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DART97: A Description of the Multi-regional, Multi-sectoral Trade Model for the Analysis of Climate Policies

by

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Abstract:

The DART model is a multi-sectoral, multi-regional dynamic computable general equilibrium model of the world developed for the analysis of international climate policies. Since the first version of DART was developed at the Kiel Institute for World Economics in 1998, the model has undergone a number of changes to run on more recent data and to analyze prevailing issues associated with international emission trading. The aim of this paper is to provide an up-to-date model description and thus to lay open the basis of the results of past and future policy analysis with DART97.

Keywords: multi-regional, multi-sectoral dynamic CGE Model,
DART Kyoto Protocol, Climate Policy
JEL classification: C68, D58, F18, Q48

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1 Introduction

The DART Model of the Kiel Institute for World Economics (IfW) is a recursive dynamic computable general equilibrium model of the world economy, covering multiple sectors and regions. It is designed for the analysis of international climate policies. The most important application is the implementation of the Kyoto Protocol either through unilateral action or through emission trading. DART is used to assess and analyze the allocative and distributional impacts of the most recent agreements and developments.

The DART model stands, as the EPPA model of the MIT (Yang et al. 1996), in the tradition of the GREEN model by the OECD (Burniaux 1992), even though the models differ in several aspects. The first version of DART (further on denoted DART93) was developed in the late 1990's and based on the data from the Global Trade Analysis Project (GTAP) in its Version 3 for 1993. DART93 was used to simulate the implementation of the Kyoto Protocol via unilateral action (e.g. emission taxes) (Springer 1999) as well as to investigate the impacts of international capital mobility (Springer 2000; Springer 2002). In addition DART93 was coupled to an ocean-atmosphere model to assess the economic impacts of climate change (Deke et al. 2001; Kurtze and Springer 1999). Meanwhile the extended and more up to date GTAP5 data set for 1997 is available, which provides for example disaggregated data for the Western and some Eastern European countries. Not only do these new data require new calibrations e.g. of the energy supply elasticities, also the conversion to a DART readable format implied changes in the data structure that in turn necessitated some modifications in DART as well. At the same time prevailing issues in the debate on the Kyoto Protocol such as different regimes for international emission trading lead to several extensions of DART.

Taken together, the version of the DART model that is currently used for policy analysis - denoted DART97 - is not entirely the same as the old version DART93 that is for example described in Springer (1998) or Klepper and Springer (2000). To lay open the basis for our studies this paper wants to give an overview over the actual version of DART97 and its benchmark calibration. Section 2 deals with the static part of DART. The following section 3 discusses the dynamics and the dynamic calibration. Section 4 summarizes the differences between DART93 and DART97. Section 5 addresses the simulation of climate policy scenarios with DART97. Section 6 concludes. Some benchmark data on production and trade structures and the dynamic development of GDP and emissions are given in the appendix.

2 The Basic-Model

The basic model, called **D**ynamic **A**pplied **R**egional **T**rade (DART) is a multi-region, multi-sector general equilibrium model of the world. It is written in the mathematical programming language GAMS and based on the GTAP5-E(nergy) data set. The 57 sectors and 66 regions of GTAP5 can be aggregated depending on the question at hand. Currently DART is used with a 10-sector aggregation and different regional aggregations covering from 12 to 27 regions (see Table 1). Among the 10 sectors are three fossil fuel production sectors, different energy intensive sectors, agriculture, and other manufactures and services. Differentiating carbon intensive industries from non-carbon intensive industries allows to depict carbon intensity differences in production among regions and to cover the scope for substitutability across carbon-intensive goods and hence the potential for terms of trade effects caused by carbon abatement policies.

Table 1: Dimensions of DART97

Production sectors/Commodities			
Energy Sectors		**Non-Energy Sectors**	
COL	Coal	AGR	Agricultural Prod.
CRU	Crude Oil	IMS	Iron Metal Steal
GAS	Natural Gas	CPP	Chemicals, Rubber, Paper, Plastic Prod.
OIL	Refined Oil Prod.	Y	Other Manufac. & Serv.
EGW	Electricity	TRN	Transport Industries

Countries and regions			
Annex B		**WEU disaggregation**	
USA	USA	AUT	Austria
WEU	West European Union	BEL	Belgium
ANC	Canada, Australia, New Zealand	DNK	Denmark
		FIN	Finland
JPN	Japan	FRA	France
FSU	Former Soviet Union	DEU	Germany
EEC	Eastern Europe	ESP	Spain
		GBR	United Kingdom
Non-Annex B		GRC	Greece
LAM	Latin America	IRL	Ireland
IND	India	ITA	Italy
PAS	Pacific Asia	LUX	Luxemburg
CPA	China, Hong Kong	NLD	Netherlands
MEA	Middle East, N. Africa	PRT	Portugal
AFR	Sub-Saharan Africa	SWE	Sweden
ROW	Rest of the World	EFT	Norway, Iceland

For the static part of DART97 the original GTAP5 data are converted into a GAMS readable format with the help of the tool GTAPtoGAMS (Rutherford and Paltsev 2000). The dynamic framework is recursively-dynamic meaning the evolution of the economies over time is described by a sequence of single-period static equilibria connected through capital accumulation and changes in labor supply. In this paper a non-technical description of the static and dynamic part of the DART model is provided. For an algebraic description of DART93 that is in most parts transferable to DART97, see Springer (1998).

The economic structure of DART97 is fully specified for each region and covers production, investment and final consumption by consumers and the government. Primary factors are labor and capital. Both are in the basic version of DART97 intersectorally mobile within a region, but cannot move between regions. Data for the factor land that was included in DART93 is not provided by the GTAPtoGAMS aggregation of the GTAP5 Energy data (see also section 4), so that land is included in capital. Fossil fuel resources are specific to fossil fuel production sectors, i.e. coal, natural gas and crude oil, in each region. Each market is perfectly competitive. Output and factor prices are fully flexible. The following sections describe the producer and consumer behavior, foreign trade, factor markets and finally the calculation of carbon dioxide emissions, that are the basis for climate policy analysis.

2.1 Producer Behavior

Producer behavior is characterized by cost minimization for a given output. All industry sectors are assumed to operate at constant returns to scale.

For the non-fossil fuel industries, a multi-level nested separable constant elasticity of substitution (CES) function describes the technological possibilities in domestic production[1]. Figure 1 shows the nested production structure. On the top level of the production function is a linear function, i.e. a Leontief function of non-energy intermediate goods and a value added composite[2]. The intermediate input of good i in sector j corresponds to a so-called Armington aggregate of non-energy inputs from domestic production and imported varieties. The value added composite is a CES function of the energy aggregate and the aggregate of the primary factors. On the lowest level labor substitutes with capital in a Cobb-Douglas technology. On the output side, products destined for domestic and international markets are treated as imperfect substitutes produced subject to a constant elasticity formation.

The differentiation between energy and non-energy intermediate products is useful in the context of climate change policy. Energy use in production and consumption produces varying amounts of the greenhouse gas (GHG) carbon dioxide (CO_2) depending on the fossil fuel source and the policies assumed to be in place. Carbon dioxide, with large emission levels, and a long lifetime in the atmosphere is the largest single contributor to the greenhouse effect. The other GHGs methane, nitrous oxide, ozone and halocarbons, as well as emissions from CO_2 deforestation are not considered in the model. The fossil fuels gas, coal and crude oil are produced from fuel-specific resources and the macro good (a composite of all other manufactures and services and factors). The production function is a CES function with a fixed factor - the fuel resource (see Figure 2).

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[1] The nesting structure and nest elasticities of the production cost functions are based on the ETA-MACRO model (Manne and Richels 1992, pp. 130).

[2] In the case of refined oil products, the intermediate input of crude oil and refined oil products are also on the top level.

