Integrating demography into a regional CGE model

Adriana M. Ignaciuk[1,2,⌂], Henk Hilderink[1] & Sonja Peterson[2]

[1] Netherlands Environmental Protection Agency
Antonie van Leeuwenhoeklaan 9
3721 MA Bilthoven
Telefoon: +31 (0) 30 274 274 5
Fax: +31 (0) 30 274 44 79
⌂ Email: Adriana.Ignaciuk@mnp.nl
[2] Kiel Institute for the World Economy
Institut für Weltwirtschaft
Düsternbrooker Weg 120
24105 Kiel
Germany
Phone: +49-431-8814-1
Fax: +49-431-85853

Abstract

Changes in global labor shares are often exogenously linked to changes in global population in (recursive) dynamic general equilibrium models (CGE). In many cases, these models carry a simplification or even misspecification for e.g. demographic behavior concerning fertility and mortality, and with that of the changing age structure of the population. In addition, participation rates of the potential labor force should be taken into account to have a better representation of the actual labor force. To account for these factors we link a recursive dynamic global CGE model, based on the GTAP 6.0 database, with a model that describes the demographic changes as the result of fertility and mortality patterns. The results indicate that the population aging has a substantial effect on the economy. Especially in Europe, where the process of aging is or will become visible within the coming decades, economic growth might be slowed down. To anticipate on these developments, various policy options are explored. The policies included in the paper are rising retirement age, increasing participation rates and changing the fertility rates. Although these options do have a significant positive effect on the average income levels, they cannot fully compensate the coming waves of aging.

1 Introduction

Changing demographics can have a substantial influence on the economy. It affects the economic growth via different routes; 1) the employment and labor productivity growth, 2) changing demand trends, and 3) changes in savings and investment behavior.

Recent trends suggest a strong global decline of fertility rates. This is not only a phenomena in developed countries but starts to play a role in developing countries as well (Lee, 2003). This of course has an impact on the labor force. In developed countries, fertility levels are far below replacement levels which will result in a change in the age structure of the population and in turn also in a decline of the working-age population. In combination with an aging population this will increase the pressure on possibilities for economic growth. This pattern of demographic changes is also expected to occur in developing countries, though they are still in the earlier stages of the demographic transition. These changes will have a substantial effect on their economic growth potential.

Dynamic computable general equilibrium (CGE) models have become a standard tool in economic policy analysis. Yet, in many models changes in global labor shares are only exogenously linked to changes in global population. These models carry a simplification of demographic behavior e.g. concerning fertility and mortality, and with that of the changing age structure of the population. Moreover they often omit the participation rate.

Many models are not very explicit in their specification of labor supply, such as e.g. the dynamic GTAP model (Ianchovichina and McDougall 2000), WIAGEM (Kemfert 2002) or PACE (Böhringer et al. 2006). An common approach followed e.g. in the EPPA model (Babiker et al. 2001) is to simply calibrate region specific productive labor supply to an exogenous GDP path by assuming augmenting Harrod-neutral technical change. Only few models such as GTEM (Tulpule et al. 1999) or WorldScan (Don 1999) explicitly account for demographic developments and participation rates in their labor supply calibration. Yet, the implications of different assumptions and demographic scenarios are not clear.

To account for the most important demographic factors and to simulate how different policies and assumptions change the labor supply function, we link a recursive dynamic global CGE model, based on the GTAP 6.0 database, with a model that describes the demographic changes as the result of fertility and mortality patterns. We are now able to explore how the different labor supply functions affect the macroeconomic outcome.

2 Linking PHOENIX to DART

To be able to link the simulation models and to understand the possible effects of this linkage, one has to know the underlying dynamics of both models. Therefore a brief description is gieven of the Population and Health model PHOENIX and the CGE model DART.

2.1 Short description of PHOENIX

The profound transformation of changing fertility and mortality patterns is generally referred to as demographic transition. It was classically defined by Notestein (1945) and Davis (1945), although its intellectual history goes back much further (Szreter, 1993). The demographic transition is not an isolated process; it is part of a much broader transformation observed in a growing number of countries since the 18th century and is commonly referred to as 'modernization'. In the economic domain, modernization involves a rise in real output and wide-ranging innovations and improvements in the production, transportation and distribution of goods. On the demographic and social side, modernization involves significant alterations in fertility, mortality and migration, as well as in family size and structure, education and the provision of public health.

At the level of the individual, modernization is characterized by an increased openness to new experiences, increased independence from authority, belief in the efficacy of science, and ambitions for oneself and one's children (Easterlin, 1983). These interrelations of manifold processes inevitably lead to a considerable variety in fertility decline between and within populations, although the pattern of the demographic transition is remarkably consistent in all parts of the world. Important differences exist in the position of individuals and groups on the trajectory of transition. The concept of demographic transition expresses plausible descriptions of the fertility decline in the idiom of post-war concerns with population and development (Cotts Watkins, 1987; Szreter, 1993).

