.03136	0.00000	-0.03466	0.01197	0.06659	1.43027	-0.00024
	4	0.00652	-0.00004	-0.00015	-0.85692	0.00001	0.00041	-0.00001	-0.00001	0.00594	0.00000	0.00004	0.00000	0.00000	0.00066	0.00000	0.00003	0.00000	0.00000	0.00048	0.00000	0.00152	-0.00001	-0.00004	0.01649	0.00000
	5	-3.25589	0.54692	3.91557	-40.08120	-0.18298	0.06350	-0.00196	-0.00754	0.54097	0.00024	0.00592	-0.00078	-0.00138	0.04136	0.00001	0.00586	-0.00038	-0.00098	0.03698	0.00002	0.16119	-0.03873	-0.05905	1.57368	-0.00001
BE	6	-0.00136	-0.00010	-0.00002	0.00884	0.00002	-0.00088	-0.00037	-0.00696	2.47820	0.00292	-0.00063	-0.00003	-0.00001	0.00849	0.00002	-0.00044	-0.00001	-0.00001	0.00550	0.00001	-0.06906	-0.00291	-0.00102	0.89332	0.00226
	7	0.00772	0.00083	0.00112	0.21912	0.00016	5.49269	-0.00580	-0.00399	-25.83009	-0.02480	0.00347	0.00027	0.00042	0.22567	0.00012	0.00238	0.00011	0.00025	0.15028	0.00009	0.36928	0.00373	0.03113	25.14240	0.01932
	8	-0.00886	-0.00009	-0.00161	0.02404	0.00003	-1.23474	-0.00310	0.11738	-8.61484	0.01206	-0.00263	0.00000	-0.00070	0.00282	0.00003	-0.00130	0.00002	-0.00048	-0.00035	0.00003	-0.38663	-0.00481	-0.13471	0.96646	0.00380
	9	-0.00008	0.00000	0.00000	0.00053	0.00000	-0.00609	-0.00015	-0.00010	0.52322	0.00005	-0.00002	0.00000	0.00000	0.00024	0.00000	-0.00001	0.00000	0.00000	0.00017	0.00000	-0.00515	0.00010	-0.00013	0.05334	0.00002
	10	0.00483	0.00035	0.00010	-0.03261	-0.00007	-18.93305	0.00663	-0.53494	10.80938	-0.19264	0.00226	0.00011	0.00004	-0.03047	-0.00006	0.00160	0.00004	0.00002	-0.01916	-0.00004	0.25564	0.01008	0.00444	-3.02310	-0.00835
DK	11	0.00069	-0.00003	-0.00002	-0.05505	0.00003	0.00032	0.00000	-0.00006	-0.51380	0.00029	1.14266	-0.00038	0.00367	0.01528	-0.00165	-0.00072	-0.00001	-0.00002	-0.12460	0.00011	0.00855	-0.00033	-0.00031	-1.20620	0.00068
	12	0.00830	0.00887	0.00479	1.62324	-0.00004	0.04651	0.00942	0.01561	16.26913	-0.00023	-0.55253	0.27306	-1.07736	-46.06750	0.01870	0.01037	0.00075	0.00619	2.21347	-0.00006	0.13605	0.05497	0.05818	38.14054	-0.00119
	13	-0.01612	-0.00026	-0.00346	0.71732	0.00027	-0.09100	-0.00025	-0.01172	7.37485	0.00140	-0.00855	-0.02093	-0.68731	-8.09907	0.00468	-0.02079	-0.00002	-0.00492	0.95040	0.00042	-0.26606	-0.00127	-0.04143	17.06190	0.00684
	14	0.00005	0.00000	0.00000	-0.00004	0.00000	0.00023	-0.00001	0.00000	-0.00158	0.00000	0.00463	0.00001	0.00025	-0.06969	-0.00011	0.00004	-0.00001	0.00000	-0.00010	0.00000	0.00074	0.00005	0.00000	-0.00360	0.00001
	15	0.00647	0.00016	0.00014	0.33131	-0.00023	0.03807	0.00027	0.00054	2.19340	-0.00141	-1.60314	0.10410	0.29417	15.73491	-0.49084	0.01197	0.00007	0.00010	0.21073	-0.00083	0.12498	0.00235	0.00230	5.29538	-0.00412
FI	16	-0.01274	-0.00037	-0.00002	0.10006	-0.00001	-0.06555	-0.00049	-0.00004	1.00842	-0.00006	-0.02013	-0.00045	-0.00003	0.28172	-0.00001	1.39047	0.00093	0.01896	0.37189	0.00043	-0.16862	-0.00303	-0.00017	2.13579	-0.00038
	17	0.10055	-0.00788	-0.05854	0.99541	0.00004	0.72401	0.00174	-0.16262	10.38360	0.00010	0.24112	-0.00609	-0.13052	3.45207	0.00010	-1.29438	-0.41040	-0.14008	15.12840	0.00629	1.43546	-0.02949	-0.54470	21.59824	0.00072
	18	-0.19300	-0.00296	-0.00973	0.00722	0.00013	-0.71700	0.01472	-0.04232	0.06847	0.00280	-0.16538	-0.00258	-0.04142	0.05626	0.00081	-0.03333	-0.00832	-0.89249	0.58760	-0.03421	-2.39213	-0.01467	-0.10329	0.10796	0.00584
	19	-0.00012	0.00000	0.00000	-0.00018	0.00000	-0.00049	0.00000	0.00000	-0.00216	0.00000	-0.00013	0.00000	0.00000	-0.00006	0.00000	-0.00065	0.00009	0.00014	-0.23388	0.00002	-0.00149	0.00000	-0.00004	-0.00502	0.00000
	20	0.02508	0.00207	0.00008	-0.54873	-0.00005	0.17077	0.00151	0.00024	-4.84669	-0.00062	0.05830	0.00203	0.00014	-1.49588	-0.00039	-12.91845	-0.01443	0.43976	1.09663	-1.09761	0.37525	0.01898	0.00097	-10.21403	-0.00070
FR	21	0.00033	0.00010	0.00008	0.01088	0.00001	0.00511	0.00045	0.00067	0.36591	0.00018	0.00016	0.00003	0.00003	0.01020	0.00001	0.00010	0.00001	0.00002	0.00577	0.00000	0.11216	0.00245	0.02265	-0.49492	0.00056
	22	-0.03369	0.00061	0.00320	-0.11297	-0.00005	-0.57319	-0.00638	0.03992	-2.53085	-0.00083	-0.01606	0.00015	0.00159	-0.08408	-0.00004	-0.01052	-0.00002	0.00091	-0.04216	-0.00002	-5.82470	0.32987	-0.56187	-5.35350	0.01871
	23	-0.00859	0.00038	0.00099	-0.09226	-0.00001	-0.16306	-0.00022	0.01271	-2.49880	0.00010	-0.00488	0.00008	0.00043	-0.06268	0.00000	-0.00346	0.00001	0.00024	-0.03305	0.00000	0.56346	-0.00600	-0.46611	-11.66029	-0.00268
	24	0.00001	0.00000	-0.00001	0.00072	0.00000	0.00008	-0.00006	-0.00018	0.02121	0.00001	0.00000	0.00000	-0.00001	0.00111	0.00000	0.00000	0.00000	0.00000	0.00054	0.00000	0.00464	0.00004	-0.00168	-0.51303	-0.00023
	25	-0.00076	-0.00014	-0.00013	-0.01723	-0.00002	-0.01152	-0.00042	-0.00077	-0.49672	-0.00046	-0.00034	-0.00006	-0.00006	-0.01703	-0.00002	-0.00021	-0.00002	-0.00003	-0.00934	-0.00001	-4.15750	-0.05268	0.90239	-38.14594	-0.10139
DE	26	-0.09255	-0.00302	-0.01638	0.07309	0.00027	-0.23647	-0.00203	-0.01176	0.43617	0.00084	-0.02037	-0.00046	-0.00286	0.03562	0.00010	-0.01024	-0.00015	-0.00123	0.01687	0.00005	-0.65338	-0.01087	-0.07895	1.02108	0.00357
	27	0.01868	0.00528	0.03554	0.06866	0.00002	-0.06622	-0.00215	0.01172	0.24944	-0.00204	-0.00474	0.00032	0.00348	0.01574	-0.00011	-0.00397	0.00006	0.00127	0.00793	-0.00008	0.11382	0.02047	0.15459	0.62043	-0.00158
	28	0.01215	-0.00049	0.00610	-0.14984	0.00008	0.00091	0.00012	0.00793	-0.56285	-0.00067	-0.00031	-0.00003	0.00090	-0.03455	-0.00003	-0.00072	0.00000	0.00039	-0.01545	-0.00003	0.05435	-0.00151	0.02971	-1.29532	-0.00028
	29	-0.00012	-0.00002	-0.00001	0.00076	0.00000	-0.00026	0.00000	-0.00005	0.00412	0.00002	-0.00002	0.00000	0.00000	0.00046	0.00000	-0.00001	0.00000	0.00000	0.00022	0.00000	-0.00079	-0.00010	-0.00010	0.01151	0.00007
	30	0.20525	0.01318	0.05776	-0.33914	0.00036	0.56462	0.00624	0.04701	-1.47378	0.00054	0.04671	0.00150	0.00817	-0.10743	0.00000	0.02504	0.00049	0.00337	-0.05154	0.00001	1.44969	0.06407	0.32736	-3.52805	-0.00108
GR	31	0.01314	-0.00012	-0.00135	0.00075	-0.00012	0.09941	0.00068	-0.00240	0.01443	-0.00096	0.00893	-0.00004	-0.00095	0.00122	-0.00011	0.00684	0.00003	-0.00073	0.00093	-0.00010	0.23566	0.00508	-0.00657	0.03397	-0.00384
	32	0.00809	0.00046	0.00172	-0.00011	-0.00011	0.04997	-0.00139	0.02863	0.05645	-0.00151	0.00400	-0.00006	0.00105	0.01156	-0.00014	0.00284	0.00004	0.00128	0.00907	-0.00014	0.15202	0.02013	0.07779	0.17242	-0.00440
	33	0.00102	0.00025	0.00135	0.00476	-0.00005	0.00572	0.00060	0.01039	0.12638	-0.00078	0.00037	0.00012	0.00077	-0.00022	-0.00007	0.00025	0.00013	0.00075	-0.00043	-0.00007	0.02020	0.00734	0.04037	0.16066	-0.00196
	34	0.00005	0.00000	0.00004	-0.00170	0.00000	0.00036	0.00000	0.00001	-0.03115	0.00002	0.00003	0.00000	0.00002	-0.00237	0.00000	0.00002	0.00000	0.00001	-0.00197	0.00000	0.00075	0.00001	0.00026	-0.07520	0.00008
	35	-0.05308	-0.00011	-0.00077	-0.00056	0.00026	-0.34306	-0.00057	-0.02542	-0.02032	0.00298	-0.02794	0.00004	-0.00062	-0.00224	0.00030	-0.01956	-0.00004	-0.00083	-0.00191	0.00028	-0.92711	-0.01368	-0.06513	-0.05414	0.00974