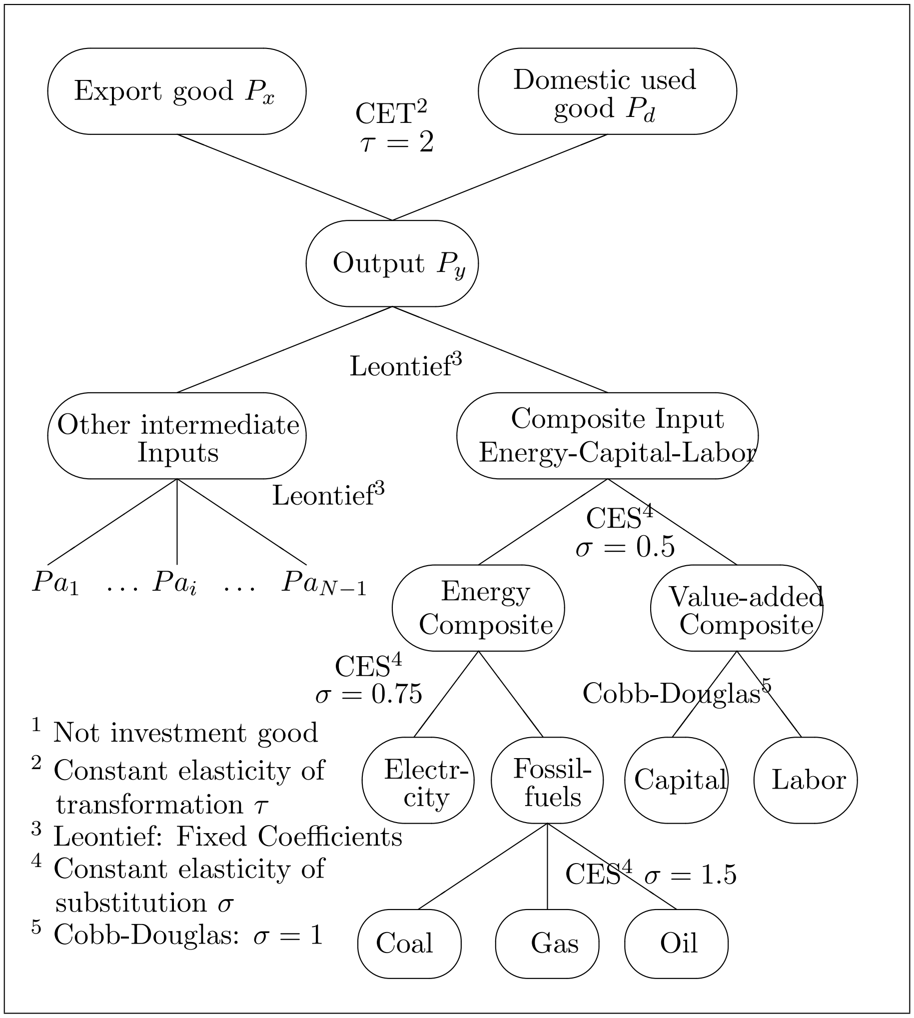


Figure 1: Production Structure of the Non Fossil Fuel Industry Sectors

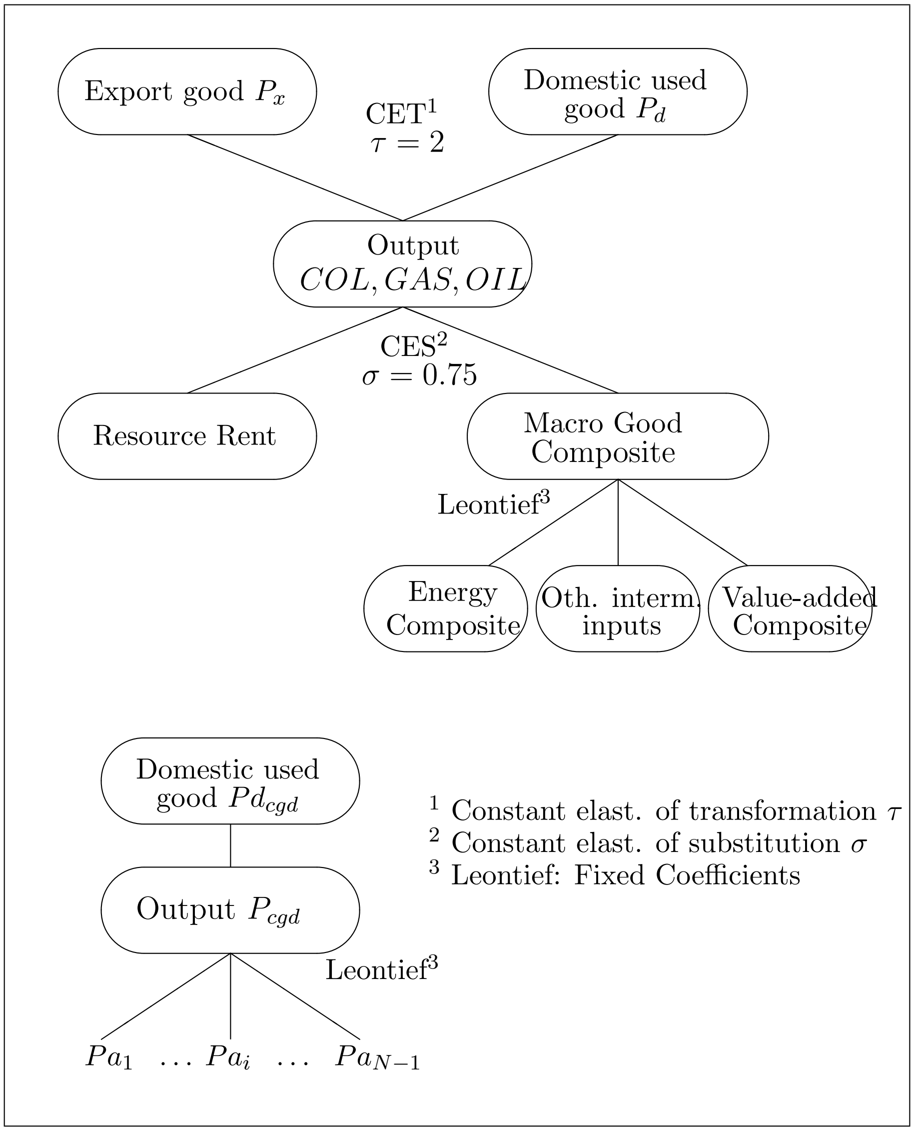


Figure 2: Production Structure of the Fossil Fuel Industry Sectors and the Investment Good CGD

In each region composite investment is a Leontief aggregation of Armington inputs by each industry sector. In the basic version of DART there are neither sector-specific investments nor cross border investment activities, i.e. investment goods are treated as non-tradables. Investment does not require direct primary factor inputs. Figure 2 shows the production structure of the investment activity.

Producer goods are directly demanded by final consumers, comprising regional households and governments, the investment sector, other industries and the export sector.

2.2 Consumption expenditure

The representative household, that comprises private households and the government sector, receives all income generated by providing primary factors to the production process. After deducting taxes and savings, the disposable income is used for maximizing utility by purchasing goods. The final consumer decides between different primary energy inputs and non-energy inputs depending on their relative price in order to receive its consumption (utility) with the lowest expenditures. A fixed share of income is saved in each period. These savings are invested in the production sector. The expenditure function of the representative household is assumed to be a Cobb-Douglas composite of an energy aggregate and a non-energy bundle. Within the non-energy consumption composite, substitution possibilities are described by a Cobb-Douglas function of Armington goods. Figure 3 shows the structure of consumer behavior.

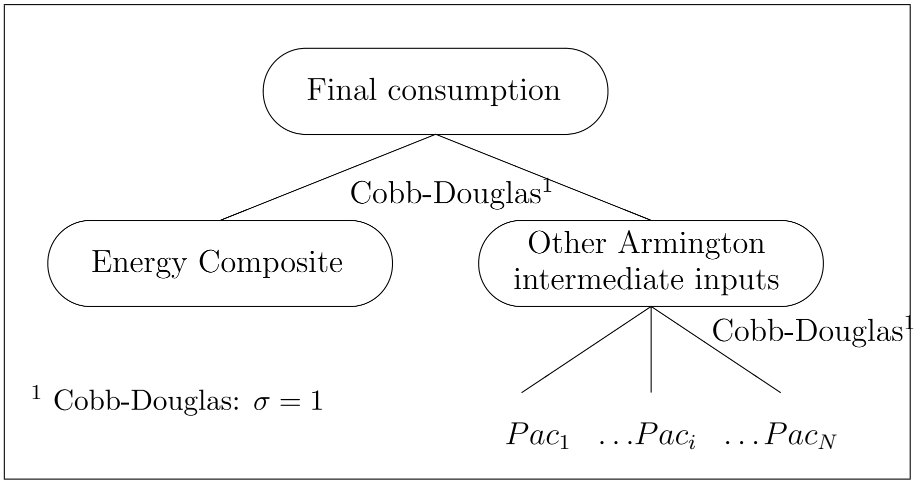


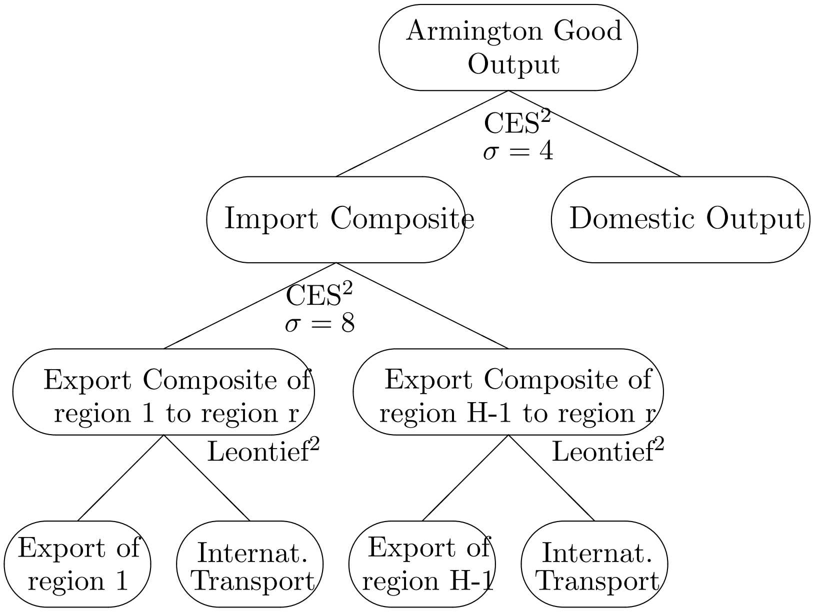
Figure 3: Final Consumption Production Structure

2.3 Foreign Trade

The world is divided into economic regions, which are linked by bilateral trade flows. All goods are traded among regions, except for the investment good. Following the proposition of Armington (1969), domestic and foreign goods are imperfect substitutes, and distinguished by country of origin.