Historical data indicate that fertility and mortality show rather gradual changes. The process of migration is less well understood, because: (i) migration consists of two components, emigration and immigration, both with different dynamics while still related with the migrant population; (ii) the relationship between the determinants, such as economic opportunities, conflict situations, extreme environmental events, and these migration components is often not fully understood; analyses of these relationships result in associative rather than causal connections; and, (iii) some of these determinants have a high incidental nature, which causes difficulties in forecasting migration patterns.

For the population projections the PHOENIX model is used (Hilderink, 2000a; Hilderink, 2000b). PHOENIX is a Population and Health model which allows to explore, develop and analyze different demographic scenarios at various geographical aggregation levels. It captures the profound transformation of fertility and mortality patterns, a process refereed to as the demographic transition theory. It describes the process of transition from high death and high birth rates to low death and low birth rates as part of the shift from a pre-industrial to a more industrialized economy.

The demographic core of PHOENIX is formed by a standard cohort-component model {Hinde, 1998 #507} consisting of 100 one-year age groups and the two sexes. The inflow of the demographic model, the number of births, is provided by fertility component while the outflow is provided by the mortality component which calculates the age and sex- specific number of deaths based on a selection of health risks. Migration, as the third demographic component, is taken exogenously. The figure below shows the PHOENIX model with the context, position and the interrelationships.

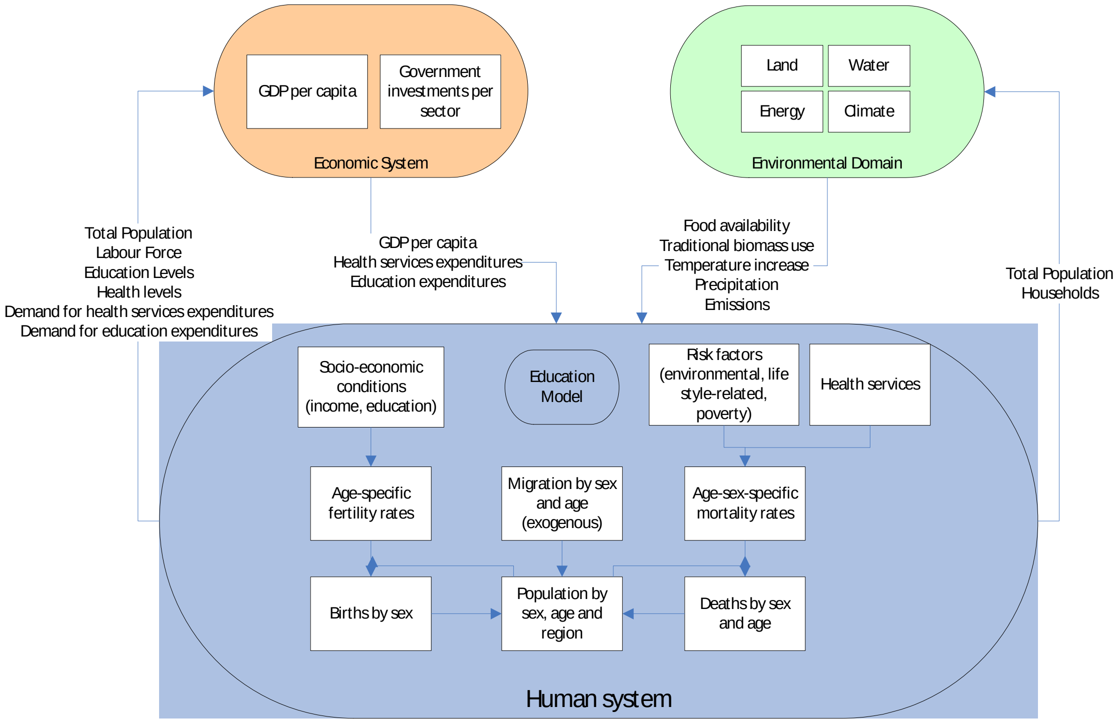

Figure 1: Conceptual model of PHOENIX

Fertility component

A fertility module is used in PHOENIX to describe age-specific fertility rates which are the result of a process of diffusion of innovation (Montgomery and Casterline, 1993; Retherford and Palmore, 1983; Rodriguez and Aravena, 1991; Rosero-Bixby and Casterline, 1993). Innovation is a concept comparable to Easterlin's modernization which is considered to be main driving force behind changes in fertility patterns (Easterlin, 1983). In PHOENIX these fertility changes are modeled through the total fertility rate (TFR), i.e. the average number of children a woman would have given current age-specific fertility rates. These age-specific fertility rates (i.e. the number of children per woman in a particular age group) are obtained using look-up functions linked to the TFR. These look-up functions are based on the region-specific data (IDB, 1997; UN, 2004). The level of TFR is modelled based on the relationship with a woman's educational attainment and economic characteristics. Women's educational attainment even has a stronger effect on fertility than does men's education or other characteristics of households, such as wealth (INFO Project, 2003). The set-off and the rate of the fertility transition are strongly influenced by (female) education levels, the higher educated tend to have less children, at least in the first demographic transition. There are theories that state that at very high development levels higher educated women have more children. The phenomena is referred to as the 2nd Demographic transition (Lesthaeghe and Van de Kaa, 1986; Van de Kaa, 1987). However, both in the Netherlands an in Japan there is no indication of such a changing pattern and is a higher level of education of women associated with lower fertility levels (CBS, 2006; Retherford et al., 2004). The various levels of educational attainment determine the final convergence level for each level (no education, primary, secondary and tertiary). The level of the human development index determines the speed of convergence.