IE	36	0.00058	0.00003	0.00005	0.00085	0.00001	0.01313	-0.00090	0.00367	0.00795	0.00096	0.00057	-0.00002	0.00009	-0.00059	0.00003	0.00018	-0.00002	0.00004	-0.00054	0.00002	0.01731	0.00074	0.00342	-0.00032	0.00093
	37	-0.00036	-0.00050	-0.00216	-0.01645	0.00004	-0.00869	0.00205	-0.09691	-1.36187	0.00487	-0.00029	-0.00012	-0.00284	-0.02413	0.00015	-0.00006	0.00005	-0.00104	-0.00845	0.00008	-0.01415	-0.01715	-0.11519	-1.07581	0.00421
	38	0.00180	-0.00107	-0.00217	-0.00735	-0.00001	0.04782	-0.01851	-0.04335	-0.87633	0.00010	0.00292	-0.00096	-0.00211	-0.02144	-0.00001	0.00145	-0.00024	-0.00064	-0.00905	0.00001	0.04547	-0.04349	-0.08787	-0.72492	-0.00174
	39	0.00000	0.00001	0.00001	-0.00014	0.00000	0.00000	0.00000	0.00028	-0.01321	0.00000	0.00000	0.00000	0.00002	-0.00038	0.00000	0.00000	0.00000	0.00001	-0.00015	0.00000	0.00000	0.00012	0.00045	-0.01186	0.00000
	40	0.00155	-0.00035	-0.00044	-0.00890	0.00000	0.08614	0.00045	-0.01813	-0.32134	-0.00195	0.00270	-0.00020	-0.00069	-0.01354	-0.00002	0.00138	0.00001	-0.00028	-0.00383	-0.00002	0.11158	-0.00644	-0.02101	-0.34596	-0.00074
IT	41	-0.00719	0.00033	0.00053	-0.01080	-0.00001	-0.02387	0.00023	0.00038	-0.07521	-0.00007	-0.00133	0.00005	0.00008	-0.00403	-0.00001	-0.00079	0.00002	0.00004	-0.00228	0.00000	-0.10502	0.00212	0.00501	-0.30467	-0.00052
	42	-0.00115	-0.00123	-0.00240	0.03162	0.00007	-0.00011	-0.00107	-0.00547	0.19026	0.00037	0.00010	-0.00009	-0.00030	0.00620	0.00002	0.00015	-0.00003	-0.00016	0.00321	0.00001	-0.01132	-0.02079	-0.04261	0.68435	0.00164
	43	0.00091	-0.00101	-0.00196	0.01346	0.00002	0.00312	-0.00174	-0.00506	0.15300	0.00006	0.00022	-0.00010	-0.00030	0.00718	0.00000	0.00015	-0.00004	-0.00016	0.00326	0.00000	0.01671	-0.01950	-0.03728	0.30473	0.00033
	44	0.00002	0.00001	0.00006	0.00011	0.00000	0.00007	0.00003	0.00019	0.00082	0.00000	0.00000	0.00000	0.00001	0.00005	0.00000	0.00000	0.00000	0.00001	0.00002	0.00000	0.00044	0.00022	0.00108	0.00042	0.00000
	45	-0.02239	0.00067	0.00137	-0.02208	-0.00011	-0.07268	0.00062	0.00083	-0.19871	-0.00044	-0.00424	0.00012	0.00024	-0.01157	-0.00003	-0.00244	0.00005	0.00012	-0.00647	-0.00002	-0.31925	0.00055	0.01008	-0.75944	-0.00294
LU	46	0.01142	0.00221	0.00337	-0.03967	0.00010	0.36728	0.00692	0.05027	-4.08369	0.00604	0.00253	0.00030	0.00057	-0.01688	0.00004	0.00168	0.00012	0.00032	-0.01039	0.00002	0.42747	0.04596	0.10471	-3.27283	0.00929
	47	-0.04797	0.00006	0.00401	-0.13542	0.00053	-1.23196	0.00400	0.07421	-13.27361	0.04653	-0.00985	0.00001	0.00082	-0.10212	0.00020	-0.00621	0.00001	0.00048	-0.06153	0.00014	-1.81897	0.00221	0.12409	-13.20079	0.04743
	48	-0.00405	0.00003	0.00011	-0.06354	-0.00001	-0.14088	0.00174	0.00208	-3.64037	-0.00062	-0.00080	0.00001	0.00002	-0.03678	-0.00001	-0.00051	0.00000	0.00001	-0.02146	0.00000	-0.17003	0.00116	0.00361	-4.24386	-0.00127
	49	0.00013	0.00000	0.00000	-0.00012	0.00000	0.00367	0.00003	-0.00021	-0.00800	-0.00005	0.00003	0.00000	0.00000	-0.00005	0.00000	0.00002	0.00000	0.00000	-0.00003	0.00000	0.00523	0.00002	-0.00016	-0.00777	-0.00004
	50	-0.06167	-0.00974	-0.01691	0.18096	-0.00062	-2.00157	-0.10521	-0.38853	15.81368	-0.03792	-0.01342	-0.00147	-0.00311	0.08196	-0.00022	-0.00882	-0.00056	-0.00180	0.04915	-0.00014	-2.43493	-0.19521	-0.55936	13.77959	-0.05300
NL	51	-0.00053	0.00001	0.00028	-0.02014	0.00000	-0.01116	-0.00004	0.00015	-0.87909	-0.00004	-0.00034	0.00000	0.00012	-0.02399	-0.00001	-0.00022	0.00000	0.00006	-0.01479	0.00000	-0.01192	0.00009	0.00410	-0.82458	-0.00028
	52	-0.01384	0.00166	-0.00939	-0.04414	-0.00136	-0.19150	-0.51101	-0.43614	-1.96043	-0.05668	-0.00882	-0.00796	-0.01385	0.01693	-0.00166	-0.00507	-0.00497	-0.00905	-0.00083	-0.00118	-0.33814	-0.08558	-0.29890	-1.34014	-0.06038
	53	0.00001	-0.00035	0.00041	0.00802	0.00000	0.00012	-0.00524	0.01136	0.25220	0.00140	0.00000	-0.00012	0.00029	0.00582	0.00003	0.00000	-0.00002	0.00018	0.00219	0.00003	0.00007	-0.00691	0.01094	0.18847	0.00066
	54	-0.00004	0.00000	-0.00003	0.00000	0.00000	-0.00061	-0.00032	-0.00090	-0.00201	0.00005	-0.00003	-0.00001	-0.00003	0.00152	0.00000	-0.00002	0.00000	-0.00002	0.00065	0.00000	-0.00098	-0.00001	-0.00070	0.00972	0.00006
	55	0.00418	-0.00001	-0.00152	0.03287	0.00016	0.07034	-0.00056	-0.03335	0.67813	0.00558	0.00273	-0.00002	-0.00147	0.09180	0.00018	0.00165	-0.00001	-0.00091	0.04246	0.00012	0.10200	0.00030	-0.02706	1.32749	0.00671
PT	56	-0.00950	0.00062	0.00204	0.03435	0.00000	-0.10767	0.00135	0.00391	0.85129	0.00001	-0.00603	0.00024	0.00085	0.04210	0.00000	-0.00331	0.00009	0.00036	0.02191	0.00000	-0.41128	0.02137	0.06917	3.39300	0.00016
	57	0.01530	-0.00262	-0.00891	-0.25113	-0.00022	0.33593	0.00438	-0.05183	-6.06575	0.00168	0.02167	-0.00060	-0.00460	-0.25814	-0.00006	0.01467	-0.00004	-0.00208	-0.13169	0.00002	0.14859	-0.03340	-0.33935	-25.63251	-0.02277
	58	0.01524	-0.00129	-0.00422	-0.20100	-0.00014	0.23826	0.00169	-0.02480	-4.65873	0.00035	0.01436	-0.00032	-0.00224	-0.20888	-0.00008	0.00904	-0.00003	-0.00102	-0.10484	-0.00001	0.56096	-0.01134	-0.15252	-19.16183	-0.01381
	59	0.00005	0.00000	-0.00001	-0.00009	0.00000	0.00053	0.00000	-0.00008	-0.00131	0.00000	0.00003	0.00000	-0.00001	-0.00010	0.00000	0.00002	0.00000	0.00000	-0.00004	0.00000	0.00291	0.00002	-0.00016	-0.00328	-0.00002
	60	0.06137	-0.00223	-0.01051	-0.10294	-0.00003	0.63017	-0.01755	-0.06229	-2.71459	-0.00052	0.03828	-0.00141	-0.00642	-0.16978	-0.00004	0.02026	-0.00056	-0.00312	-0.08085	-0.00002	2.94874	-0.14143	-0.56586	-7.40087	-0.00271
ES	61	0.00124	-0.00017	-0.00037	-0.00167	0.00001	0.00833	-0.00034	-0.00103	-0.02509	0.00005	0.00055	-0.00005	-0.00014	-0.00153	0.00000	0.00034	-0.00002	-0.00007	-0.00087	0.00000	0.06235	-0.00619	-0.01665	-0.16740	0.00063
	62	-0.00889	-0.00584	-0.00909	-0.64692	0.00024	-0.00789	-0.00369	-0.04264	-9.17940	0.00611	0.00093	-0.00105	-0.00309	-0.36787	0.00032	0.00196	-0.00028	-0.00170	-0.21154	0.00026	-0.73582	-0.45596	-0.75006	-71.80515	0.02511
	63	0.00545	-0.00139	-0.00339	-0.22244	-0.00001	0.05395	-0.00157	-0.01504	-3.13417	0.00111	0.00412	-0.00031	-0.00124	-0.15203	0.00003	0.00304	-0.00009	-0.00068	-0.08504	0.00004	0.21648	-0.09044	-0.24401	-22.39656	-0.00174
	64	-0.00005	0.00000	0.00000	0.00012	0.00000	-0.00032	0.00000	0.00001	0.00210	0.00000	-0.00002	0.00000	0.00000	0.00011	0.00000	-0.00001	0.00000	0.00000	0.00008	0.00000	-0.00112	-0.00005	0.00012	0.02396	0.00002
	65	-0.00375	0.00027	0.00115	0.00129	-0.00002	-0.02237	0.00277	0.00833	0.01606	-0.00023	-0.00165	0.00017	0.00062	0.00207	-0.00002	-0.00101	0.00007	0.00037	0.00074	-0.00001	-0.25165	0.03490	0.09089	-0.20908	-0.00129
SE	66	-0.01372	-0.00006	-0.00162	0.06079	-0.00002	-0.10991	-0.00022	-0.00645	1.01487	-0.00024	-0.04501	-0.00006	-0.00433	0.26468	-0.00009	-0.02626	0.00001	-0.00213	0.11479	-0.00005	-0.21913	-0.00050	-0.01963	1.61213	-0.00061
	67	0.24722	-0.00380	-0.02867	0.88231	-0.00053	2.00425	-0.00740	-0.07590	18.91356	-0.00582	0.48649	-0.01331	-0.12454	6.61357	-0.00532	0.24692	-0.00526	-0.06704	3.65421	-0.00327	3.72298	-0.02123	-0.28551	28.91269	-0.01500