Import demand is derived from a three stage, nested, separable CES cost or expenditure function respectively and distinguishes between imported and domestically produced goods as well as between the country of origin. The structure of foreign trade is shown in Figure 4. The imports of one region r are equivalent to the exports of all other regions rr into that region r including transport. Transport costs, distinguished by commodity and bilateral flow, apply to international trade but not to domestic sales. The exports are connected to transport costs by a Leontief function on the third level. International transports are treated as a worldwide activity which is financed by domestic production proportional to the trade flows of each commodity. There is no special sector for transports related to international trade.

On the export side, the Armington assumption applies to final output of the industry sectors destined for domestic and international markets. Here, produced commodities for the domestic and for the international market are no perfect substitutes. Exports are not differentiated by country of destination.



[1] Constant elasticity of substitution τ
[2] Leontief: Fixed coefficients

Figure 4: Structure of Foreign Trade (Armington Good Production of Good i in Region r

2.4 Factor markets

Factor markets are perfectly competitive and full employment of all factors is assumed. Labor is assumed to be a homogenous good, mobile across industries within regions but internationally immobile. In the basic version of the DART model capital is also inter-sectorally but not internationally mobile. Regional capital stocks are given at the beginning of each time period and result from the capital accumulation equation. In every time period they earn a correspondent amount of income measured as physical units in terms of capital services.

2.5 Carbon dioxide emissions

Gas and coal each have a fixed carbon content. To calculate the associated carbon dioxide emissions one simply has to multiply the physical quantity of gas and coal used in either domestic production or domestic consumption (which is given in the GTAP data) and multiply it by its emission coefficient. DART97 uses the recommendations from the IPPC (1996) which are 0.0258 kgC/MJ for coal and 0.0153 kgC/MJ for gas.

For oil emissions the calculation is more complicated. In order to determine the CO_2 emissions which originate from the use of crude oil in the different production and consumption processes one needs to know at which point in the value-added chain this fossil fuel is actually burned, i.e. leads to emissions. In the current model crude oil only enters the production of refined oil products where it is not burned. Only refined oil products are burned as inputs in production or as final consumption goods. One cannot use the domestic use of crude oil for determining CO_2 emissions since some of these oil products are exported and some are imported, hence there is no one-to-one correspondence between crude oil consumption and emissions.

Since crude oil is the emission relevant input in refined oil production, only the crude oil share can be used for determining CO_2 emissions. The emission coefficient for crude oil is set to (IPCC, 1996) 0.02 KgC/MJ. Refined oil consumption is composed of domestically produced and imported oil products. Both may have different carbon contents due to different input shares of crude oil in the production of refined oil products. The crude oil share in the production of oil products in region R is given by

$$Crush(R) = \frac{vafm(CRU, OIL, R)}{vdm(OIL, R) + vxm(OIL, R)}$$

i.e. the quantity of crude oil in refined oil production, denoted here $vafm(CRU, OIL, R)$, as a share of the value of the output of refined oil products (domestic $vdm(OIL, R)$ and exports $vxm(OIL, R)$).

Originally the regional carbon emissions in DART were calculated for gas, coal and refined oil use at the point where the Armington aggregate of domestic and foreign fossil energy enters domestic production or consumption by multiplying the physical quantity of energy by its emission coefficient. For oil a regional carbon coefficient $CEC(R)$ was calculated as the crude oil share in oil products which are burned in that particular region R:

$$CEC(R) =$$

$$\frac{(vdm(OIL, R) * Crush(R) + \sum_s [vxmd(OIL, S, R) * Crush(S)) * 0.02}{\sum_s vxmd(OIL, S, R) + vdm(OIL, R)}$$

The denominator denotes all oil products which are used in region R. The nominator denotes the amount of crude oil in these products multiplied by the emission coefficient for crude oil.

This was only possible though, as oil could be treated as a homogeneous good so that only net exports and imports had to be considered. These could be assumed to have the same carbon coefficient as in the base year. Now, in the GTAP5 data, the implicitly given oil prices are not the same across countries as in the GTAP3 data, but differ considerably. Thus, assuming a homogeneous good would lead to miscalculations. For this reason oil is now also treated as an Armington good with bilateral trade flows. As these trade flows change in every time period it is now necessary to calculate the emissions from refined oil use at the point where the imports enter the Armington aggregation by multiplying the imported quantity of region S by its crude oil share $Crush(S)$ and the emission coefficient.

3 Dynamics

The DART model is recursive-dynamic, meaning that it solves for a sequence of static one-period equilibria for future time periods connected through capital accumulation and changes in labor supply. The dynamics of the DART model are defined by equations which describe how the endowments of the primary factors capital and labor evolve over time. The major driving exogenous factors of the labor dynamic are population change, the rate of labor productivity growth and the change in human capital. The driving forces for capital accumulation are the savings rate and the gross rate of return on capital, and thus the endogenous rate of capital accumulation. The DART model is recursive in the sense that it is solved stepwise in time without any ability to anticipate possible future changes, relative prices or constraints.

The savings behavior of regional households is characterized by a constant savings rate over time. This rather ad-hoc assumption seems consistent with empirical observable, regional different, but nearly constant savings rates of economies, which adjust according to income developments over very long time periods (for savings rates see Schmidt-Hebbel and Serven 1997). Additionally, a wide range of empirical evidence in macroeconomic literature neglect the theoretically elegant permanent income hypothesis and shows that a huge fraction of the consumption decisions are based entirely on current after tax income.

The following sections describe the evolution of labor and capital supply in more detail.

3.1 Labor supply

Labor supply considers human capital accumulation and is, therefore, measured in efficiency units, $L_{r,t}$. It evolves exogenously over time. Hence, labor supply for each region r at the beginning of time period t+1 is given by:

$$\bar{L}_{r,t+1} = \bar{L}_{r,t} * (1 + gp_{r,t} + ga_{r,t} + gh_r)$$

where the bar denotes exogenous variables. An increase of effective labor implies either growth of the human capital accumulated per physical unit of labor, gh_r, population growth, gp_r, or total factor productivity, ga_r, or the sum of all.

The standard version of DART97 assumes constant, but regionally different labor productivity improvement rates ga_r and declining population growth rates over time, $gp_{r,t}$, according to the World Bank population growth projections. Because of the lack of data for the evolution of the labor participation rate in the future the growth rate of population instead of the labor force is used implying that the labor participation rate is constant over time.

The human growth rates of human capital gh_r are also assumed to be constant over time and regionally different. The 1990 levels of human capital endowments are taken from Hall and Jones (1999)[3]. They are then aggregated to the regions of the model. For the future development of the endowments, we assume that the maximum endowment of 12 years of schooling will be reached in 2050 and that this process starts at the computed 1990 levels and continues in a linear fashion. This approach can be be criticized as being rather ad-hoc. Since we could not identify a reasonable indicator for the future development of human capital endowments, we simply assumed optimistically that there is complete convergence in human capital intensities in the long run.

3.2 Capital formation

Current period's investment augments the capital stock in the next period. The aggregated regional capital stock, Kst at period t is updated by an accumulation function equating the next-period capital stock, Kst_{t+1}, to the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment, $Iq_{r,t}$. The equation of motion for capital stock $Kst_{r,t+1}$ in region r is given by:

$$Kst_{r,t+1} = (1 - \delta_t)Kst_{r,t} + Iq_{r,t}$$

where δ_t denotes the exogenously given constant depreciation rate. According to the GTAP5 data set δ is equal to 0.04, and we use the

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[3] The countries missing from the 127 country data set of Hall and Jones are determined by taking human capital intensity from a neighboring similar country.

same value for all time periods. The allocation of capital among sectors follows from the intra-period optimization of the firms.