Mortality component

The mortality component of PHOENIX determines the outflow of the population. Where the inflow of the population, the number of births, concerns only the first age group, mortality is specified for all age groups separately. Mortality patterns resemble a U-shape. Mortality is high for the children up to five years, relatively low between 5 and 25 and then steadily increasing to high levels. Also a distinction between the two sexes is essential. Especially at higher ages, women show lower mortality. The causes behind mortality are much more fragmented then it is the case for fertility. The methodology applied captures the causal chains between health risk factors and health outcomes and is largely based on existing approaches (WHO, 2002) and Disease Control Priorities Project (DCPP) (Cairncross and Valdmanis, 2006). Health risks taken into account can be clustered into three categories, environmental (food-, water-, energy- and climate-related), behavior (smoking, overweight and blood pressure) and social-economic status. In addition, the level of health services expenditures is determines the effect of these health risks on mortality.

Migration

Given the difficulties in capturing migration dynamics, net migration is taken into account exogenously, based on the data provided by the (UN, 2004) The UN assumes that “the future path of international migration is set on the basis of past international migration estimates and an assessment of the policy stance of countries with regard to future international migration flows”. It is not further specified what these policy stances are. The only variant included is the zero migration variant. Lutz (Lutz, 1996) provides a better starting point to vary with future migration patterns. The age structure of migrants are assumed to be constant in time and the same for all regions and are based on the European migration flows (Eurostat, 2005).

Education model

Education plays an important role, both for economy as for population dynamics. To address the various facets of education dynamics a simple education module has been developed as part of PHOENIX. The population model serves rather well as an integrative platform for education modeling since it facilitates detailed modeling by distinction of 100 age groups and the two sexes. Furthermore, mortality and fertility processes are endogenously included, and the interaction with the economy module is taken into account through both labor and investments in education, allowing the analysis of both causes and consequences of education levels.

2.2 Short description of DART

The Dynamic Applied Regional Trade (DART) model is a recursive-dynamic computable general equilibrium (CGE) model of the world economy. DART is a multi-regional, multi-sectoral model.

As in the standard CGE, consumers maximize their utility function subject to the budget constraints. The final consumer decides between different goods depending on their relative price in order to receive its consumption (utility) with the lowest expenditures. In each period, a fixed share of income is saved. Producer behavior is characterized by cost minimization for a given output, with an assumption of constant returns to scale. For the detailed description of different production functions see (Klepper et al., 2003). Produced goods are directly demanded by final consumers (comprising regional households and government), the investment sector, other industries and the export sector.

Factor markets are perfectly competitive; all factors are utilized. Labor is assumed to be a homogenous good, mobile across industries within regions but internationally immobile. In this 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 results from the capital accumulation equation.

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. Domestic and foreign goods are imperfect substitutes (Armington, 1969), and distinguished by country of origin. Import demand is distinguishes between imported and domestically produced goods as well as between the country of origin. 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.

DART accounts for the CO_2 emissions related to both production and consumption of fossil fuels. The carbon content differs per energy source. 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 projections of the IEA (2006).

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 main factors influencing the development of labor supply in the original version of the model are population and productivity growth and human capital accumulation. For current version of the model this approach is modified to reflect better the labor growth. We use the population data of population cohort 15-65 from the UN medium scenario and the labor participation rate from the OECD. Labor is measured in efficiency units. It evolves exogenously over time. An increase of effective labor implies either growth of the human capital accumulated per physical unit of labor, physical labor growth or factor productivity or the sum of all. The human growth rates of human capital 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). 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 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.

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. Current period's investment augments the capital stock in the next period. The aggregated regional capital stock, at period t is updated by an accumulation function equating the next-period capital stock, to the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment. According to the GTAP6 dataset depreciation rate is equal 4% and we use the same value for all time periods. The allocation of capital among sectors follows from the intra-period optimization of the firms. The savings behavior of regional households is characterized by a constant savings rate over time. This 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. Additionally, a wide range of empirical evidence in macro economic 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 (Klepper et al., 2003).

Table 1 Region definition

Abbreviation	*Region*	*Abbreviation*	*Region*
CAN	Canada	ASTAN	Asia –Stan
USA	USA	RUS	Russia
MEX	Mexico	MEA	Middle East
RCAM	Rest Central America	IND	India
BRA	Brazil	KOR	Korea
RSAM	Rest South America	CPA	China
NAF	Northern Africa	SEAS	Southeastern Asia
WEAF	West-East Africa	IDN	Indonesia
SAF	South Africa	JPN	Japan
WEU	Western Europe	OCA	Oceania:
CEU	Central Europe	RSAS	Rest of South Asia
TUR	Turkey	RSAF	Rest of Southern Africa

In the current version DART has 24 regions and 11 sectors, see Table 1 and 2, but it can be easily disaggregated within GTAP classification to up to 87 regions and 57 sectors (in GTAP6).