	68	0.00068	0.00066	-0.00061	-0.17966	0.00016	0.00707	-0.00005	-0.00423	-2.60486	0.00107	0.00406	-0.00079	-0.00415	-0.83852	0.00100	0.00283	-0.00184	-0.00230	-0.20521	0.00042	0.01336	0.00021	-0.00777	-3.86994	0.00367
	69	0.00010	0.00000	-0.00003	0.00071	0.00000	0.00077	-0.00001	-0.00013	0.01509	0.00000	0.00023	-0.00001	-0.00019	0.00234	0.00000	0.00012	-0.00001	-0.00010	0.00088	0.00000	0.00152	-0.00001	-0.00037	0.02265	0.00000
	70	0.15277	0.00069	0.01543	-0.61250	0.00019	1.20538	0.00249	0.04161	-11.40455	0.00270	0.42163	0.00167	0.03191	-3.25335	0.00126	0.23448	0.00064	0.01474	-1.72308	0.00078	2.36813	0.00616	0.17655	-18.03295	0.00676
UK	71	-0.00793	0.00015	0.00015	0.02328	0.00000	-0.10575	0.00056	-0.00033	0.63321	0.00001	-0.00619	0.00009	0.00006	0.04106	0.00000	-0.00369	0.00004	0.00002	0.02430	0.00000	-0.27729	0.00382	0.00301	1.50455	0.00008
	72	0.00138	0.00071	0.00297	-0.09060	0.00015	0.01025	-0.00450	0.04201	-1.82839	0.00576	0.00078	-0.00009	0.00255	-0.06944	0.00032	0.00022	-0.00022	0.00141	-0.03278	0.00026	0.03409	0.00782	0.11426	-3.99976	0.01259
	73	-0.00146	-0.00002	0.00042	-0.01805	-0.00001	-0.01464	-0.00075	0.01015	0.03557	-0.00003	-0.00076	-0.00006	0.00063	-0.00092	0.00000	-0.00027	-0.00006	0.00038	0.01060	0.00000	-0.02602	-0.00482	0.01658	0.31191	-0.00021
	74	0.00005	0.00000	0.00000	0.00041	0.00000	0.00049	-0.00001	-0.00004	0.02146	-0.00002	0.00004	0.00000	0.00000	0.00027	0.00000	0.00002	0.00000	0.00000	0.00044	0.00000	0.00198	0.00013	-0.00001	0.05188	-0.00006
	75	0.00011	-0.00114	-0.00131	-0.14986	0.00007	0.09421	-0.00354	-0.01360	-3.24749	0.00172	0.00330	-0.00046	-0.00079	-0.12873	0.00011	0.00491	-0.00016	-0.00040	-0.07136	0.00008	0.17760	-0.04740	-0.05805	-7.01742	0.00445

		DE					GR					IE					IT					LU				
		V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36	V37	V38	V39	V40	V41	V42	V43	V44	V45	V46	V47	V48	V49	V50
AT	1	-0.68152	-0.02066	0.04120	-4.61635	0.00667	-0.00043	0.00002	0.00005	-0.00149	0.00000	-0.00208	0.00024	0.00051	-0.00692	0.00004	-0.09911	0.00331	0.01095	-0.37244	0.00062	-0.00018	0.00001	0.00003	-0.00059	0.00000
	2	-0.33851	0.01063	1.64672	30.91937	0.01994	-0.00021	-0.00005	0.00041	0.01326	0.00001	-0.00146	0.00002	0.00364	0.05886	0.00007	-0.06281	0.00922	0.14351	2.74054	0.00174	-0.00013	0.00004	0.00025	0.00497	0.00000
	3	-0.52399	-0.21494	0.86805	22.25101	0.00134	-0.00020	0.00001	0.00031	0.00858	0.00000	-0.00114	0.00057	0.00300	0.05102	-0.00001	-0.04611	0.01271	0.10189	1.87888	0.00001	-0.00008	0.00005	0.00020	0.00295	0.00000
	4	0.01566	0.00023	0.00016	0.01124	0.00001	0.00001	0.00000	0.00000	0.00007	0.00000	0.00004	0.00000	0.00000	0.00024	0.00000	0.00201	0.00004	0.00000	0.01752	0.00000	0.00000	0.00000	0.00000	0.00004	0.00000
	5	2.07275	0.50797	0.08355	33.21932	0.02071	0.00108	-0.00010	-0.00020	0.00952	0.00000	0.00511	-0.00172	-0.00233	0.05924	0.00000	0.21829	-0.03154	-0.05709	2.34158	0.00134	0.00038	-0.00009	-0.00015	0.00318	0.00000
BE	6	-0.10839	0.00554	0.00001	2.00507	0.00275	-0.00013	0.00000	0.00000	0.00156	0.00000	-0.00192	-0.00018	-0.00005	0.02523	0.00014	-0.01662	-0.00018	-0.00013	0.20547	0.00031	-0.00027	-0.00002	-0.00001	0.00357	0.00000
	7	0.57727	-0.08075	-0.04534	53.90254	0.02519	0.00072	0.00002	0.00004	0.04037	0.00003	0.00989	0.00088	0.00185	0.72690	0.00109	0.09352	-0.00138	0.00316	5.52155	0.00274	0.00141	0.00001	0.00015	0.10475	0.00005
	8	-0.40815	0.00274	-0.24367	2.12262	0.00944	-0.00071	0.00000	-0.00016	0.00267	0.00001	-0.00889	-0.00010	-0.00597	0.07757	0.00028	-0.09331	-0.00083	-0.02668	0.15457	0.00094	-0.00172	-0.00004	-0.00102	0.00446	0.00001
	9	-0.00374	-0.00009	-0.00012	0.12318	0.00007	-0.00001	0.00000	0.00000	0.00009	0.00000	-0.00012	0.00000	-0.00001	0.00292	0.00000	-0.00093	0.00002	-0.00002	0.00924	0.00001	-0.00003	0.00000	0.00000	0.00025	0.00000
	10	0.39670	-0.01907	0.00178	-6.74954	-0.01003	0.00047	0.00001	0.00001	-0.00548	-0.00001	0.00719	0.00061	0.00023	-0.07948	-0.00051	0.05982	0.00056	0.00065	-0.71575	-0.00115	0.00101	0.00007	0.00003	-0.01175	-0.00001
DK	11	0.00673	0.00041	-0.00110	-11.83865	0.00585	0.00004	0.00000	0.00000	-0.01070	0.00000	0.00019	-0.00002	-0.00002	-0.10196	0.00006	0.00426	-0.00015	-0.00015	-0.60716	0.00041	0.00002	0.00000	0.00000	-0.00187	0.00000
	12	0.68872	-0.52484	0.19026	249.43680	-0.00377	0.00090	0.00018	0.00036	0.26285	-0.00001	0.00590	0.00449	0.00451	1.58704	-0.00010	0.07143	0.00604	0.02456	20.60493	-0.00036	0.00025	0.00019	0.00013	0.07014	0.00000
	13	-1.31486	0.01621	-0.15498	108.38340	0.02540	-0.00172	0.00000	-0.00026	0.11559	0.00004	-0.01131	-0.00011	-0.00328	0.65219	0.00057	-0.13985	-0.00004	-0.01811	9.18664	0.00222	-0.00050	-0.00001	-0.00010	0.03156	0.00000
	14	0.00293	0.00019	0.00017	-0.01057	0.00004	0.00000	0.00000	0.00000	-0.00001	0.00000	0.00003	0.00000	0.00000	0.00016	0.00000	0.00039	0.00004	0.00001	-0.00219	0.00000	0.00000	0.00000	0.00000	-0.00001	0.00000
	15	0.89780	0.00100	0.00826	40.52764	-0.03983	0.00104	0.00001	0.00001	0.04691	-0.00003	0.00743	0.00015	0.00015	0.37779	-0.00033	0.05636	0.00082	0.00095	3.01827	-0.00249	0.00019	0.00000	0.00000	0.01012	-0.00001
FI	16	-0.64013	0.00647	-0.00022	11.94698	-0.00060	-0.00138	-0.00002	0.00000	0.01852	0.00000	-0.00495	-0.00015	-0.00001	0.06533	-0.00002	-0.10067	-0.00094	-0.00007	1.33812	-0.00010	-0.00019	0.00000	0.00000	0.00239	0.00000
	17	5.80012	0.32516	-1.48844	122.35000	0.00181	0.00888	-0.00007	-0.00449	0.19166	0.00001	0.04197	-0.00154	-0.02653	0.72393	0.00003	0.92474	-0.01030	-0.31124	12.79472	0.00024	0.00189	-0.00008	-0.00084	0.02222	0.00000
	18	-7.89511	0.00898	-1.03210	1.40215	0.02958	-0.02159	-0.00004	-0.00130	0.00229	0.00004	-0.06474	0.00023	-0.00274	0.01373	0.00045	-1.41654	-0.03090	-0.12668	0.02964	0.00341	-0.00260	-0.00002	-0.00020	-0.00003	0.00000
	19	-0.00507	0.00000	0.00035	-0.01536	0.00001	-0.00001	0.00000	0.00000	-0.00002	0.00000	-0.00004	0.00000	0.00000	0.00003	0.00000	-0.00088	0.00000	0.00002	-0.00366	0.00000	0.00000	0.00000	0.00000	-0.00001	0.00000
	20	1.81186	-0.02779	0.00225	-61.65427	-0.00953	0.00324	0.00011	0.00001	-0.10135	-0.00001	0.01308	0.00084	0.00004	-0.41473	-0.00004	0.21897	0.00818	0.00050	-6.27736	-0.00096	0.00042	0.00002	0.00000	-0.01058	0.00000
FR	21	0.02130	-0.00414	0.00071	1.74638	0.00093	0.00004	0.00000	0.00001	0.00206	0.00000	0.00023	0.00008	0.00008	0.01329	0.00003	0.00673	0.00044	0.00099	0.39826	0.00023	0.00003	0.00001	0.00001	0.00144	0.00000
	22	-2.55406	-0.09545	0.09918	-9.31052	-0.00426	-0.00414	-0.00004	0.00024	-0.01437	-0.00001	-0.02823	-0.00010	0.00367	-0.09786	-0.00012	-0.80937	-0.02142	0.04045	-2.67855	-0.00105	-0.00287	0.00000	0.00027	-0.01088	0.00000
	23	-0.76729	-0.02332	0.03930	-10.76763	0.00046	-0.00115	0.00000	0.00008	-0.01459	0.00000	-0.00801	0.00019	0.00110	-0.11219	-0.00001	-0.20742	-0.00004	0.01728	-2.60412	0.00013	-0.00074	0.00002	0.00010	-0.00978	0.00000
	24	0.00035	0.00000	-0.00056	0.08617	0.00005	0.00000	0.00000	0.00000	0.00011	0.00000	0.00000	0.00000	-0.00001	-0.00055	0.00000	0.00012	-0.00003	-0.00022	0.01725	0.00001	0.00000	0.00000	0.00000	0.00008	0.00000