As data on the regional physical capital stocks are not available with the GTAP data, the capital accumulation has to be rearranged by using physical capital earnings $K_{r,t}$ i.e. return to capital, instead of the capital stock $Kst_{r,t}$. Using the stock-flow-conversion, the capital earnings in period 0 for region r are given by

$$K_{r,0} = rk_{r,0} * Kst_{r,t}$$

where $rk_{r,0}$ denotes the gross rate of return on capital in region r in period 0 which is defined as

$$rk_{r,0} = \frac{K_{r,0}}{pi_{r,0} * Kst_{r,0}}$$

$pi_{r,0}$ is the actual price of investment or in other words, the price of constructing a unit of capital. Exploiting the unit price convention $pi_{r,0} = 1$ we can use $rk_{r,0}$ as a (fixed) scaling factor. Thus, the capital accumulation equation can be rewritten in terms of physical units of capital services.

$$(*) K_{r,t+1} = (1 - \delta_t) K_{r,t} + Iq_{r,t} * pi_{r,t} * rk_{r,0}$$

where $K_{r,t}$ denotes the physical unit of the factor capital in period t which earns 1\$ in the initial time period and $Iq_{r,t} * pi_{r,t}$ is the value of real gross investment. Once the variables have been scaled, the physical, i.e. quantity, units of capital services can be updated according to equation $(*)$; whereas the actual value of gross investment has to be scaled with the benchmark gross rate of return in every time period.

3.3 Dynamic Calibration

The dynamics of the DART model are driven by saving rates, population growth, and total factor productivity.

For the capital accumulation we assume (as in DART93) constant, but regional different saving rates. Already in DART93 the rates from CPA, PAS and PAO are allowed to adjust to income changes so that the originally high rates fall over time and become comparable to the saving rates in the other regions. For CPA and PAS comparable adjustments are again necessary in DART97 (see Table 2). These adjustments make sure that these two regions tend to converge towards a balanced growth path. Without these adjustments capital stocks will grow far beyond any realistic level with the consequence that either the rates of return on capital would collapse, or - if we introduce capital mobility - these regions would become major exporters of capital.

Adjustments in the original size of the capital stocks (as in DART93) for CPA and FSU are no longer necessary. The old GTAP data had very high capital stocks in these two regions which may have been derived from the accounting data from the socialist times. The measures of capital stocks in the GTAP5 data do obviously no longer contain capital that was accumulated during the periods of a centrally planned resource allocation. They now seem to reflect the productive capital stocks and are in line with the fundamentals of these economics.

Given these adjustments, the yearly growth rates of GDP in most regions are still much higher than recent projections. As increases in the labor productivity were rather optimistic in DART93, we adjusted them downwards by 20% for all regions except the USA and IND. In addition, the assumption that the maximal human capital endowment will be reached in 2050 in the regions containing the developing countries leads to unrealistic high growth rates in LAM, MEA, AFR and ROW. We thus assume, that the maximal human capital endowment will only be reached in 2090.

Table 2 summarizes the choice of the key parameters from the dynamics for the year 1997 on.

Finally, the supply elasticities of fossil fuels are chosen in such a way that the carbon emission in 2030 resulting from the model in the business as usual scenario meet the newest projections of the IEA (IEA 2002). The resulting elasticities for a regional aggregation without the WEU disaggregation are 0.57 for coal, 2.5 for gas and 0.36 for crude oil.

Some data for the production and trade structures, the economic growth and the development of the CO_2 emissions in selected regions resulting from the benchmark scenario are given in the Appendix at the end of this paper.

4 DART97 vs. DART93

As already mentioned DART97 is based on the GTAP5 data set reconciled with the GTAPtoGAMS package. The changes that had to be made in the structure of the DART97 model compared to the original DART93 version where mainly due to the changes in the definition of variables and their aggregations in the converted data set. With the new data set DART97 is calibrated and hence produces new parameter and revised benchmark development up to the year 2030. Even if most of the changes from DART93 to DART97 have already been mentioned in the model description, this section summarizes all differences between DART93 and DART97.

Table 2: Dynamic key parameters for selected regions for 1997 in %

	Total growth in labor efficiency	**techn. progr.**	**Hum. capital**	**Popu- lation**	**Sav. Rate**
USA	2.20	1.20	0.10	1.00	17.6
WEU	2.00	0.60	1.20	0.20	18.9
AUT	2.10	0.60	1.40	0.10	25.4
BEL	1.90	0.60	1.10	0.20	20.0
DNK	1.90	0.60	0.50	0.40	17.2
FIN	1.80	0.60	0.90	0.30	17.3
FRA	2.40	0.60	1.40	0.40	17.4
DEU	1.70	0.60	1.00	0.10	20.4
ESP	2.00	0.60	1.30	0.10	21.1
GBR	2.00	0.60	1.10	0.30	17.1
GRC	2.00	0.60	1.10	0.30	21.3
IRL	2.90	0.60	1.30	1.10	20.2
ITA	2.50	0.60	1.80	0.10	17.2
NLD	2.10	0.60	1.10	0.50	20.9
PRT	3.10	0.60	2.40	0.20	26.2
SWE	1.50	0.60	0.90	0.00	13.9
ANC	2.20	0.50	0.60	1.10	19.9
JPN	1.80	0.50	1.00	0.30	28.8
FSU	2.90	2.50	0.50	-0.10	21.1
EEC	3.20	2.50	0.90	-0.20	23.2
LAM	5.40	1.50	2.30	1.60	20.2
IND	5.90	1.50	2.70	1.70	24.1
PAS	6.50	2.50	2.50	1.50	31.1*
CPA	6.30	3.50	1.90	0.90	36.5**
MEA	5.70	1.00	2.60	2.10	22.6
AFR	6.10	1.50	2.40	2.20	16.7

Falls by 1 (*) resp. 0.5(**) percentage point per year up to 2010

4.1 Calibration to the new data base

New Data Dart97 is based on the GTAP5-EG database of 1997 data, while DART93 was based on the GTAP3 data for 1993.

Regional aggregation GTAP5 provides a disaggregation of the Western European and some Eastern European countries. Depending on the question at hand, DART97 uses these data and runs with up to 30 regions.

New calibration of fossil fuel supply elasticities DART97 is calibrated to the latest emission projections of the IEA (IEA 2002).

Regional saving rates DART assumes constant but regional different saving rates. Already in DART93 some of the saving rates implicitly given in the GTAP3 data were assumed to fall over time in the long run as they seemed to be unsustainable in the long run. This is again necessary in DART97.

Efficiency of labor As with the original DART93 growth rates of technical progress and human capital endowments the overall growth in some regions turned out to be too high given the empirical observations over the last years, the exogenous rates of technical progress was adjusted downwards by 20% in all regions except the USA and India. In addition, it was assumed that the maximum endowment of human capital will be reached in LAM, MEA, AFR and ROW only after a 100 years and not after 60 years as in DART93.

Fewer corrections of GTAP data With the new GTAP data two data adjustments that were necessary in DART93 are now obsolete. First, with the old data the cost share of crude oil input in the refined oil production was considerably lower in the regions Europe and Pacific OECD (Japan, Australia, New

Zealand) when compared to the other regions. The reason was probably that mineral oil taxes were not included in the GTAP3 data. As the low cost share appeared to be essentially impossible given the technology of producing ”oil products” an ad hoc output tax on mineral oil was introduced in DART93 thus increasing the share to the same level as in the other countries. Now, with the GTAP5 data all cost shares of crude oil input in refined oil production seem to be in a realistic range and the mineral oil tax is obviously included in the data making the ad hoc tax obsolete.

Second, it was necessary in DART93 to adjust the GTAP capital stocks for China and the Former Soviet Union downwards as the GTAP data seemed to refer to capital stocks accumulated during the period of a centrally planned resource allocation. With the introduction of markets and competition and the apparent forced depreciation of these capital stocks this adjustment became obsolete. All capital stocks in DART97 are now based on the actual GRAP5 data.

4.2 Changes in the structure of the model

No factor land: For a conversion of the data with GTAPinGAMS it is now necessary to aggregate the five primary factors provided by the GTAP data set to labor and capital. For this reason DART97 sofar only includes the factors capital and labor.

No explicit government sector: GTAPtoGAMS now only provides data jointly for the physical energy use in private and public consumption. As the physical energy use is needed to calculate emissions we aggregated the formerly separated sectors private consumption and the government to one sector final consumption. As both sectors used to have exactly the same structure with exactly the same elasticities, this change has little implications.

Oil as a non-homogeneous good In DART93 the implicitly given oil prices were the same for all countries, so that oil could be treated as a homogeneous good. Now, the oil prices differ considerably across countries, so that assuming a homogeneous good leads to miscalculations. Thus, oil is now treated as an Armington good and instead of only net trade flows there are now bilateral trade flows as for every other traded good.

5 Climate Policy Analysis with DART97

DART is designed to analyze different climate policy scenarios, especially those associated with the implementation of the Kyoto Protocol. In this Protocol the industrialized Annex B countries agreed to reduce their greenhouse gas emissions by on average 5.2% below their 1990 emission level in the first commitment period from 2010 to 2012.