Table 2 Sectoral division

Abbreviation	*Sector*	*Abbreviation*	*Sector*
AGR	Agricultural sector	PET	Petroleum sector
ANIM	Animal sector	ELE	Electricity
FORE	Forestry	MAN	Manufactures
COAL	Coal	PUB	Public administration
OIL	Oil	SERV	Services
GAS	Gas		

2.3 Linking models

As described above PHOENIX uses GDP projections on a regional level to describe the demographic development for the coming decades. In turn the demographic output of PHOENIX, is used to update the labor supply functions of DART. In this way, a soft link between both models is established.

In principle, DART uses the population data from PHOENIX to calculate the macroeconomic effects. These population data are the population aged 15 to 65 years, representing the labour force. Economic data are used in PHOENIX as driving force for fertility, mortality and education (Figure 2).

Both models work with similar region definition with one exception; Phoenix disaggregates further the African regions. To be able to link both model in a consistent way, the data are to be straightforwardly aggregated for those data being transfered from PHOENIX to DART. For the flows from DART to PHOENIX, GDP growth rates are assumed to be equal for the disaggregated African regions and determine with the 2001 level the future pathway.

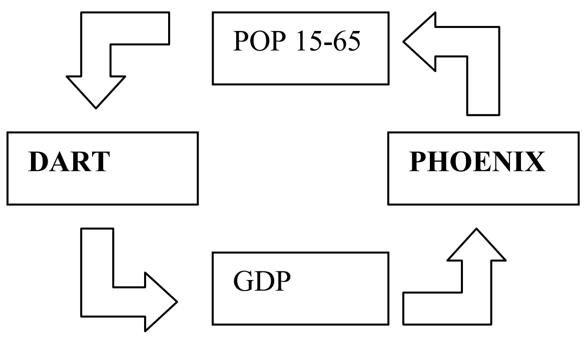

Figure 2 Schematic overview of model linking DART-PHOENIX

3 Data and parameters

The simulation results of both models depend also on the used input data, not only concerning the base year but also for future developments. The most relevant data and parameters, including their sources are described.

3.1 PHOENIX

Most of the data needed for PHOENIX are coming from the UN Population Division {UN, 2006}. For almost 200 countries, detailed demographic data concenring age-structure, fertility, motality and migration patterns are provided. For the future projection, the baseline scenarios as applied in the OECD Environmental Outlook, is taken as guidance. It provides trends on food, water, energy and climate, necessary for future mortality trends. The economic data of the OECD reference scenario are reproduced by DART. This reference sceanrio results in a continuing demographic transition in all developing countries, resulting in a slowing down of population growth. In developed countries, where the demographic transition is already completed, no major changes in absolute fertility levels and in the decrease of mortality are assumed.

3.2 DART

The standard structure of DART including the description of the nesting structure of production and consumption function and substitution elastictises are described in details in Klepper at al (2003) and Springer (2002). Concerning the dataset, DART follows the GTAP developments. Currently it is based on the GTAP6 database, meaning that the base year for DART is 2001.

3.2.1 Population

The population data are taken from the UN medium scenario for the basic run of the model. The labor supply functions are updated accordingly to the scenario using the PHOENIX input.

3.2.2 Labor participation

The participation rate is generally defined as the percentage of adults who actually work or are unemployed. The labor market fluctuations are explained by many economic factors; at the margins, in the developed countries, a) in the younger age cohorts by female decisions to stay working or taking care of children and b) in the older age cohorts by the decision determining the pension age (OECD, 2003).

In recent years the trends to the participation were downward sloping in the OECD countries, though looking at the historical observations, from the sixties the long term average participation rate is constant, around 60% (OECD, 2003). For the non-OECD countries, there is often a lack of data to analyze the trends. Therefore, following the OECD, it is assumed that non-OECD countries are slowly converging to the long term participation rate of 60%. The participation rates used in DART are in Table 3.

Table 3 Participation rates

	2001	2005	2010	2020	2030
CAN	66%	65%	64%	62%	60%
USA	67%	66%	65%	63%	61%
MEX	59%	60%	60%	62%	64%
RCAM	63%	63%	62%	62%	62%
BRA	67%	67%	66%	65%	65%
RSAM	63%	63%	63%	63%	62%
NAF	48%	48%	49%	50%	52%
WEAF	51%	52%	52%	53%	54%
SAF	50%	50%	51%	52%	53%
WEU	59%	58%	58%	57%	55%
CEU	59%	59%	58%	57%	55%
TUR	50%	51%	51%	53%	55%
ASTN	64%	64%	64%	63%	63%
RUS	59%	59%	59%	59%	59%
MEA	50%	50%	51%	52%	53%
IND	64%	64%	64%	63%	63%
KOR	61%	60%	58%	55%	51%
CPA	66%	66%	65%	65%	64%
SEAS	72%	72%	71%	70%	68%
IDN	68%	68%	67%	66%	65%
JPN	62%	61%	60%	58%	56%
OCN	65%	65%	64%	62%	61%
RSAS	63%	63%	63%	62%	62%
RSAF	51%	51%	52%	53%	53%

4 Scenarios

The demographic module of the Benchmark scenario is calibrated to reflect the projection of the labor development until 2030 coming from the UN Medium scenario; the age cohort 15-65 is used and the participation rates based on the OECD projections. Under the Benchmark Scenario we are able to capture the aging structure of the population and the size of real labor.