	25	-0.04790	0.00850	0.00073	-2.23108	-0.00244	-0.00009	-0.00001	-0.00001	-0.00276	0.00000	-0.00054	-0.00010	-0.00012	-0.01528	-0.00007	-0.01596	0.00122	-0.00071	-0.55677	-0.00055	-0.00006	0.00000	-0.00001	-0.00212	0.00000
DE	26	-3.47490	-0.09590	-0.02101	16.23968	0.00997	-0.00255	-0.00003	-0.00020	0.00374	0.00001	-0.01499	-0.00055	-0.00320	0.02288	0.00018	-0.33372	-0.00151	-0.02017	0.52184	0.00121	-0.00137	-0.00003	-0.00018	0.00199	0.00000
	27	-1.03316	-1.73226	-0.52670	-4.92722	-0.01618	-0.00010	0.00002	0.00028	0.00239	-0.00001	0.00050	0.00081	0.00468	0.02201	-0.00017	-0.00011	0.00758	0.06142	0.29418	-0.00202	0.00011	0.00004	0.00043	0.00106	0.00000
	28	-0.14950	-0.11318	0.97056	-3.70970	-0.00411	0.00015	0.00000	0.00009	-0.00531	0.00000	0.00067	-0.00005	0.00102	-0.04545	-0.00006	0.02101	-0.00067	0.01517	-0.60495	-0.00069	0.00010	0.00000	0.00008	-0.00229	0.00000
	29	-0.01525	0.00003	0.00071	-0.52035	0.00059	0.00000	0.00000	0.00000	0.00003	0.00000	-0.00002	0.00000	0.00000	0.00018	0.00000	-0.00040	-0.00010	-0.00012	0.00628	0.00003	0.00000	0.00000	0.00000	0.00002	0.00000
	30	-9.72869	-0.60705	-0.10887	########	-0.10876	0.00613	0.00014	0.00078	-0.01381	0.00000	0.03614	0.00249	0.01143	-0.10367	-0.00012	0.73909	0.01780	0.09925	-1.79127	0.00087	0.00296	0.00012	0.00071	-0.00668	0.00001
GR	31	0.60273	0.03063	0.02872	0.12399	-0.01081	-0.06941	-0.00184	0.00077	0.43281	-0.00145	0.00436	0.00004	-0.00051	0.00058	-0.00012	0.32102	0.01150	-0.01764	0.04684	-0.00637	0.00047	0.00000	-0.00004	0.00005	0.00000
	32	0.34601	0.06278	0.45916	0.36319	-0.01533	0.03206	0.03088	0.00070	0.23773	-0.00418	0.00264	0.00012	0.00130	-0.00311	-0.00018	0.22264	0.09351	0.29151	0.19350	-0.00688	0.00027	0.00003	0.00017	0.00039	0.00000
	33	0.04323	0.01781	0.14082	1.46502	-0.00781	-0.00289	-0.00054	-0.30832	-0.49721	-0.00143	0.00032	0.00012	0.00075	0.00807	-0.00008	0.03607	0.02790	0.11605	0.10308	-0.00317	0.00003	0.00001	0.00008	0.00015	0.00000
	34	0.00215	0.00022	-0.00155	-0.30227	0.00020	-0.00076	-0.00004	0.00001	0.12680	-0.00001	0.00001	0.00000	0.00001	-0.00161	0.00000	0.00100	0.00004	0.00034	-0.12045	0.00013	0.00000	0.00000	0.00000	-0.00011	0.00000
	35	-2.14196	-0.05885	-0.40575	-0.19119	0.03223	-0.05020	0.00025	0.00725	1.89017	-0.22638	-0.01621	-0.00007	-0.00113	-0.00048	0.00036	-1.34754	-0.05069	-0.20380	-0.08281	0.01654	-0.00176	-0.00001	-0.00012	-0.00009	0.00001
IE	36	0.02344	-0.00130	0.00919	-0.03461	0.00224	0.00006	0.00000	0.00001	0.00007	0.00000	0.33102	0.00031	0.00302	1.21021	0.00154	0.00921	0.00035	0.00164	-0.00294	0.00041	0.00002	0.00000	0.00000	0.00000	0.00000
	37	-0.01260	0.02457	-0.18792	-2.82862	0.01225	-0.00004	0.00000	-0.00025	-0.00381	0.00001	0.03797	-0.67522	0.10591	-3.83378	-0.01022	-0.00620	-0.00627	-0.04946	-0.42250	0.00217	-0.00001	-0.00001	-0.00010	-0.00055	0.00000
	38	0.14209	0.03702	0.01556	-2.10822	0.00161	0.00023	-0.00006	-0.00014	-0.00229	0.00000	-0.01055	0.01619	0.00287	-6.01670	0.00040	0.02908	-0.01412	-0.02762	-0.31184	0.00010	0.00005	-0.00003	-0.00007	-0.00041	0.00000
	39	-0.00001	-0.00045	0.00007	-0.03140	0.00000	0.00000	0.00000	0.00000	-0.00004	0.00000	0.00001	-0.00005	-0.00007	0.53798	0.00000	0.00000	0.00002	0.00015	-0.00516	0.00000	0.00000	0.00000	0.00000	-0.00001	0.00000
	40	0.21021	0.01815	-0.03685	-0.68503	-0.00328	0.00032	-0.00001	-0.00006	-0.00135	0.00000	-0.76483	-0.03429	-0.31951	17.73692	0.53669	0.04182	-0.00004	-0.00809	-0.16878	-0.00063	0.00006	-0.00001	-0.00002	-0.00028	0.00000
IT	41	-0.18380	-0.00838	-0.00641	-0.74792	-0.00075	-0.00074	0.00000	0.00001	-0.00222	0.00000	-0.00148	0.00009	0.00014	-0.00431	-0.00002	-0.09562	-0.00289	0.00291	1.29045	-0.00060	-0.00013	0.00000	0.00001	-0.00033	0.00000
	42	0.01284	-0.01093	-0.05840	2.06085	0.00431	-0.00007	-0.00016	-0.00033	0.00700	0.00001	0.00003	-0.00026	-0.00063	0.01350	0.00004	0.02346	-0.62412	-0.02346	1.38229	0.00208	-0.00001	-0.00002	-0.00005	0.00069	0.00000
	43	0.02976	-0.01952	-0.05235	1.35233	0.00110	0.00011	-0.00018	-0.00028	0.00204	0.00000	0.00025	-0.00023	-0.00058	0.00301	0.00000	-0.11809	0.00281	-0.52363	1.77655	-0.00118	0.00002	-0.00002	-0.00004	0.00057	0.00000
	44	0.00072	0.00018	0.00188	0.00265	0.00000	0.00000	0.00000	0.00001	-0.00001	0.00000	0.00001	0.00000	0.00002	-0.00001	0.00000	0.00330	-0.00002	-0.00092	-0.64198	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
	45	-0.53006	-0.02298	-0.02001	-1.86029	-0.00483	-0.00205	-0.00001	0.00004	-0.00460	-0.00002	-0.00438	0.00015	0.00033	-0.00861	-0.00007	-13.11920	0.07343	-0.09689	-8.32811	0.02866	-0.00041	0.00001	0.00002	-0.00086	0.00000
LU	46	0.87282	-0.13895	-0.02041	-9.26792	0.01348	0.00032	0.00002	0.00004	-0.00195	0.00000	0.00237	0.00051	0.00089	-0.01695	0.00009	0.08372	0.00261	0.01076	-0.54462	0.00091	-0.31003	0.00278	0.00055	1.10765	0.00017
	47	-3.18421	0.00018	-0.05232	-41.51377	0.09233	-0.00128	0.00000	0.00006	-0.00923	0.00002	-0.00975	0.00002	0.00111	-0.04300	0.00047	-0.33879	0.00007	0.00938	-2.73915	0.00579	-0.02213	0.98762	0.02420	0.23256	-0.00052
	48	-0.30442	-0.00010	-0.00009	-12.37967	-0.00250	-0.00011	0.00000	0.00000	-0.00331	0.00000	-0.00085	0.00001	0.00003	-0.01440	-0.00002	-0.02881	0.00003	0.00030	-0.96803	-0.00018	0.03071	0.00640	-0.72885	1.13759	-0.00019
	49	0.01106	0.00010	-0.00022	-0.01952	-0.00007	0.00000	0.00000	0.00000	-0.00001	0.00000	0.00003	0.00000	0.00000	-0.00004	0.00000	0.00106	0.00000	-0.00002	-0.00139	0.00000	0.00003	-0.00004	-0.00031	-0.38259	0.00000
	50	-4.73516	0.56807	-0.13327	38.73498	-0.08462	-0.00171	-0.00008	-0.00025	0.00887	-0.00003	-0.01307	-0.00221	-0.00475	0.06781	-0.00053	-0.45285	-0.00704	-0.05894	2.47357	-0.00571	0.59265	0.05698	0.44355	18.10612	-0.73512
NL	51	-0.04222	-0.00078	-0.01124	-3.97253	-0.00042	-0.00006	0.00000	0.00001	-0.00365	0.00000	-0.00034	0.00001	0.00020	-0.02888	-0.00002	-0.00508	0.00001	0.00072	-0.33150	-0.00005	-0.00002	0.00000	0.00001	-0.00133	0.00000
	52	-0.80297	-1.87511	-1.57342	-7.97905	-0.24455	-0.00129	-0.00101	-0.00157	-0.00697	-0.00026	-0.00808	-0.00387	-0.01446	-0.16407	-0.00380	-0.12470	-0.00703	-0.07985	-0.26508	-0.02128	-0.00062	-0.00031	-0.00053	-0.00088	-0.00004
	53	-0.00019	-0.00807	0.04677	0.94592	0.00775	0.00000	-0.00001	0.00004	0.00115	0.00000	0.00000	-0.00020	0.00047	0.00630	0.00005	0.00006	-0.00223	0.00420	0.07446	0.00055	0.00000	-0.00002	0.00003	0.00035	0.00000
	54	-0.00251	-0.00072	-0.00269	-0.00519	0.00022	0.00000	0.00000	0.00000	0.00001	0.00000	-0.00002	0.00000	-0.00004	-0.00227	0.00000	-0.00038	0.00002	-0.00020	0.00906	0.00002	0.00000	0.00000	0.00000	0.00004	0.00000
	55	0.28073	0.00042	-0.08427	2.27412	0.02461	0.00041	0.00000	-0.00013	0.00419	0.00003	0.00256	0.00000	-0.00163	-0.06060	0.00038	0.03992	0.00021	-0.00775	0.75195	0.00217	0.00018	0.00000	-0.00006	0.00328	0.00000
PT	56	-0.78299	-0.02983	-0.06638	8.38271	0.00009	-0.00079	0.00002	0.00007	0.00518	0.00000	-0.00414	0.00036	0.00103	0.03490	0.00001	-0.16442	0.00355	0.01131	1.23610	0.00001	-0.00039	0.00002	0.00007	0.00249	0.00000
	57	2.06713	0.21623	-0.26020	-58.71542	0.00736	0.00151	0.00004	-0.00028	-0.03833	-0.00002	0.00900	-0.00075	-0.00439	-0.28202	-0.00007	0.29295	-0.00534	-0.10600	-8.66530	-0.00081	0.00071	-0.00008	-0.00041	-0.01609	0.00000