To simulate the allocative implications of the Kyoto Protocol an emission reduction scheme has to be assumed - which is quite arbitrary. In DART93 emission reductions started in 1990 and took place in a constant rate until 2010. Today, in 2003, we know that CO_2 emissions have grown in most countries since 1990, so that this assumption becomes unrealistic. Instead we now assume, that Annex B countries start abatement in 2005, the year where the European emission trading is scheduled to start. In the following years emissions are reduced by the same absolute amount each year, until the target is reached in 2010.

To calculate the appropriate emission targets for DART97, we run the model for the year 1997 with the benchmark data. The resulting 1997 emissions are compared to the actual IEA data (IEA 2002). As GTAP5 and DART97 slightly overestimates emissions for some countries and underestimates it for others, we use the differences to adjust the official 1990 emission data from IEA (2002). These adjusted 1990 data are finally multiplied with the reduction requirement implied by the Kyoto Protocol or the follow up agreements in Bonn and Marrakech to arrive at the final target.

DART93 was used to assess the implications of unilateral action taken to implement the Kyoto Protocol. It was assumed that the domestic target was achieved efficiently either through domestic emission trading or through a carbon tax high enough to reach the target. Meanwhile, it is likely that international emissions trading will take place. Thus, DART97 includes the possibility to model emissions trading among any number of regions. This makes it possible to analyze prevailing issues such as excess emission rights in the countries of the former Eastern Block (so called "hot-air") and the withdrawal of the United States from the Kyoto Protocol (Klepper and Peterson 2002b; Klepper and Peterson 2002a). Other issues such as targets for carbon intensities (that is the emission GDP ratio) and European Emission trading will be analyzed in future.

6 Concluding Remarks

This paper presents an up-to date model description of the dynamic multi-regional, multi-sectoral general equilibrium trade model DART97. Though there have been no serious changes compared to the original version of the model, DART93, it might prove helpful to present the assumptions and aggregates as well as the basic data for the new benchmark run. DART97 is now running on the latest available data, while most comparable models still rely on 1995 or older data.

DART97 is a powerful tool to analyze international climate policies especially those associated with the Kyoto-Protocol. DART97 has been used recently to assess the implications of different schemes for international emissions trading where important issues are the role of the United States and the economies with hot air. As new issues become prevailing, DART will be expended and augmented.

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A Appendix

The following tables and figures present selected benchmark data for DART97. The region FEC comprises the two regions FSU and EEC.

Table 3: Primary Factor Supply- Factor Income in 1997

	billion 1997 US$			in percent of total income		
	Labor	**Capital**	**Rent**	**Labor**	**Capital**	**Rent**
USA	489.5	299.0	5.0	61.7	37.7	0.6
WEU	390.7	320.3	2.5	54.8	44.9	0.4
ANC	53.8	39.3	2.3	56.4	41.2	2.4
JPN	218.3	145.6	0.0	60.0	40.0	0.0
FEC	44.8	28.3	6.1	56.6	35.8	7.7
MEA	37.5	33.9	9.9	46.1	41.7	12.2
CPA	45.0	37.7	1.6	53.4	44.8	1.9
PAS	59.0	64.7	1.8	47.0	51.6	1.4
IND	13.7	20.9	0.5	39.1	59.6	1.3
LAM	80.1	96.2	4.5	44.3	53.2	2.5
AFR	17.3	12.7	1.6	54.7	40.1	5.2
ROW	40.8	32.9	1.4	54.3	43.8	1.8

Table 4: Production Structure by Region 1997

In billion 1997 US$

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Cgd**	**Y**
USA	5.4	3.3	4.4	23.5	16.3	29.6	88.9	81.9	119.7	149.0	1075.0
WEU	2.2	0.9	2.0	18.6	10.2	51.7	107.0	120.1	105.2	139.8	1017.3
ANC	2.2	1.3	1.7	4.0	2.4	7.3	13.6	17.6	22.0	21.8	122.0
JPN	0.0	0.0	0.1	16.8	6.0	30.3	46.5	45.2	76.5	122.3	531.0
FEC	4.5	1.6	5.5	6.5	4.4	9.1	11.5	20.9	14.7	19.1	96.5
MEA	15.6	0.1	2.2	3.6	6.0	6.4	9.2	23.3	13.6	20.8	92.0
CPA	1.9	1.2	0.2	3.8	3.7	21.0	20.6	41.2	19.5	37.1	151.7
PAS	1.6	0.3	1.2	5.3	5.9	14.0	21.8	35.5	23.3	42.8	180.8
IND	0.4	0.3	0.2	2.9	1.2	4.1	5.0	18.6	6.6	9.6	34.7
LAM	6.0	0.2	1.0	4.8	5.0	17.3	28.9	65.6	32.5	40.0	195.4
AFR	2.7	0.9	0.1	2.1	1.2	3.0	3.1	14.7	5.6	5.8	32.7
ROW	2.5	0.1	0.8	2.3	0.8	6.4	10.4	24.4	12.8	16.7	89.1

In percent of total output

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Cgd**	**Y**
USA	0.3	0.2	0.3	1.5	1.0	1.9	5.6	5.1	7.5	9.3	67.3
WEU	0.1	0.1	0.1	1.2	0.6	3.3	6.8	7.6	6.7	8.9	64.6
ANC	1.0	0.6	0.8	1.9	1.1	3.4	6.3	8.2	10.2	10.1	56.6
JPN	0.0	0.0	0.0	1.9	0.7	3.5	5.3	5.2	8.7	14.0	60.7
FEC	2.3	0.8	2.8	3.4	2.3	4.7	5.9	10.8	7.6	9.8	49.6
MEA	8.1	0.0	1.1	1.9	3.1	3.3	4.8	12.1	7.0	10.8	47.7
CPA	0.6	0.4	0.1	1.2	1.2	6.9	6.8	13.6	6.5	12.3	50.2
PAS	0.5	0.1	0.4	1.6	1.8	4.2	6.6	10.7	7.0	12.9	54.4
IND	0.5	0.3	0.2	3.5	1.5	4.9	5.9	22.2	7.9	11.5	41.5
LAM	1.5	0.0	0.2	1.2	1.3	4.4	7.3	16.5	8.2	10.1	49.3
AFR	3.7	1.2	0.1	2.9	1.6	4.2	4.3	20.5	7.8	8.1	45.6
ROW	1.5	0.1	0.5	1.4	0.5	3.8	6.3	14.7	7.7	10.1	53.6

Table 5: Sectoral Exports by Region 1997

In billion 1997 US$

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	0.1	0.4	0.0	0.0	0.7	3.4	10.9	7.2	17.4	47.5
WEU	1.3	0.0	0.5	0.9	3.0	16.9	37.7	20.2	40.6	120.3
ANC	1.1	0.9	0.9	0.2	0.3	3.0	3.9	4.3	6.9	11.6
JPN		0.0			0.1	3.0	4.6	0.3	12.1	29.7
FEC	1.9	0.4	1.9	0.5	1.2	4.2	2.4	2.1	3.1	8.6
MEA	11.4	0.0	0.7	0.0	2.3	0.9	1.5	1.2	2.3	8.0
CPA	0.3	0.2	0.0	0.0	0.1	1.4	2.2	1.6	1.6	24.3
PAS	0.8	0.2	0.6	0.0	1.6	3.0	6.3	3.4	6.1	48.0
IND	0.0				0.0	0.2	0.4	0.8	0.4	2.8
LAM	3.1	0.1	0.0	0.2	1.0	2.9	2.3	6.4	5.1	12.1
AFR	2.4	0.3	0.0	0.1	0.1	1.4	0.4	1.8	0.8	2.6
ROW	2.3	0.0	0.5	0.3	0.2	1.8	3.2	1.8	2.0	10.9

In percent of total exports

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	0.1	0.5	0.0	0.0	0.8	3.9	12.4	8.2	19.9	54.1
WEU	0.5	0.0	0.2	0.4	1.3	7.0	15.6	8.4	16.8	49.8
ANC	3.3	2.7	2.6	0.5	0.9	9.0	11.8	13.0	21.0	35.2
JPN	0.0	0.0	0.0	0.0	0.2	6.0	9.1	0.7	24.2	59.7
FEC	7.3	1.4	7.3	2.1	4.6	16.0	9.2	8.1	11.8	32.5
MEA	40.3	0.0	2.5	0.0	8.1	3.3	5.2	4.1	8.0	28.5
CPA	0.8	0.5	0.1	0.1	0.4	4.3	6.9	5.0	5.1	76.8
PAS	1.2	0.2	0.8	0.0	2.3	4.3	9.0	4.9	8.6	68.6
IND	0.2	0.0	0.0	0.0	0.5	4.8	9.4	17.1	8.0	60.0
LAM	9.2	0.4	0.1	0.6	3.0	8.6	6.9	19.4	15.3	36.5
AFR	24.3	3.0	0.0	0.6	0.6	14.5	4.4	18.1	8.3	26.1
ROW	9.9	0.1	2.1	1.4	0.8	7.7	13.8	8.0	8.9	47.3