Effects of population growth (Population Scenario)

First, we analyze the effects of a labor force specification as a function of the population growth. This specification that is also used in the standard, non-linked version of DART implicitly assumes that there is no change in participation rates and that the structure of the population remains constant. Further in the paper, we refer to it as Population Scenario. Comparing the results of this scenario against the Benchmark we are able to see the size of a misspecification that is often seen once the population growth is used as proxy for the labor growth.

The increased pension age in developed countries (Pension Scenario)

In many developed countries, aging population structure calls for additional policies to keep the working force as high as possible and to decrease at the same time the amount of pensioners. In this scenario, we included the next population cohort 65-70 in the active labor force and applied the respective participation rate. One has to keep in mind that the participation rate of this group is very low. Despite the effect of increasing size of labor, the secondary effects of changing the savings patterns can play a role.

Quicker conversion of fertility rates (Fertility Scenario)

Post-war Europe is characterized by the economic growth which resulted in improvements in the health situation. Also fertility levels went below the so-called replacement level of 2.1, a level required to achieve a stable population in the long term. Currently, many countries know very low Total Fertility Rate (TFR) such as the Netherlands with 1.7, Spain with 1.2 and the Ukraine as low as 1.1 children per woman in 2001 (UN, 2004). At the same time, many African countries still have a TFR of over 5 childeren per woman, while India, though already on its way in the demographic transition, still had a TFR of 3.2 children er woman. Under the Fertility Scenario we analyze the effects of fertility transition completely stagnating in all developing coutries, comparable with the UN constant fertility variant (UN, 2004). This has a substantial effect of the population between 15 and 65 years, although most of the effect will be visible at the longer term, when the additional children being born due to the higher fertility levels, enter the labor force ages and also starting a reproductive carreer themselves, with similar high fertility rates.

Movements of labor force across the regions (Migration Scenario)

Migration due to economic but also due to other sorts of reasons e.g. bad environmental conditions, or security reasons is expected to increase substantially. With increasing speed of climate change, people might be forced to move away from delta regions, or look for better soils to produce their agricultural goods. Many of these changes will happen within the regions, but also between regions it is expected to have large consequences. First order effects can be visible in reducing the labor force in the poorer regions, but one cannot neglect the remittances that are sent back to the home countries of the migrants. We will analyze these effects under the Migration Scenario.

Changing participation structure (Participation Scenario)

Increasing level of wealth can influence the participation level twofold; in a European model the participation decline and stabilizes on around 60% level and in an American model we can observe an increase of participation level with an increase of income. In our benchmark we assumed, following the OECD scenario that the developing countries will follow the European path. What is the American model is chosen? The implication of it we will analyze under the Participation Scenario.

5 Results and Discussion

We present and discuss the results in the following order. First we focus on the Benchmark vs. Population scenario. We analyze the effect of the misspecification that is often carried by the CGE models that use population growth as a proxy of labor force growth. Next, we analyze the results of the Pension, Fertility, Migration and Participation Scenarios compared to our Benchmark Scenario.

5.1 Benchmark vs. Population Scenario

The pattern of GDP growth follows the pattern of labor growth for all regions. In Figure 3, we see the growth rates of labor and GDP for a selection of countries. Within the selection we present two developed regions, USA and Western Europe, two transition countries Brazil and China and two developing ones India and Sub Saharan Africa. It is noticeable that for the young populations e.g. in Sub-Saharan Africa and India the misspecification of the GDP calculation using the population growth data is rather small. They show larger expansion of labor force especially in the beginning period. For the developed countries e.g. USA and Western Europe the GDP levels are substantial different. The labor force declines quicker than the size of population. It is a clear pattern for an old population, with much higher levels of pensioners. Similar patterns is visible in other developed regions e.g. Japan.