	58	1.66878	0.11320	-0.10980	-43.94829	0.00010	0.00143	0.00002	-0.00014	-0.02899	-0.00002	0.00815	-0.00039	-0.00219	-0.21025	-0.00011	0.29858	0.00009	-0.04543	-6.59791	-0.00099	0.00068	-0.00004	-0.00019	-0.01274	0.00000
	59	0.00438	0.00003	-0.00035	-0.00606	-0.00003	0.00000	0.00000	0.00000	-0.00001	0.00000	0.00002	0.00000	-0.00001	-0.00003	0.00000	0.00103	0.00001	-0.00005	-0.00153	-0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
	60	4.75395	-0.02740	-0.21076	-22.44915	-0.00453	0.00493	-0.00016	-0.00071	-0.01508	0.00000	0.02665	-0.00149	-0.00698	-0.04262	-0.00007	1.06734	-0.03051	-0.13857	-3.35932	-0.00072	0.00259	-0.00009	-0.00039	-0.00872	0.00000
ES	61	0.06920	0.00520	-0.00029	-0.25763	0.00051	0.00016	-0.00001	-0.00003	-0.00040	0.00000	0.00066	-0.00011	-0.00026	-0.00165	0.00001	0.02476	-0.00100	-0.00396	-0.06544	0.00014	0.00003	0.00000	-0.00001	-0.00007	0.00000
	62	-0.04648	0.03952	-0.43599	########	0.06551	-0.00098	-0.00036	-0.00108	-0.17665	0.00007	-0.00267	-0.00356	-0.00690	-0.88621	0.00069	-0.21944	-0.14301	-0.25387	-24.87839	0.01775	-0.00017	-0.00011	-0.00026	-0.02119	0.00001
	63	0.47558	0.02027	-0.12760	-33.43331	0.01241	0.00080	-0.00008	-0.00037	-0.05591	0.00000	0.00383	-0.00084	-0.00261	-0.25910	0.00000	0.10173	-0.02585	-0.07882	-8.16479	0.00328	0.00015	-0.00003	-0.00009	-0.00782	0.00000
	64	-0.00203	-0.00018	0.00022	0.02862	0.00001	-0.00001	0.00000	0.00000	0.00004	0.00000	-0.00002	0.00000	0.00000	0.00027	0.00000	-0.00078	-0.00003	0.00006	0.00808	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000
	65	-0.21702	0.02338	0.08051	-0.02606	-0.00189	-0.00053	0.00006	0.00018	-0.00008	0.00000	-0.00226	0.00025	0.00119	-0.00351	-0.00005	-0.08082	0.00905	0.02814	-0.03329	-0.00042	-0.00009	0.00001	0.00003	0.00007	0.00000
SE	66	-0.68131	0.00211	-0.00498	6.84617	-0.00170	-0.00106	0.00000	-0.00008	0.00753	0.00000	-0.00674	-0.00003	-0.00112	0.03911	-0.00004	-0.10486	0.00000	-0.00527	0.84176	-0.00020	-0.00030	0.00000	-0.00003	0.00232	0.00000
	67	11.10615	0.15203	0.19862	138.46030	-0.04809	0.01788	-0.00008	-0.00106	0.13375	-0.00007	0.10630	-0.00167	-0.01562	0.76617	-0.00095	1.87791	-0.00017	-0.07743	14.32580	-0.00530	0.00541	-0.00006	-0.00048	0.03845	-0.00001
	68	0.04560	-0.04244	-0.02642	-15.03398	0.00824	0.00006	-0.00001	-0.00004	-0.01948	0.00002	0.00044	0.00002	-0.00046	-0.10999	0.00020	0.00631	-0.00093	-0.00358	-1.88725	0.00105	0.00002	0.00001	-0.00001	-0.00534	0.00000
	69	0.00449	0.00002	-0.00024	0.10444	0.00000	0.00001	0.00000	0.00000	0.00010	0.00000	0.00004	0.00000	-0.00002	0.00039	0.00000	0.00074	0.00000	-0.00011	0.01171	0.00000	0.00000	0.00000	0.00000	0.00003	0.00000
	70	7.26075	-0.01972	-0.17737	-81.83165	0.02013	0.01162	0.00003	0.00062	-0.08355	0.00003	0.07143	0.00042	0.00971	-0.45053	0.00047	1.14842	0.00036	0.03697	-9.34682	0.00231	0.00328	0.00001	0.00025	-0.02538	0.00000
UK	71	-0.47883	-0.00486	-0.00848	3.70106	0.00016	-0.00093	0.00001	0.00001	0.00457	0.00000	-0.02628	0.00042	-0.00016	0.21508	0.00000	-0.10310	0.00032	-0.00007	0.58461	0.00002	-0.00028	0.00000	0.00000	0.00147	0.00000
	72	0.02644	-0.04982	0.20620	-8.62570	0.03302	0.00010	-0.00002	0.00028	-0.01411	0.00004	-0.00078	-0.00194	0.02445	-1.19547	0.00363	0.01351	0.00191	0.04128	-1.26238	0.00506	0.00004	0.00002	0.00015	-0.00308	0.00001
	73	-0.04166	-0.00673	0.05440	2.06704	-0.00005	-0.00013	-0.00001	0.00006	0.00019	0.00000	0.00142	-0.00143	0.00517	0.13983	-0.00002	-0.01267	-0.00127	0.00749	0.11543	-0.00003	-0.00004	0.00000	0.00003	0.00000	0.00000
	74	0.00242	0.00000	-0.00021	0.15604	-0.00013	0.00000	0.00000	0.00000	0.00016	0.00000	0.00021	0.00003	-0.00001	0.02268	-0.00001	0.00065	0.00004	-0.00001	0.01383	-0.00002	0.00000	0.00000	0.00000	0.00002	0.00000
	75	0.72992	0.00222	-0.06308	-18.26668	0.00957	0.00093	-0.00008	-0.00012	-0.02612	0.00001	0.07231	-0.00852	-0.00918	-1.94122	0.00121	0.03190	-0.01190	-0.01657	-2.45283	0.00155	0.00003	-0.00003	-0.00006	-0.00603	0.00000

IE	IE	IT	IT	IT	IT	IT	LU	LU	LU	LU	LU	NL	NL	NL	NL	NL	PT	PT	PT	PT	PT	ES	ES	ES	ES	ES	SE	SE	SE	SE	SE	UK	UK	UK	UK	UK	
Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph1	ec100g	Δln(ec4	Δln(sc4	Δln(sc5	Δln(ph110(t))	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(ph110(t))
-423.5	82702	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE ec100g(t-1)
-1.503	11.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(sc410(t))
-0.887	129.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(sc510(t))
7E-04	-0.215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(ph110(t))
0	0	-0.771	-230.9	-8.762	33.26	-93054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT ec100g(t-1)
0	0	0.004	2.43	0.013	0.228	87.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(ec410(t-1))
0	0	0.026	-0.546	8.909	-3.272	22447	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(sc410(t))
0	0	0.002	-0.143	0.219	-1.377	911.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(sc510(t))
0	0	4E-05	0.003	0.004	0.002	9.122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(ph110(t))
0	0	0	0	0	0	0	0.547	0.86	0	0	6527	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU ec100g(t-1)
0	0	0	0	0	0	0	-9E-06	-0.108	0	0	-11.69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(sc510(t))
0	0	0	0	0	0	0	-1E-06	-1E-04	0	0	-0.046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	2.951	44.09	0	-20.38	1E+05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0.156	3.622	0	-6.71	9520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.227	0	-0.045	657.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	-7E-06	-3E-04	0	-0.002	0.229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-9.877	-3375	932.6	0	4E+06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.213	-71.54	13.25	0	65284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	3.057	-0.393	0	-2676	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4E-05	-0.011	0.003	0	19.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006	90.02	-62.26	0	-17864	0	0	0	0	0	0	0	0	0	0	ES ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006	1.503	0.736	0	186.3	0	0	0	0	0	0	0	0	0	0	ES Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	1.754	-0.338	0	244.9	0	0	0	0	0	0	0	0	0	0	ES Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	ES Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3E-07	8E-04	2E-05	0	-0.178	0	0	0	0	0	0	0	0	0	0	ES Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.081	12.6	0	-83.48	53001	0	0	0	0	0	SE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4E-05	0.665	0	-4.319	0.007	0	0	0	0	0	SE Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SE Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2E-05	-0.023	0	-0.206	53.07	0	0	0	0	0	SE Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1E-06	-6E-05	0	3E-04	-0.346	0	0	0	0	0	SE Δln(ph110(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.084	-1.393	0	-0.351	-11936	UK ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	1.607	0	0.87	-185.3	UK Δln(ec410(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	UK Δln(sc410(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004	0.367	0	-0.298	-13.75	UK Δln(sc510(t))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4E-07	-0.001	0	0.002	-0.052	UK Δln(ph110(t))