Table 6: Sectoral Imports by Region 1997

In billion 1997 US$

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	5.9	0.0	0.8	0.2	0.8	5.4	8.9	5.2	19.1	58.3
WEU	7.2	0.7	1.9	1.0	3.3	15.8	31.9	22.2	39.1	116.9
ANC	0.8	0.1	0.0	0.1	0.2	1.8	4.0	1.7	6.9	15.8
JPN	2.9	0.6	0.7		0.9	2.3	3.2	7.8	6.1	20.3
FEC	1.0	0.2	1.3	0.5	0.6	1.9	4.0	3.8	3.8	13.9
MEA	0.7	0.1	0.1	0.0	0.8	2.1	3.2	4.7	4.3	16.7
CPA	0.5	0.0	0.0	0.0	0.7	3.1	5.1	2.9	2.4	19.2
PAS	3.7	0.4	0.2	0.0	1.6	6.1	7.3	5.3	6.8	39.9
IND	0.5	0.0	0.0	0.0	0.3	0.9	0.9	0.4	0.4	2.3
LAM	0.9	0.1	0.0	0.2	0.9	2.0	5.8	3.5	7.0	18.7
AFR	0.3	0.0		0.0	0.3	0.6	1.2	1.0	1.8	5.6
ROW	0.3	0.0	0.1	0.2	0.9	1.8	3.4	3.0	3.9	11.8

In percent of total imports

	Cru	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	5.6	0.0	0.8	0.2	0.8	5.2	8.5	5.0	18.2	55.6
WEU	3.0	0.3	0.8	0.4	1.4	6.6	13.3	9.2	16.3	48.7
ANC	2.6	0.3	0.0	0.2	0.7	5.8	12.6	5.5	22.1	50.2
JPN	6.5	1.4	1.5	0.0	1.9	5.1	7.2	17.4	13.6	45.4
FEC	3.3	0.7	4.3	1.7	1.9	6.1	12.9	12.3	12.3	44.6
MEA	2.2	0.4	0.3	0.1	2.3	6.5	9.7	14.5	13.2	50.8
CPA	1.3	0.1	0.1	0.1	2.2	9.2	14.9	8.6	7.0	56.6
PAS	5.2	0.6	0.3	0.0	2.2	8.6	10.2	7.4	9.6	56.0
IND	9.1	0.8	0.0	0.2	5.8	15.1	15.5	6.1	7.6	39.8
LAM	2.4	0.3	0.1	0.6	2.3	5.1	14.8	9.0	17.8	47.6
AFR	2.7	0.2	0.0	0.3	2.4	5.1	11.5	9.2	16.3	52.2
ROW	1.3	0.1	0.2	0.7	3.53	7.0	13.5	11.9	15.2	46.6

Table 7: Production Structure by Region 2030 in Percent Total Output

Real	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Cgd**	**Y**
USA	0.2	0.2	0.2	1.5	0.5	1.9	6.9	5.5	6.6	8.9	67.4
WEU	0.1	0.0	0.1	1.2	0.3	3.6	5.6	7.4	7.1	9.6	65.1
ANC	0.7	0.6	0.7	2.0	0.5	3.6	6.1	8.2	8.9	10.9	57.9
JPN	0.0	0.0	0.0	2.0	0.4	3.6	5.4	5.0	8.7	14.1	60.8
FEC	1.7	0.6	2.9	2.3	1.3	4.3	5.4	9.9	8.0	11.2	52.5
MEA	2.7	0.0	0.8	1.4	1.2	3.4	4.6	13.4	7.1	12.4	53.0
CPA	0.2	0.1	0.0	1.0	0.5	7.6	7.1	16.4	7.0	8.8	51.3
PAS	0.1	0.0	0.3	1.5	0.8	4.7	7.2	11.9	7.2	10.4	55.9
IND	0.1	0.1	0.2	3.3	0.5	5.3	5.4	24.1	7.5	10.5	42.9
LAM	0.5	0.0	0.2	1.1	0.5	4.5	7.7	16.4	8.3	10.2	50.6
AFR	1.1	0.4	0.0	2.0	1.0	3.6	4.4	22.3	8.3	8.5	48.4
ROW	0.2	0.0	0.2	1.4	0.2	3.7	8.1	16.9	6.9	9.4	53.0

Values	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Cgd**	**Y**
USA	0.7	0.4	0.3	1.6	1.5	1.9	6.0	5.2	7.0	8.8	66.7
WEU	0.3	0.1	0.2	1.4	1.0	3.5	7.0	7.2	8.0	9.2	62.2
ANC	2.0	1.6	1.0	2.1	1.5	3.6	6.3	7.8	9.7	10.1	54.4
JPN	0.0	0.0	0.0	2.1	1.0	3.6	5.7	5.0	9.3	13.8	59.6
FEC	4.3	1.2	3.4	3.5	3.3	4.4	5.7	9.6	7.8	9.6	47.4
MEA	13.3	0.1	1.3	2.2	4.2	2.9	4.2	11.0	6.4	11.1	43.3
CPA	1.0	0.7	0.1	2.0	2.1	7.6	8.0	14.8	7.0	8.5	48.3
PAS	0.7	0.1	0.5	2.0	2.9	4.7	7.5	11.1	7.5	10.3	52.7
IND	0.7	0.5	0.4	4.2	2.0	5.5	6.5	21.1	8.4	10.8	39.9
LAM	2.2	0.1	0.4	1.4	1.8	4.5	7.6	15.9	8.5	9.8	47.8
AFR	4.6	1.7	0.2	3.6	2.5	3.8	4.5	19.7	8.2	7.8	43.3
ROW	1.3	0.1	0.4	1.7	0.7	3.8	7.8	15.1	7.7	9.6	51.7

Table 8: Export Structure 2030 in Percent Total Exports

Real	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	0.1	0.5	0.0	0.0	0.6	4.0	14.1	8.9	19.6	52.1
WEU	0.4	0.0	0.2	0.5	0.7	7.8	15.2	8.0	16.7	50.5
ANC	2.6	2.9	2.8	0.8	0.5	10.6	12.1	13.4	18.7	35.5
JPN	0.0	0.0	0.0	0.0	0.3	6.9	9.9	0.7	24.4	57.9
FEC	5.7	1.1	8.6	1.4	3.1	15.2	8.9	7.4	13.7	34.9
MEA	32.6	0.0	2.6	0.0	6.1	3.9	6.0	5.0	9.2	34.7
CPA	0.2	0.1	0.0	0.1	0.2	4.6	6.6	6.0	5.9	76.4
PAS	0.4	0.1	0.7	0.0	1.3	4.7	9.9	5.5	8.7	68.8
IND	0.0	0.0	0.0	0.0	0.2	5.0	7.5	18.8	7.2	61.2
LAM	4.5	0.2	0.1	0.6	1.6	9.6	8.1	20.1	16.8	38.5
AFR	10.3	1.1	0.0	0.3	0.6	14.3	5.4	23.2	11.3	33.5
ROW	2.6	0.0	0.8	1.7	0.4	7.2	19.8	11.3	7.4	48.8

Values	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	0.4	1.4	0.1	0.1	1.6	4.0	14.4	8.2	20.5	49.4
WEU	1.2	0.0	0.3	0.5	2.0	7.8	15.7	7.6	17.4	47.5
ANC	7.1	8.0	3.2	0.8	1.4	9.5	11.1	11.3	17.7	29.9
JPN	0.0	0.0	0.0	0.0	0.7	7.2	10.5	0.6	25.7	55.3
FEC	14.5	2.6	8.8	1.5	7.1	13.1	7.9	5.9	11.7	26.9
MEA	58.1	0.0	1.8	0.0	9.6	2.2	3.4	2.5	5.1	17.2
CPA	0.8	0.3	0.1	0.1	0.7	4.9	7.2	5.7	6.5	73.8
PAS	1.6	0.4	1.0	0.0	3.9	4.8	10.3	4.9	9.1	64.1
IND	0.2	0.0	0.0	0.0	0.6	5.3	8.5	18.1	8.1	59.3
LAM	13.4	0.5	0.1	0.6	4.1	8.7	7.5	16.9	15.8	32.4
AFR	28.5	3.1	0.0	0.3	1.3	11.9	4.5	16.8	9.3	24.4
ROW	9.0	0.1	1.1	1.9	1.1	7.1	18.7	9.6	7.7	43.8