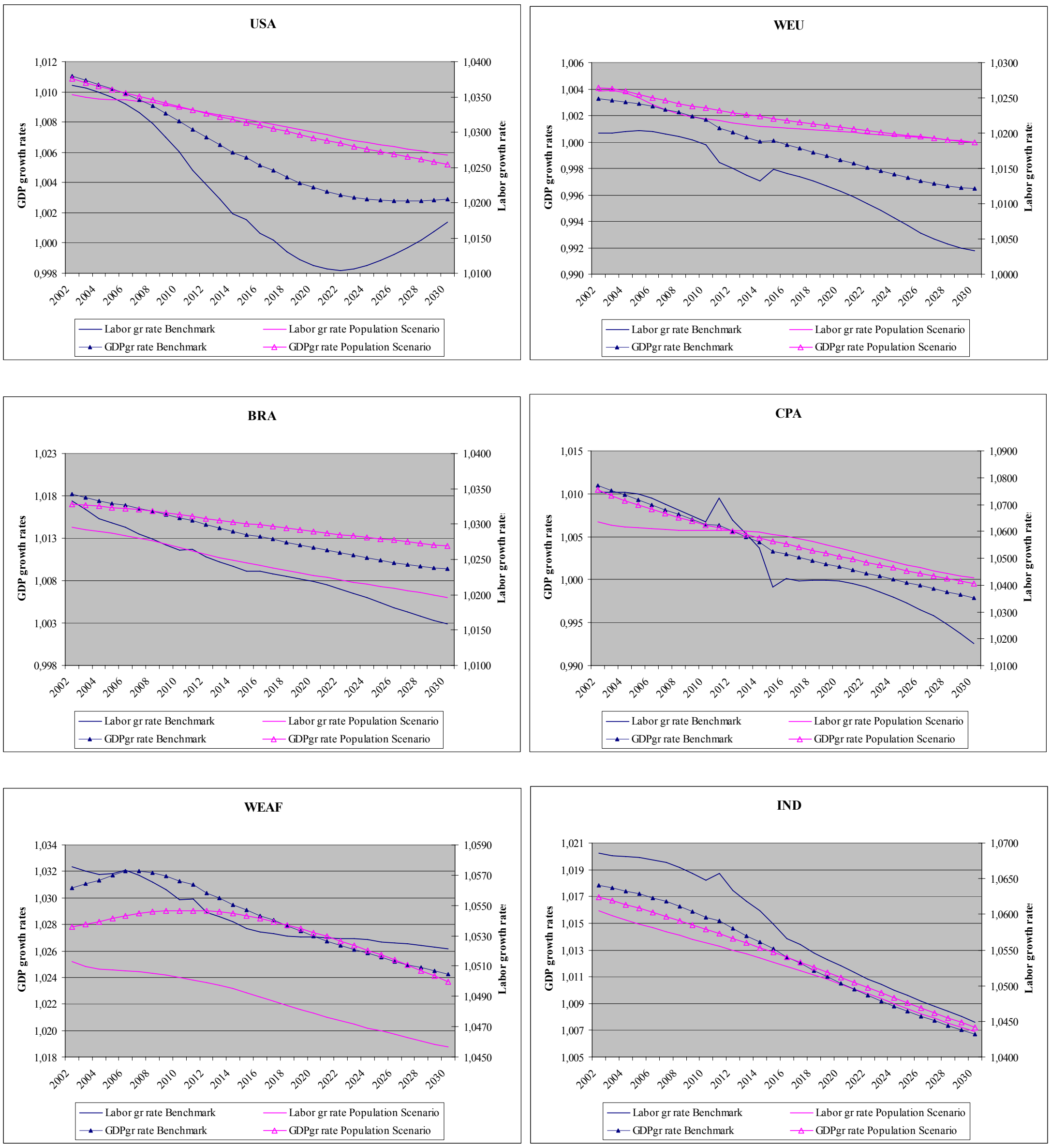

Figure 3 The GDP growth rates and growth rates of labor in Benchmark and Population Scenario for a selection of regions

Such differences are observable on all levels of economic activities. For India and Sub-Saharan Africa the sectoral productions are generally under determined, especially for Africa the difference is rather large, amount to 11-12%. The opposite situation is noticeable in the USA and Western Europe; there it is 10-12% overestimation of the production levels for e.g. Agricultural and Manufactures Sectors (see Table 4).

Table 4 Changes in production in Agricultural and Manufactures Sectors for a selection of regions

Agricultural production	**Benchmark** *2001*	**Benchmark** *2030*	**Population Scenario** *2030*
USA	611,925	1305,838	1432,712
BRA	70,92539	154,1436	157,3826
WEAF	63,67184	312,0044	275,9965
WEU	627,1685	1038,671	1141,556
IND	149,1018	509,5879	492,3465
CPA	364,4341	1519,446	1570,638
Manufactures production			
USA	4174,447	7725,832	8681,615
BRA	229,6908	472,7424	475,7511
WEAF	43,952	210,3479	186,1616
WEU	4430,124	6633,234	7274,409
IND	246,646	1338,826	1276,32
CPA	1896,698	9835,861	10109,35

Table 5 Changes in trade pattern in Agricultural Sector in Benchmark and Population Scenario for a selection of regions

	Export Benchmark	**Import Benchmark**	**Export Benchmark**	**Import Benchmark**	**Export Population Scenario**	**Import Population Scenario**
	2001	*2001*	*2030*	*2030*	*2030*	*2030*
USA	46,1	44,8	112,7	77,9	122,9	83,2
BRA	13,0	3,6	30,6	6,4	31,5	6,3
WEAF	8,4	7,7	40,8	27,3	35,2	27,9
WEU	129,7	160,2	228,6	234,8	251,9	251,4
IND	7,4	6,8	17,6	55,8	17,3	52,1
CPA	14,7	27,5	48,5	166,9	50,7	170,3