$G^{-1}H$ Model I (continued)

		NL					PT					ES					SE					UK				
		V51	V52	V53	V54	V55	V56	V57	V58	V59	V60	V61	V62	V63	V64	V65	V66	V67	V68	V69	V70	V71	V72	V73	V74	V75
AT	1	-0.03066	0.00373	0.00659	-0.08259	0.00027	-0.00110	-0.00011	-0.00005	-0.00606	0.00001	-0.02126	0.00109	0.00201	-0.05489	0.00013	-0.00459	0.00009	0.00049	-0.01191	0.00006	-0.05077	0.00342	0.00502	-0.26151	0.00034
	2	-0.01739	0.00829	0.05059	0.71095	0.00065	-0.00095	-0.00073	-0.00018	0.04331	0.00002	-0.01812	-0.00118	0.01663	0.49472	0.00024	0.00168	0.00108	0.00865	0.12622	0.00016	-0.02538	0.01045	0.06562	2.46648	0.00080
	3	-0.01064	0.01233	0.04195	0.49593	-0.00009	-0.00058	-0.00030	0.00001	0.02259	0.00000	-0.01217	0.00111	0.01208	0.32700	0.00000	-0.00032	0.00148	0.00679	0.09962	-0.00003	-0.01908	0.00878	0.04908	1.21913	-0.00007
	4	0.00061	-0.00001	-0.00002	0.00532	0.00000	0.00002	0.00000	0.00000	0.00046	0.00000	0.00040	-0.00001	-0.00001	0.00252	0.00000	0.00009	0.00000	0.00000	0.00017	0.00000	0.00096	-0.00002	0.00000	0.01822	0.00000
	5	0.05928	-0.02655	-0.03463	0.53535	0.00000	0.00224	0.00002	-0.00004	0.02679	0.00000	0.05190	-0.00640	-0.00805	0.36681	0.00010	0.01157	-0.00225	-0.00376	0.10945	0.00001	0.11852	-0.01460	-0.02884	1.22955	0.00027
BE	6	-0.03864	-0.00401	-0.00096	0.40722	0.00151	-0.00046	0.00003	0.00000	0.00861	0.00001	-0.00815	-0.00029	-0.00007	0.07387	0.00018	-0.00186	-0.00001	-0.00002	0.01692	0.00008	-0.03274	-0.00147	-0.00031	0.59219	0.00080
	7	0.20702	0.01546	0.03397	12.36160	0.01370	0.00249	-0.00040	-0.00025	0.23921	0.00011	0.04571	0.00185	0.00248	1.98090	0.00147	0.01062	-0.00042	0.00014	0.42231	0.00062	0.18419	0.00687	0.00645	15.84547	0.00695
	8	-0.27369	-0.00623	-0.13126	0.72642	0.00271	-0.00216	0.00000	-0.00031	-0.00678	0.00003	-0.03959	0.00018	-0.00808	0.13577	0.00051	-0.01644	-0.00033	-0.00600	0.07616	0.00011	-0.22403	-0.00198	-0.07856	0.48831	0.00185
	9	-0.00406	0.00012	-0.00013	0.03296	0.00002	-0.00003	0.00000	0.00000	0.00018	0.00000	-0.00038	0.00000	-0.00001	0.00510	0.00000	-0.00014	0.00000	-0.00001	0.00194	0.00000	-0.00214	0.00002	-0.00006	0.02316	0.00001
	10	0.14387	0.01440	0.00420	-1.33496	-0.00545	0.00169	-0.00012	-0.00001	-0.02975	-0.00005	0.02951	0.00096	0.00032	-0.25309	-0.00066	0.00629	0.00009	0.00009	-0.05803	-0.00031	0.11581	0.00608	0.00162	-2.10785	-0.00297
DK	11	0.00936	-0.00042	-0.00035	-0.99839	0.00062	0.00012	0.00000	0.00000	-0.01369	0.00001	0.00127	-0.00004	-0.00004	-0.28340	0.00017	0.01925	-0.00062	-0.00050	-2.25272	0.00071	0.01212	-0.00025	-0.00046	-1.92266	0.00108
	12	0.09653	0.10686	0.07061	23.21959	-0.00092	0.00209	-0.00228	-0.00013	0.78577	-0.00002	0.03411	0.00916	0.00987	7.07421	-0.00019	0.02958	0.02931	0.06638	10.83941	-0.00092	0.15624	0.11690	0.08294	71.80365	-0.00120
	13	-0.18718	-0.00307	-0.05193	10.01921	0.00552	-0.00411	0.00008	0.00011	0.35712	0.00009	-0.06699	-0.00022	-0.00729	3.12916	0.00110	-0.02831	-0.00107	-0.05235	2.84898	0.00665	-0.30015	-0.00370	-0.06325	32.83615	0.00734
	14	0.00057	0.00001	-0.00001	-0.00032	0.00001	0.00001	0.00000	0.00000	-0.00016	0.00000	0.00017	-0.00001	0.00000	-0.00030	0.00000	0.00020	0.00012	0.00005	0.00965	0.00001	0.00094	-0.00006	0.00003	-0.00918	0.00001
	15	0.09343	0.00241	0.00215	4.27402	-0.00457	0.00196	0.00002	0.00002	0.07073	-0.00006	0.02773	0.00031	0.00032	1.13670	-0.00087	0.16709	0.00281	0.00239	6.73898	-0.01040	0.14206	0.00222	0.00270	8.25033	-0.00746
FI	16	-0.10123	-0.00354	-0.00015	1.09634	-0.00022	-0.00268	0.00003	0.00000	0.04841	-0.00001	-0.04686	-0.00065	-0.00003	0.46121	-0.00007	-0.02551	-0.00337	-0.00014	0.96860	-0.00017	-0.20740	-0.00441	-0.00019	4.02415	-0.00029
	17	0.71741	-0.06662	-0.61136	11.39361	0.00052	0.02363	0.00175	0.00166	0.43231	0.00001	0.48407	-0.00382	-0.10611	4.94454	0.00011	-1.96381	-0.07471	-0.87975	13.55963	0.00126	1.42491	-0.07358	-0.98994	41.15172	0.00085
	18	-1.59045	-0.03339	-0.15492	0.10984	0.00364	-0.03863	-0.00065	-0.00184	-0.00358	0.00011	-0.59822	0.00469	-0.01805	0.05874	0.00188	-2.85499	-0.19273	-0.57519	0.67699	-0.00366	-3.25357	-0.02415	-0.44877	0.15011	0.00708
	19	-0.00095	0.00000	-0.00002	-0.00157	0.00000	-0.00002	0.00000	0.00000	-0.00021	0.00000	-0.00039	0.00000	-0.00001	-0.00052	0.00000	-0.00112	0.00000	0.00019	0.00833	0.00000	-0.00194	0.00000	0.00010	-0.01073	0.00000
	20	0.20171	0.02037	0.00088	-5.93591	-0.00072	0.00609	0.00000	0.00000	-0.18116	-0.00002	0.11226	0.00300	0.00016	-2.46611	-0.00031	-0.08375	0.02910	0.00122	-10.15146	-0.00157	0.41936	0.02191	0.00137	-18.14040	-0.00207
FR	21	0.00297	0.00108	0.00091	0.13894	0.00019	0.00016	-0.00004	-0.00001	0.01331	0.00001	0.00470	0.00074	0.00073	0.21111	0.00021	0.00031	0.00002	0.00005	0.01398	0.00003	0.00688	0.00140	0.00112	0.58109	0.00033
	22	-0.33077	0.00197	0.03609	-1.19796	-0.00088	-0.02315	-0.00126	-0.00095	-0.07041	-0.00004	-0.60684	-0.01327	0.03109	-1.16146	-0.00075	-0.02428	-0.00012	0.00351	-0.10075	-0.00015	-0.71186	-0.00020	0.05721	-4.34974	-0.00165
	23	-0.08195	0.00359	0.01217	-1.04599	-0.00010	-0.00597	-0.00023	-0.00005	-0.06285	0.00000	-0.16077	-0.00017	0.01127	-1.56569	0.00009	-0.00573	0.00025	0.00122	-0.12509	-0.00002	-0.17877	0.00373	0.02119	-3.65359	-0.00007
	24	0.00006	-0.00004	-0.00014	0.00523	0.00001	0.00000	0.00000	0.00000	0.00119	0.00000	0.00008	-0.00006	-0.00018	-0.00429	0.00001	0.00000	0.00000	-0.00001	-0.00005	0.00000	0.00012	-0.00013	-0.00025	0.05651	0.00001
	25	-0.00704	-0.00112	-0.00118	-0.20524	-0.00041	-0.00040	0.00010	0.00003	-0.01961	-0.00002	-0.01123	-0.00018	-0.00071	-0.22342	-0.00046	-0.00072	0.00004	-0.00004	-0.01457	-0.00006	-0.01605	-0.00150	-0.00093	-0.87937	-0.00076
DE	26	-0.28657	-0.01022	-0.05288	0.34937	0.00168	-0.00800	0.00021	0.00048	0.01983	0.00004	-0.14727	-0.00243	-0.01107	0.16702	0.00062	-0.02868	-0.00002	-0.00131	0.03004	0.00021	-0.39917	-0.00692	-0.02409	0.86838	0.00173
	27	0.07200	0.01799	0.11806	0.24419	-0.00068	0.00145	-0.00005	-0.00038	0.00791	-0.00003	-0.01740	0.00192	0.01133	0.12019	-0.00083	-0.00052	0.00107	0.00904	0.03088	-0.00017	-0.01510	0.00253	0.07549	0.38534	-0.00193
	28	0.03448	-0.00155	0.02094	-0.51106	-0.00017	0.00050	0.00002	0.00005	-0.01433	-0.00001	0.00346	-0.00007	0.00400	-0.25672	-0.00034	0.00482	-0.00014	0.00220	-0.07105	-0.00001	0.03385	-0.00067	0.02114	-0.89235	-0.00059
	29	-0.00036	-0.00004	-0.00005	0.00432	0.00004	-0.00001	0.00000	0.00000	0.00028	0.00000	-0.00017	0.00000	-0.00002	0.00146	0.00002	-0.00004	-0.00001	-0.00002	0.00007	0.00000	-0.00048	-0.00003	-0.00015	0.01011	0.00004
	30	0.61513	0.04533	0.19786	-1.33621	-0.00045	0.01763	-0.00006	0.00007	-0.05592	-0.00001	0.33583	0.00966	0.03694	-0.63082	-0.00009	0.06925	0.00194	0.01059	-0.14698	-0.00008	0.89480	0.02393	0.11857	-2.61148	0.00012
GR	31	0.12689	0.00005	-0.01605	0.01367	-0.00231	0.00209	0.00014	0.00032	0.00045	-0.00003	0.08895	0.00096	-0.00327	0.00803	-0.00104	0.00888	0.00030	-0.00054	0.00091	-0.00026	0.17586	0.00053	-0.00675	0.03405	-0.00231