Table 9: Import Structure 2030 in Percent Total Imports

Real	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	2.5	0.0	0.7	0.1	0.3	4.6	6.6	4.8	16.1	64.3
WEU	1.5	0.2	0.7	0.3	0.7	6.2	13.3	10.0	15.7	51.4
ANC	0.9	0.1	0.0	0.1	0.3	4.9	11.5	6.0	21.7	54.4
JPN	4.3	0.7	1.5	0.0	0.4	4.6	6.5	18.7	12.0	51.4
FEC	1.4	0.3	3.3	2.4	0.8	6.6	13.0	14.2	11.1	46.9
MEA	0.9	0.2	0.4	0.1	1.0	5.8	8.9	16.0	12.4	54.4
CPA	2.0	0.5	0.2	0.2	2.1	9.2	18.9	8.3	5.1	53.4
PAS	3.4	0.4	0.6	0.0	1.4	9.4	11.0	7.6	9.1	57.2
IND	6.4	1.2	0.0	0.2	3.7	17.6	21.9	5.6	8.2	35.2
LAM	1.5	0.2	0.1	0.8	1.5	5.0	13.9	9.8	17.4	49.9
AFR	2.7	0.3	0.0	0.9	0.7	6.5	12.2	8.9	14.4	53.3
ROW	1.0	0.2	0.7	0.5	2.0	8.4	11.8	9.0	18.6	47.9

Values	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**
USA	7.6	0.0	0.8	0.1	0.7	4.5	6.7	4.4	16.5	58.5
WEU	4.6	0.5	1.0	0.4	1.9	6.2	13.6	9.1	16.3	46.5
ANC	2.9	0.4	0.0	0.1	0.8	5.0	11.9	5.6	22.7	50.6
JPN	13.1	1.9	1.8	0.0	1.1	4.2	6.2	16.1	11.7	44.0
FEC	4.1	0.7	3.9	2.9	2.0	6.5	13.1	12.9	11.2	42.5
MEA	2.8	0.4	0.5	0.1	2.9	5.9	9.2	14.8	12.9	50.5
CPA	6.2	1.4	0.3	0.3	5.4	8.8	18.4	7.3	5.1	46.8
PAS	10.2	1.1	0.7	0.0	3.7	8.8	10.6	6.5	8.9	49.5
IND	17.0	2.8	0.0	0.2	8.7	14.3	18.7	4.1	7.0	27.1
LAM	4.3	0.5	0.1	0.9	3.9	4.9	13.7	8.8	17.5	45.3
AFR	8.4	0.8	0.0	1.1	2.0	6.3	12.2	8.0	14.4	46.8
ROW	3.0	0.4	0.8	0.6	5.4	8.1	11.7	8.1	18.7	43.1

Table 10: Export Share in World Exports 2030 (quantities in percent)

Real	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**	**Total**
USA	0.6	20.5	0.7	1.3	6.3	6.2	12.6	11.2	14.9	10.2	10.6
WEU	5.4	1.0	9.9	36.4	21.1	33.4	37.3	28.0	35.1	27.3	29.4
ANC	4.4	39.9	13.8	7.4	2.0	5.5	3.6	5.6	4.8	2.3	3.6
JPN	0.0	0.3	0.0	0.0	1.8	6.7	5.5	0.5	11.6	7.1	6.6
FEC	9.0	14.7	39.8	12.1	10.6	7.5	2.5	2.9	3.3	2.2	3.4
MEA	46.3	0.0	10.7	0.2	18.8	1.7	1.5	1.8	2.0	1.9	3.0
CPA	0.8	2.7	0.4	1.3	1.9	6.3	5.2	6.7	4.0	13.3	9.4
PAS	3.5	8.0	17.0	0.1	23.3	12.3	14.8	11.6	11.2	22.7	17.9
IND	0.0	0.0	0.0	0.0	0.3	1.0	0.9	3.1	0.7	1.6	1.4
LAM	12.9	4.8	0.6	8.9	9.8	8.5	4.1	14.5	7.3	4.3	6.1
AFR	8.9	7.7	0.0	1.5	1.2	3.8	0.8	5.0	1.5	1.1	1.8
ROW	8.3	0.4	7.1	30.6	2.9	7.1	11.2	9.1	3.6	6.1	6.8

Table 11: Import Share in World Imports 2030 (quantities in percent)

Real	**Cru**	**Col**	**Gas**	**Egw**	**Oil**	**ISM**	**CPP**	**Agr**	**Trn**	**Y**	**Total**
USA	14.9	0.5	12.0	4.5	3.2	8.5	7.0	6.4	14.8	15.1	12.6
WEU	20.0	18.0	29.9	26.8	18.8	25.5	31.2	28.9	31.8	26.7	27.8
ANC	1.6	2.0	0.1	0.8	1.1	2.7	3.6	2.3	5.8	3.7	3.7
JPN	11.3	14.8	11.5	0.0	2.2	3.7	3.0	10.6	4.8	5.2	5.5
FEC	3.0	4.9	21.0	29.7	3.3	4.3	4.8	6.5	3.6	3.9	4.4
MEA	2.7	3.7	3.6	1.6	6.3	5.4	4.7	10.4	5.7	6.3	6.3
CPA	7.5	14.7	2.0	5.1	15.8	10.6	12.4	6.8	2.9	7.7	7.8
PAS	24.5	24.2	12.5	0.3	20.7	21.0	14.1	12.0	10.0	16.2	15.2
IND	3.6	5.4	0.0	0.6	4.4	3.1	2.2	0.7	0.7	0.8	1.2
LAM	4.9	5.6	1.1	15.1	10.1	5.2	8.2	7.2	8.9	6.5	7.0
AFR	2.9	2.3	0.0	5.8	1.6	2.1	2.3	2.0	2.3	2.2	2.2
ROW	3.1	3.9	6.3	9.7	12.6	8.0	6.4	6.1	8.7	5.7	6.4

Table 12: Income Shares - Factor Income Structure 2030 (in percent)

	Real			Values		
	Labor	**Capital**	**Rent**	**Labor**	**Capital**	**Rent**
USA	61.2	37.2	1.6	49.5	50.4	0.2
WEU	54.6	44.6	0.8	50.7	49.0	0.4
ANC	54.5	39.5	5.9	42.2	56.5	1.3
JPN	60.1	39.8	0.0	47.2	52.8	0.0
FEC	54.5	33.7	11.8	59.6	36.9	3.4
MEA	40.7	36.1	23.2	41.2	53.6	5.2
CPA	51.8	43.5	4.7	48.2	51.4	0.3
PAS	46.8	51.3	1.8	39.5	60.1	0.3
IND	38.8	58.9	2.3	30.8	68.9	0.3
LAM	43.7	52.3	4.0	44.3	54.9	0.7
AFR	50.8	38.0	11.2	68.1	30.6	1.3
ROW	54.1	43.7	2.2	25.0	74.7	0.3

Table 13: Revealed comparative Advantage (RCA) 1997 and 2030

	ISM		**CPP**		**Agr**		**Trn**		**Y**	
USA	-0.28	-0.15	0.38	0.76	0.49	0.63	0.09	0.20	-0.03	-0.16
WEU	0.06	0.23	0.16	0.16	-0.10	-0.19	0.03	0.08	0.02	0.01
ANC	0.44	0.65	-0.07	-0.07	0.85	0.70	-0.05	-0.25	-0.36	-0.53
JPN	0.17	0.53	0.24	0.52	-3.25	-3.25	0.58	0.79	0.27	0.23
FEC	0.96	0.70	-0.34	-0.51	-0.42	-0.78	-0.05	0.04	-0.32	-0.46
MEA	-0.70	-1.00	-0.63	-0.99	-1.25	-1.77	-0.50	-0.92	-0.58	-1.07
CPA	-0.77	-0.59	-0.76	-0.94	-0.54	-0.25	-0.32	0.23	0.31	0.46
PAS	-0.70	-0.61	-0.12	-0.03	-0.41	-0.28	-0.10	0.02	0.20	0.26
IND	-1.15	-0.99	-0.49	-0.79	1.03	1.47	0.05	0.14	0.41	0.78
LAM	0.53	0.58	-0.76	-0.61	0.77	0.65	-0.15	-0.10	-0.26	-0.34
AFR	1.04	0.63	-0.95	-1.00	0.67	0.74	-0.68	-0.44	-0.69	-0.65
ROW	0.10	-0.14	0.02	0.46	-0.39	0.18	-0.54	-0.89	0.01	0.02