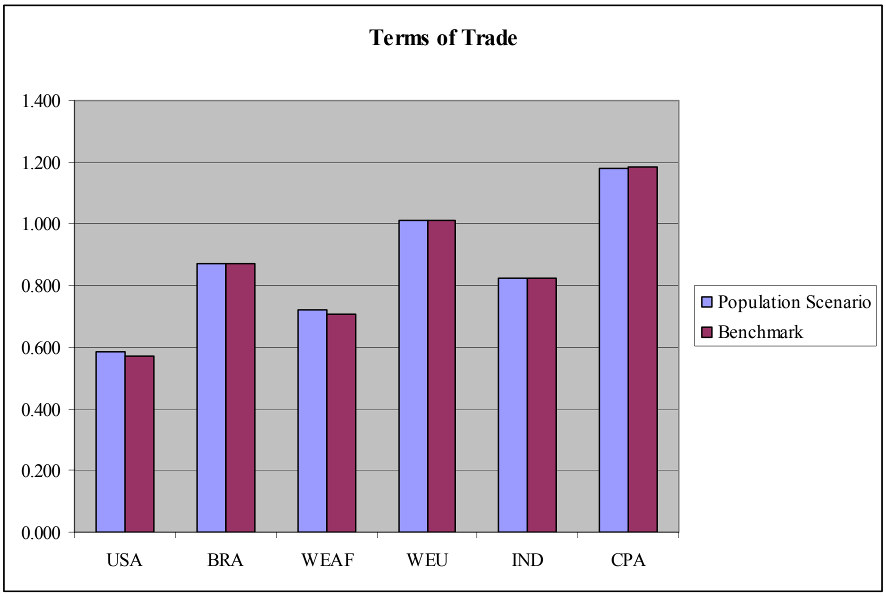

Figure 4 Terms of trade in Benchmark and Population Scenario for a selection of regions (2030)

With an increasing agricultural production level also the exports level increases (see Table 5). This holds for all the regions. However, comparing the Benchmark to the Population Scenario the trade balance for agricultural commodities is different. In the Benchmark Sub-Saharan Africa exports 14% more than in the Population Scenario. USA and Western Europe exports substantially less of agricultural products in the Benchmark compared to Population scenario. The trade balance in general is also slightly different for these two specifications (Figure 4). USA and Sub Saharan Africa's terms of trade is lower in the Benchmark compared to the Population Scenario.

The specification of the labor growth rates affects the projected size of natural resources use. Generally, the amount of fossil fuels use increase over the years in both scenarios but in the Benchmark Scenario the overall use of natural resources is smaller than in the Population Scenario. The comparison of the demand for oil for these two specifications and for selection of countries you find in Table 6.

Table 6 Demand for oil for a selection of regions

Demand for Oil	**Benchmark**	**Benchmark**	**Population Scenario**
	2001	*2030*	*2030*
USA	925	1056	1120
BRA	100	127	126
WEAF	33	80	72
WEU	808	759	793
IND	118	300	279
CPA	384	1129	1131

5.2 Benchmark vs demographic scenarios

In the Figure 5 we see how different demographic projections and policy stimulating labor supply result in different GDP development paths. In all presented regions the increased participation rate increased the most the GDP growth. This is a direct measure that can be stimulated in order to prevent the ageing of the labor force. In Western Europe it has the largest impact. The constant fertility scenario, as given by the UN, has rather small effect on the economy. One has to keep in mind that the fixed fertility rate has its impact with a time lag. Concerning the analyzed period only in the Sub Saharan Africa it plays a role. The increased pension age, as expected plays a role in the developed countries mainly. Both in the US and Western Europe such policy instrument bring a small change in the national economies. One has to keep in mind that in practice only a very limited amount of workers are willing to continue working until they are seventies.