	32	0.08757	0.01591	0.06142	0.04473	-0.00263	0.00120	0.00032	0.00078	0.00590	-0.00004	0.04932	0.00189	0.02103	-0.00537	-0.00146	0.00851	0.00306	0.01071	-0.01745	-0.00030	0.10907	0.00659	0.09428	0.27288	-0.00297
	33	0.01220	0.00638	0.03041	0.02149	-0.00116	0.00016	0.00006	0.00029	-0.00119	-0.00002	0.00672	0.00193	0.01040	0.08891	-0.00069	0.00100	0.00059	0.00304	0.03152	-0.00014	0.01365	0.00392	0.03375	0.09865	-0.00150
	34	0.00040	-0.00002	0.00045	-0.03291	0.00005	0.00001	0.00000	-0.00001	-0.00086	0.00000	0.00030	0.00000	0.00006	-0.02026	0.00002	0.00004	0.00000	0.00001	-0.00288	0.00001	0.00062	0.00000	0.00011	-0.06669	0.00005
	35	-0.53770	-0.00713	-0.03942	-0.01979	0.00591	-0.00738	-0.00025	-0.00083	-0.00103	0.00008	-0.31851	-0.00159	-0.01739	-0.00961	0.00307	-0.05440	-0.00174	-0.00802	0.00046	0.00063	-0.71766	-0.00543	-0.07222	-0.05792	0.00632
IE	36	0.00992	0.00065	0.00249	0.01440	0.00054	0.00012	0.00000	0.00001	-0.00074	0.00001	0.00376	-0.00031	0.00051	0.00338	0.00021	0.00154	0.00026	0.00038	0.00371	0.00005	0.04758	-0.00329	0.02328	-0.06099	0.00551
	37	-0.00864	-0.01593	-0.08897	-0.57135	0.00236	-0.00010	-0.00001	-0.00028	-0.00363	0.00004	-0.00239	-0.00026	-0.01413	-0.23059	0.00106	-0.00100	-0.00181	-0.01049	-0.08867	0.00026	-0.06881	-0.07192	-0.88349	-7.16191	0.02048
	38	0.01596	-0.03996	-0.06956	-0.28937	-0.00106	0.00038	-0.00001	0.00001	-0.00703	-0.00001	0.01483	-0.00616	-0.00875	-0.13342	-0.00009	0.00343	-0.00177	-0.00324	-0.03720	-0.00008	-0.18757	-0.36448	-0.77446	-5.08237	-0.01080
	39	0.00000	0.00015	0.00038	-0.00507	0.00000	0.00000	0.00000	0.00000	-0.00012	0.00000	0.00000	0.00001	0.00006	-0.00209	0.00000	0.00000	0.00000	0.00003	-0.00055	0.00000	0.00000	0.00070	0.00303	-0.07061	-0.00001
	40	0.05108	-0.00600	-0.01464	-0.19314	-0.00068	0.00101	0.00013	-0.00003	-0.00268	-0.00001	0.02244	0.00002	-0.00326	-0.06040	-0.00025	0.00211	-0.00079	-0.00166	-0.02019	0.00002	0.36850	0.02427	-0.08420	-0.56503	-0.01540
IT	41	-0.02512	0.00131	0.00196	-0.05645	-0.00013	-0.00101	-0.00005	-0.00004	-0.00424	-0.00001	-0.02852	0.00050	0.00065	-0.06117	-0.00011	-0.00256	-0.00001	0.00004	-0.00478	-0.00002	-0.04519	0.00090	0.00080	-0.16626	-0.00018
	42	-0.00375	-0.00502	-0.01060	0.12332	0.00036	-0.00011	-0.00013	-0.00024	0.00506	0.00002	-0.00270	-0.00367	-0.00772	0.18702	0.00047	-0.00043	-0.00043	-0.00104	0.02204	0.00004	-0.00605	-0.00518	-0.01572	0.32509	0.00068
	43	0.00359	-0.00423	-0.00873	0.05567	0.00004	0.00015	-0.00012	-0.00024	0.00530	0.00000	0.00350	-0.00416	-0.00733	0.06807	0.00009	0.00028	-0.00029	-0.00071	0.01113	0.00000	0.00555	-0.00611	-0.01276	0.33367	0.00014
	44	0.00008	0.00006	0.00028	0.00034	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00010	0.00004	0.00023	-0.00007	0.00000	0.00000	0.00000	0.00003	0.00005	0.00000	0.00012	0.00010	0.00043	0.00214	0.00000
	45	-0.07915	0.00254	0.00476	-0.13408	-0.00067	-0.00308	-0.00022	-0.00017	-0.01274	-0.00003	-0.08650	0.00109	0.00198	-0.13741	-0.00064	-0.00767	-0.00017	-0.00005	-0.00893	-0.00008	-0.14052	0.00236	0.00125	-0.47461	-0.00097
LU	46	0.08656	0.02092	0.03193	-0.49853	0.00188	0.00146	-0.00023	-0.00012	-0.01399	0.00003	0.03480	0.00290	0.00455	-0.17037	0.00044	0.00488	0.00015	0.00069	-0.02461	0.00012	0.11059	0.01073	0.01573	-1.00280	0.00157
	47	-0.39129	0.00070	0.03516	-1.78450	0.00917	-0.00599	-0.00001	-0.00021	-0.09074	0.00013	-0.13569	0.00016	0.00690	-0.69858	0.00261	-0.02069	-0.00001	-0.00013	-0.06038	0.00061	-0.45964	0.00058	0.01099	-5.80541	0.00865
	48	-0.03416	0.00034	0.00093	-0.64822	-0.00029	-0.00052	0.00000	0.00000	-0.03066	0.00000	-0.01155	0.00008	0.00019	-0.23025	-0.00009	-0.00173	0.00000	0.00001	-0.02231	-0.00002	-0.03860	0.00031	0.00039	-1.98845	-0.00029
	49	0.00105	0.00000	-0.00005	-0.00134	-0.00001	0.00002	0.00000	0.00000	-0.00003	0.00000	0.00046	0.00000	-0.00001	-0.00044	0.00000	0.00004	0.00000	0.00000	-0.00007	0.00000	0.00123	0.00000	-0.00004	-0.00283	-0.00001
	50	-0.49221	-0.09221	-0.16366	2.13641	-0.01068	-0.00811	0.00133	0.00062	0.06670	-0.00015	-0.18680	-0.01361	-0.02618	0.73485	-0.00267	-0.02551	-0.00030	-0.00376	0.10095	-0.00073	-0.59378	-0.05899	-0.08918	4.75739	-0.00944
NL	51	0.27470	0.00376	0.05228	-1.05292	0.00126	-0.00013	0.00000	-0.00003	-0.01183	0.00000	-0.00269	0.00002	0.00041	-0.13477	-0.00004	-0.00072	0.00000	0.00011	-0.04028	-0.00002	-0.01158	0.00002	0.00111	-0.99064	-0.00018
	52	1.24912	-0.02543	0.01696	8.58315	-0.24747	-0.00351	0.00229	-0.00028	0.01555	-0.00066	-0.06067	-0.04443	-0.07610	-0.33904	-0.01159	-0.01572	0.00343	0.00102	-0.22052	-0.00522	-0.27984	-0.48065	-0.30029	0.35509	-0.05307
	53	-0.01579	-0.00534	-0.15419	-0.19247	0.00207	0.00000	0.00002	0.00004	0.00112	0.00001	0.00001	-0.00041	0.00159	0.03912	0.00030	0.00003	-0.00086	0.00105	0.01822	0.00000	0.00028	-0.00999	0.01416	0.29347	0.00115
	54	-0.00135	0.00000	-0.00126	-0.04446	-0.00021	-0.00001	0.00000	0.00000	0.00086	0.00000	-0.00019	-0.00003	-0.00016	-0.00104	0.00001	-0.00004	0.00001	-0.00002	-0.00299	0.00000	-0.00082	-0.00036	-0.00077	0.05632	0.00005
	55	-42.68382	-0.00314	-0.39817	-2.90025	0.11317	0.00111	0.00002	0.00021	0.04834	0.00007	0.02039	-0.00003	-0.00603	0.09400	0.00115	0.00430	0.00004	-0.00116	-0.08782	0.00057	0.08579	-0.00082	-0.02899	3.38682	0.00589
PT	56	-0.11214	0.00907	0.02655	0.70099	0.00006	0.72203	0.00013	0.00181	2.24099	0.00050	-0.42965	0.01155	-0.00519	5.34588	-0.00019	-0.01273	0.00023	0.00075	0.07023	0.00001	-0.23107	0.00631	0.01333	2.10471	0.00006
	57	0.06999	-0.03782	-0.15468	-4.98213	-0.00407	0.00139	-0.76274	0.14276	-6.83869	-0.00172	-1.96775	-0.25640	-1.45743	-37.99627	-0.03678	0.00402	-0.00217	-0.01318	-0.60556	-0.00047	0.29255	-0.01498	-0.19921	-14.21199	-0.00409
	58	0.14758	-0.01766	-0.07131	-3.88091	-0.00293	-0.21246	0.05509	-0.39383	-5.56163	0.00116	-0.27444	-0.09382	-0.63123	-28.74145	-0.01602	0.01194	-0.00091	-0.00588	-0.44764	-0.00038	0.34449	-0.00702	-0.08758	-11.10579	-0.00339
	59	0.00067	0.00000	-0.00014	-0.00116	-0.00001	0.00141	0.00022	-0.00018	0.39833	-0.00001	0.00247	0.00003	-0.00135	0.00040	-0.00002	0.00004	0.00000	-0.00001	-0.00004	0.00000	0.00119	0.00000	-0.00016	-0.00412	-0.00001
	60	0.78093	-0.03935	-0.15124	-1.58428	-0.00080	-3.42103	0.23574	0.12305	71.79065	0.01729	2.94801	-0.13031	0.19266	2.47530	-0.00195	0.07435	-0.00056	-0.00487	-0.10605	-0.00011	1.46385	-0.06974	-0.16367	-7.85882	-0.00121
ES	61	0.00958	-0.00154	-0.00330	-0.01926	0.00010	0.00180	0.00018	0.00008	-0.00997	0.00002	0.04874	-0.00276	0.00869	-1.02571	0.00008	0.00103	-0.00003	-0.00015	-0.00192	0.00001	0.02337	-0.00210	-0.00382	-0.08550	0.00018
	62	-0.08991	-0.06366	-0.10317	-7.12034	0.00450	-0.06300	-0.03344	-0.04927	-4.45468	0.00158	0.14191	-0.89639	-0.01401	-60.65841	0.02107	-0.01050	-0.00600	-0.01136	-1.20243	0.00055	-0.19986	-0.08847	-0.22970	-26.31423	0.01407
	63	0.03737	-0.01443	-0.03639	-2.40430	-0.00011	-0.00536	-0.00493	-0.01285	-1.31184	0.00017	-0.80585	-0.01533	-0.54144	-9.70085	-0.00047	0.00300	-0.00109	-0.00351	-0.34530	-0.00007	0.09210	-0.02113	-0.07287	-9.66177	0.00156