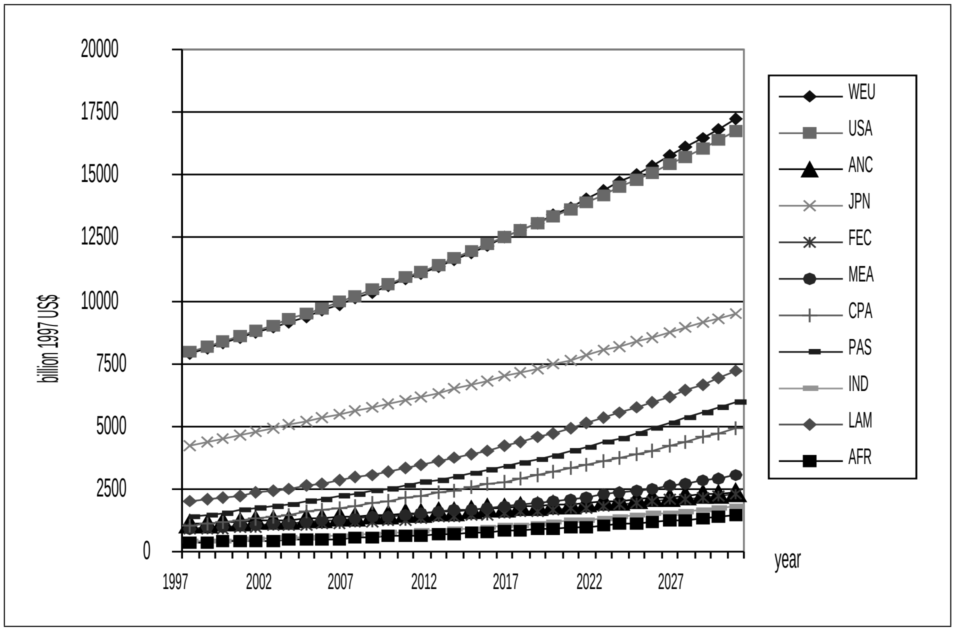
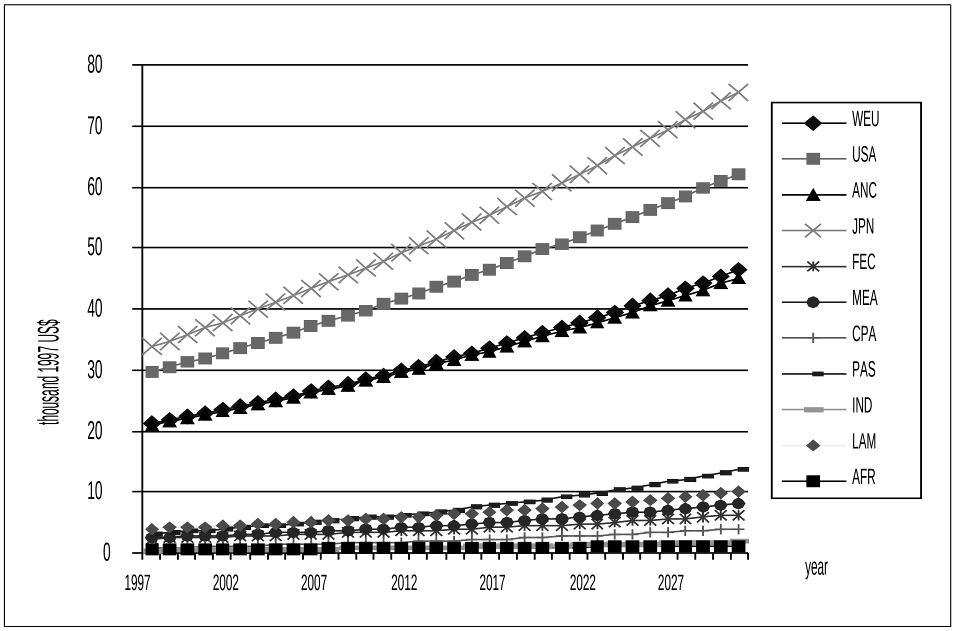


Figure 5: GDP and GDP per capita by region



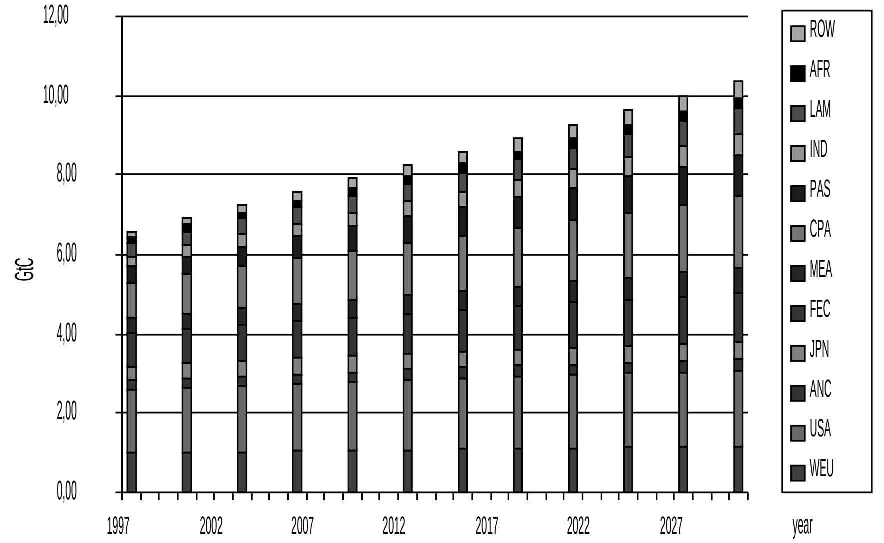
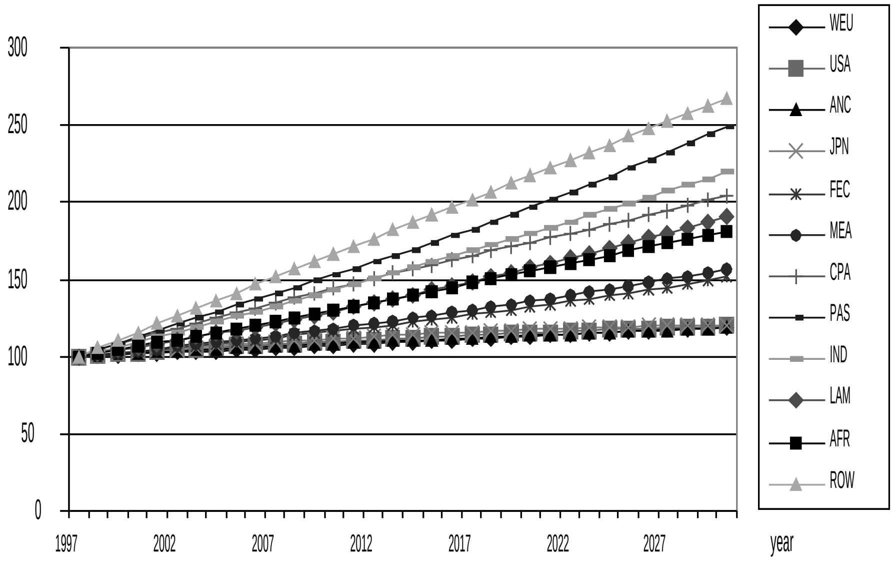


Figure 6: CO_2 emissions and Index CO_2 emissions



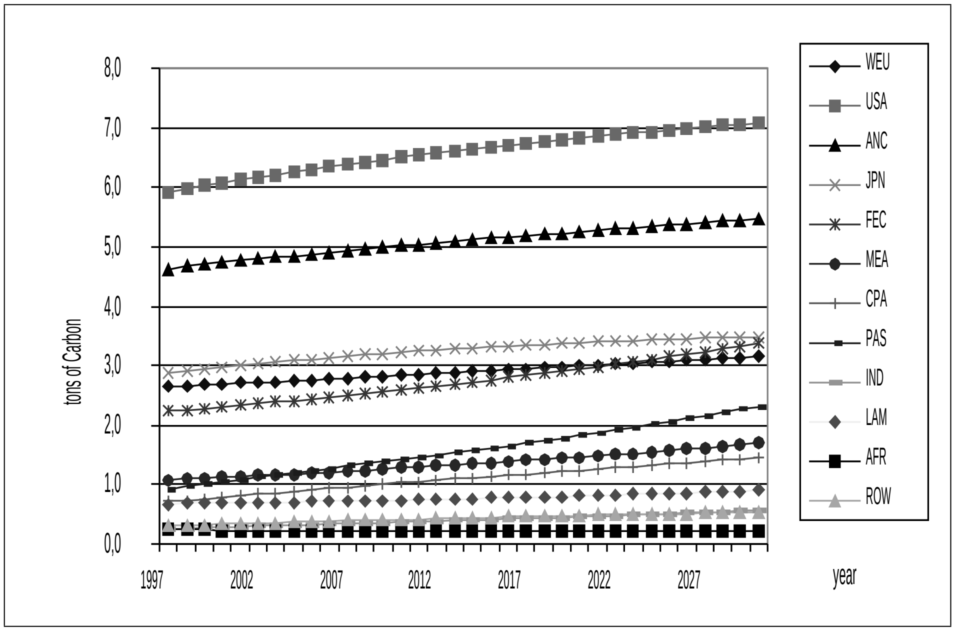


Figure 7: CO_2 emissions per capita and CO_2 intensity by region