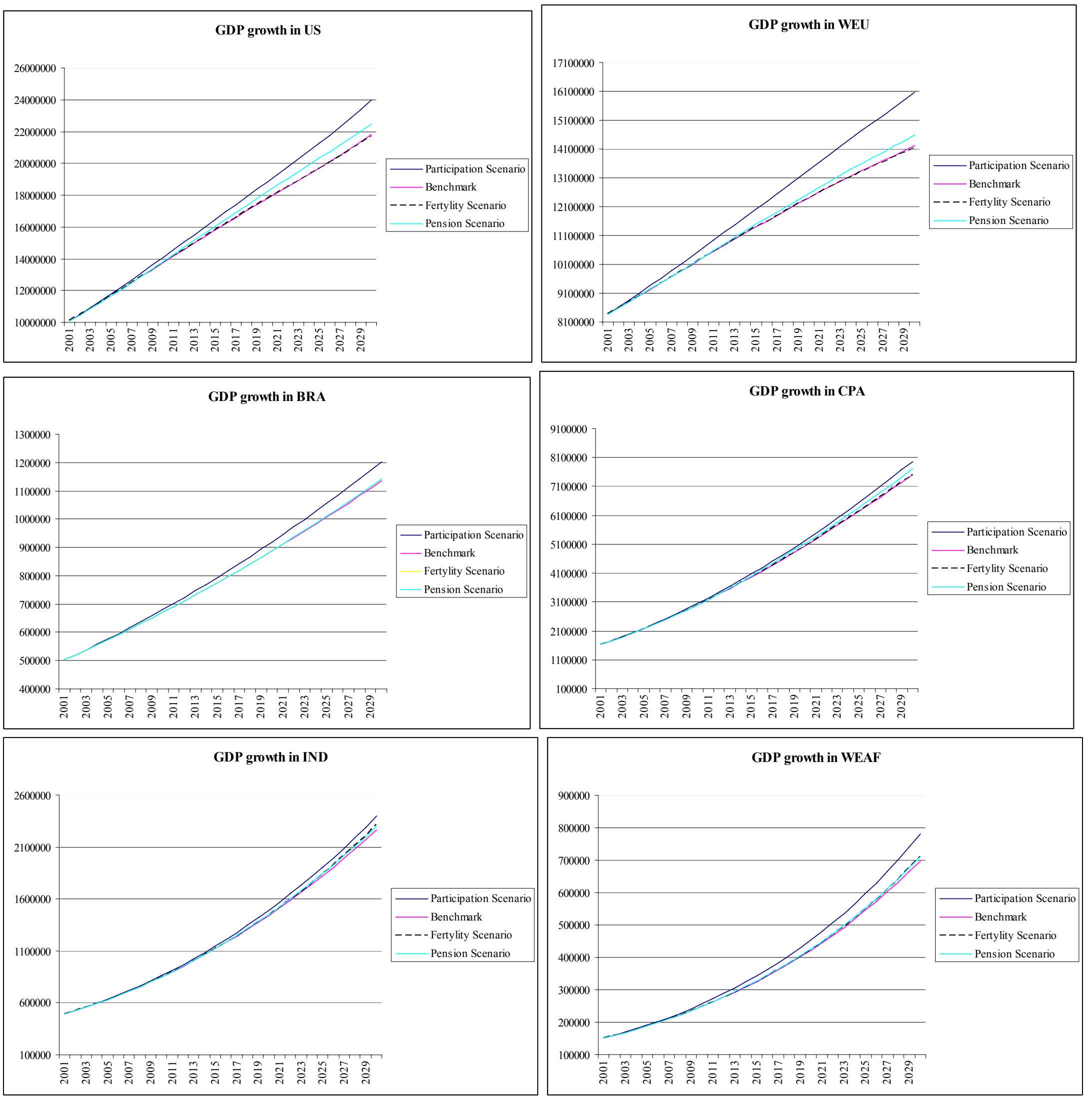

Figure 5 GDP growth in selection of countries under the Benchmark and Participation, Fertility and Pension Scenarios

6 Conclusions

In this paper we present two different models; the demographic model PHOENIX and the computable general equilibrium (CGE) model DART. To combine the strengths of these models we linked them to create a system where the labor supply is calculated on the basis of several indicators i.e. income and income depends on the labor force. PHOENIX uses GDP projections on a regional level to describe the demographic development for the coming decades. The demographic output of PHOENIX is used in DART to calculate regional labor supply functions of DART, which have a major influence on the size of the economies. The linked model system not only implies a better, more realistic representation of the labor force in the CGE model DART, but the advantage of such a model system is also that it can be used to analyze the economic implications of different demographic scenarios - such as faster converging fertility rates or changing participation structures - and of policies - such as an increased pension age.

The simulation of different demographic scenarios that are shown in this paper only give a first impression of the potential of the linked modeling system. Yet, it is possible to draw some first conclusions:

Linking the CGE model DART to the demographic model PHOENIX provides more consistent and plausible future projections, since feedbacks are taken into account. Accounting for the most important demographic developments and projections, such as participation and fertility instead of simply assuming that the labor force grows in line with population is shown to make a difference. Especially for the developed countries the labor supply and also the GDP levels resulting from the coupled model system are substantially different from the original DART results affecting also inter alia sectoral production and export structures. However, due to the inertia of the demographic changes, the scenarios have their major impact beyond the time horizon of 2030, although the effects are becoming visible before. Especially, the effects of a constant fertility scenario on the labor force can only be observed after 15 year, when the first changes in number of new-borns will enter the working-aged population.

Increasing participation rates and rising the pension age, an issue higly discussed in European countries, will have an substantial effect on the economic growth. This is under the assumption that participation rates among the population aged 65-70 years is the same as on average.

Altogether, these first findings motivate to further improve the linked model system by e.g. also linking human capital formation in DART or the saving rates to demographic factors provided by PHOENIX and to use the model system to analyze in more detail the implications of different demographic scenarios.

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