	64	-0.00028	0.00001	0.00001	0.00215	0.00000	0.00003	-0.00002	0.00001	0.00205	0.00000	0.00338	-0.00011	0.00089	-0.14093	0.00000	-0.00006	0.00000	0.00000	0.00023	0.00000	-0.00091	-0.00004	0.00006	0.00646	0.00000
	65	-0.03276	0.00376	0.01294	-0.00482	-0.00031	-0.01192	0.00248	0.00364	-0.02976	0.00004	-1.85468	0.07503	1.92945	-0.11798	-0.24180	-0.00267	0.00018	0.00103	-0.00189	-0.00006	-0.07071	0.01455	0.02769	0.08370	-0.00054
SE	66	-0.15480	-0.00069	-0.01940	0.86103	-0.00043	-0.00276	0.00001	0.00008	0.03388	-0.00001	-0.05124	-0.00013	-0.00325	0.26760	-0.00012	0.08005	-0.00031	-0.01726	-0.02602	-0.00255	-0.25753	-0.00082	-0.01457	2.94410	-0.00060
	67	2.47814	-0.04682	-0.34838	14.85533	-0.01228	0.04629	0.00097	0.00255	0.58837	-0.00018	0.92082	-0.00666	-0.04836	5.04645	-0.00281	3.67988	-0.96980	0.12229	-17.78173	-0.02208	4.38943	-0.04735	-0.25013	53.27401	-0.01732
	68	0.00839	0.00586	-0.00961	-2.21783	0.00281	0.00019	-0.00028	0.00002	-0.06169	0.00004	0.00345	-0.00034	-0.00142	-0.71403	0.00049	0.06502	0.01146	-0.32210	-1.51629	0.00557	0.01185	0.00900	-0.01385	-7.26968	0.00390
	69	0.00104	-0.00002	-0.00041	0.00976	0.00000	0.00002	0.00000	0.00000	0.00051	0.00000	0.00036	0.00000	-0.00007	0.00370	0.00000	0.00515	0.00002	-0.00003	-0.45217	0.00000	0.00176	-0.00003	-0.00037	0.04442	0.00000
	70	1.66237	0.00842	0.17037	-9.45304	0.00496	0.02941	-0.00013	-0.00101	-0.38645	0.00009	0.55660	0.00164	0.02804	-3.01352	0.00139	17.78939	-0.00254	-0.27162	-85.14437	0.40245	2.84175	0.00903	0.07859	-32.75609	0.00693
UK	71	-0.14152	0.00244	0.00134	0.69785	0.00003	-0.00305	-0.00001	-0.00002	0.02549	0.00000	-0.06447	0.00078	0.00016	0.26707	0.00003	-0.01605	-0.00003	-0.00015	0.05596	0.00001	0.01782	0.00117	-0.00105	2.35537	0.00003
	72	0.02133	0.00944	0.08992	-2.50673	0.00730	0.00028	-0.00017	0.00024	-0.01259	0.00016	0.00599	-0.00280	0.01584	-0.94079	0.00341	0.00319	0.00195	0.01257	-0.35336	0.00074	-0.48977	-0.70539	0.80347	2.24311	-0.00195
	73	-0.01695	-0.00209	0.01519	-0.02479	-0.00010	-0.00012	-0.00011	-0.00002	0.01549	0.00000	-0.00553	-0.00127	0.00367	0.06106	0.00001	-0.00493	0.00007	0.00235	-0.00858	-0.00003	0.50329	0.00384	0.52629	-0.46267	-0.00082
	74	0.00103	0.00008	-0.00002	0.02889	-0.00003	0.00002	0.00000	0.00000	0.00021	0.00000	0.00040	0.00002	-0.00002	0.01397	-0.00001	0.00005	0.00001	0.00000	0.00506	0.00000	-0.00473	-0.00006	0.00076	-0.11776	-0.00005
	75	0.04982	-0.03037	-0.03520	-3.99616	0.00261	0.00215	-0.00042	-0.00039	-0.04631	0.00005	0.04100	-0.00529	-0.00684	-1.62613	0.00092	0.00988	-0.00293	-0.00384	-0.58977	0.00029	0.35459	0.07158	0.33513	-11.23292	-0.28674

IE Δln(pc3	IE Δln(cc1	IT ec100g	IT Δln(ec3	IT Δln(pc1	IT Δln(pc3	IT Δln(cc1	LU ec100g	LU Δln(ec3	LU Δln(pc1	LU Δln(pc3	LU Δln(cc1	NL ec100g	NL Δln(ec3	NL Δln(pc1	NL Δln(pc3	NL Δln(cc1	PT ec100g	PT Δln(ec3	PT Δln(pc1	PT Δln(pc3	PT Δln(cc1	ES ec100g	ES Δln(ec3	ES Δln(pc1	ES Δln(pc3	ES Δln(cc1	SE ec100g	SE Δln(ec3	SE Δln(pc1	SE Δln(pc3	SE Δln(cc1	UK ec100g	UK Δln(ec3	UK Δln(pc1	UK Δln(pc3	UK Δln(cc100(t-1))	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AT Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BE Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FI Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FR Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DE Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GR Δln(cc100(t-1))
148.6	198.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE ec100g(t-1)
0.027	0.226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(ec320(t-1))
0.256	-2.011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(pc100(t-1))
-0.252	-1.371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(pc310(t-1))
0.004	-1.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IE Δln(cc100(t-1))
0	0	0.281	444.7	-925.7	8893	595.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT ec100g(t-1)
0	0	2E-04	-0.011	-0.329	3.06	0.012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(ec320(t-1))
0	0	2E-04	-0.035	-2.51	6.386	0.405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(pc100(t-1))
0	0	4E-06	-6E-04	-3E-04	0.539	2E-04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(pc310(t-1))
0	0	-8E-05	0.512	-0.816	9.133	0.063	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	IT Δln(cc100(t-1))
0	0	0	0	0	0	0	-0.52	112	0	90.67	11716	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(pc100(t-1))
0	0	0	0	0	0	0	1E-05	0.017	0	0.076	1.983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(pc310(t-1))
0	0	0	0	0	0	0	9E-06	0.003	0	-0.003	-30.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LU Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0.641	-0.899	-2.537	36.7	-19.93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	1E-04	-1.352	-0.002	-0.106	-0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.308	0.384	1.011	5.874	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	4E-06	-3E-04	-0.013	-1.032	0.095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	2E-05	-0.21	-5E-04	0.12	0.117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NL Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.098	0.599	13.05	56.31	-61.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3E-05	-0.035	-0.004	0.002	-0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2E-04	3E-04	-0.804	-0.035	-0.032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3E-06	2E-04	-0.01	-0.224	0.013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7E-05	0.074	-0.007	-0.078	-0.224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PT Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.505	101	-4.341	-4.05	-47.68	0	0	0	0	0	0	0	0	0	0	ES ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1E-05	-0.471	-0.018	-0.002	0.06	0	0	0	0	0	0	0	0	0	0	ES Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2E-04	-0.331	1.091	-0.103	-0.075	0	0	0	0	0	0	0	0	0	0	ES Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1E-05	4E-04	4E-04	-0.772	0.02	0	0	0	0	0	0	0	0	0	0	ES Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-9E-05	0.176	0.032	-0.112	-0.399	0	0	0	0	0	0	0	0	0	0	ES Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.264	592.5	0	-0.573	-83.31	0	0	0	0	0	SE ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SE Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1E-04	0.215	0	-0.029	-0.035	0	0	0	0	0	SE Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4E-06	0.091	0	-0.278	-0.081	0	0	0	0	0	SE Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4E-07	0.074	0	0.025	-0.65	0	0	0	0	0	SE Δln(cc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.388	-367.4	155.8	-788.4	-1578	UK ec100g(t-1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6E-06	0.613	-0.067	-3E-04	-0.051	UK Δln(ec320(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4E-05	-0.043	-0.717	-0.187	-0.568	UK Δln(pc100(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2E-05	9E-04	-6E-04	-0.886	0.097	UK Δln(pc310(t-1))
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5E-06	-0.038	-0.044	0.013	-0.504	UK Δln(cc100(t-1))