A MACROECONOMIC BASELINE WITH STRUCTURAL CHANGE

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Introduction

Recent projections from the United Nations show world population reaching 9 billion by 2050. When this is coupled with the strong economic growth that has recently characterised many developing countries (particularly China and India), it is easy to see that global economic development will be proceeding at a rapid rate over the coming years. Illustrative of the potential for growth is Africa, which averaged only 1.9 percent growth per annum from 1986 to 1995. If the expected growth rate of 4.5 percent for 2004 is realised, its performance will have more than doubled to 3.9 percent between 1995 and 2004 (it has been even faster during the latest 4 years).2 Such growth rates, and the increasing volumes of trade that they are associated with, lead to stronger interdependencies among countries (both OECD and non-OECD). This strong economic growth has recently been associated with increased prices for oil and most natural-resource commodities – indicative of elevated demand for goods whose real prices had actually been falling throughout much of the twentieth century.

World growth, however, is of interest not only because of the absolute scale of economic activity that may be achieved during the coming decades. It is also of interest for the structural changes that economies may undergo during that process. During no period of time, for example, is it possible to find evidence that growth across economic sectors was evenly distributed so that aggregate growth was identical to the growth of individual sectors.

This document describes core elements of a baseline scenario that attempts to capture both the aggregate growth rates that historical data justify, as well as the structural change that is seen in that data. A key feature that implements structural change in the baseline is that there are differences in sectoral productivity growth that lead to changes sector size.

The information presented here is intended to serve as a base set of drivers that can, for most applications, be considered model-independent – the process of enriching these drivers with a more complete picture of how the economy (and the environment) will evolve is more model dependent. We also show some initial results and economic implications of the baseline within a GAMS-based CGE model – the (OECD/World Bank) JOBS/LINKAGE model. This is a recursive dynamic CGE model built from neoclassical economic theory. It has rigorous micro-foundations and explicitly determines simultaneous equilibrium in a broad ranges of markets (goods, factors, etc.) both domestics and international. It is calibrated on data for the 2001 base year both in levels and in growth rates, on the basis of the GTAP 6 database.

The paper is structured in the following way: the first section contains a brief presentation of the model and discussion of some underlying modelling issues, followed by a description of the dynamic

2. See IMF (2004), global growth during 2004 was anticipated to be 5.0 percent.

calibration of the model (exogenous driver), and lastly presentation of some initial results that highlight some novel findings.

The JOBS/LINKAGES Model

This work in based on simulations of the JOBS model. JOBS is similar to the LINKAGE version 6.0 model (van der Mensbrugghe, 2005). It was developed previously at the OECD for the Linkages II project and has continued to be used and developed further at the World Bank. The LINKAGE model itself was in turn derived from the GREEN model which was used in a series of analyses of policies to combat climate change in the early 1990's.

LINKAGE is a recursive dynamic neo-classical general equilibrium model that has been constructed mainly to assess the economic impacts of globalization on individual regions of the world. Through a careful examination of these economic impacts, some inferences – both within and outside the model -- can be made regarding environmental impacts as well. This has been the main use of JOBS at OECD. For environmental issues, fewer of the refinements made in LINKAGE version 6 are needed. Moreover, because an important use of JOBS' is in applications where regional detail is desired, a trade-off needs to be made between some of the features in LINKAGE, and greater regional coverage.

Model Specifications

Among the characteristics JOBS retains are the following: three production archetypes, for "Crops" sectors, "Livestock" sectors and Other Goods and Services sectors; technological relations modelled using a nested sequence of CES functions; four kinds of genuine resource factor: land, labour, capital, and a sector-specific natural resource; energy is an input that is combined with capital; trade is modelled using nested Armington and production transformation structures; two vintages of capital; and a full range of market policy instruments (tax rates).

All production is assumed to operate under cost minimization with a perfect market assumption and return to scale technology. The production technology is specified as a set of nested CES production functions in a tree-looking like way. At the upper node of this tree the output for each sector is of a combination of aggregate intermediate demand and value added.

Total output is the sum of two different production streams resulting from the distinction between production with an "old" capital vintage, and production with a "new" capital vintage. The substitution possibilities among factors are assumed to be higher with new capital than with old capital. In other word technologies have putty/semi-putty specifications. This will imply longer adjustment of quantities to prices changes. Capital accumulation is modelled as in traditional Solow/Swan growth models.

The valued-added bundle is a CES combination of labour and a broad concept of capital. In the "crop" kind of production, the broad capital is a CES combination of fertilizer and a bundle of capital-land-energy. This aims at reflecting the possibility of substitution between extensive and intensive cropping. In the "livestock" sectors, substitution possibilities are between bundles of land and feed on the one hand, and of capital-energy-labour bundle on the other hand. This reflects a choice between intensive and extensive livestock production. Production in other sectors is characterised by substitution between labour and a bundle of capital-energy (and possibly specific factor for sectors of primary resources).

Household consumption demand is the result of static maximization behaviour in the fashion of an "Extended Linear Expenditure System". A representative consumer in each region, taking prices as given, optimally allocates disposal income among the full set of consumption commodities and savings. Saving is considered as a standard good and therefore does not rely on a forward-looking behaviour by the consumer.

The government in each region collects various kinds of taxes in order to finance a given sequence of non-productive government expenditures. For simplicity and without loss of generality it is assumed in the baseline that these expenditures grow at the same rate as the real GDP of the previous period. Government budget is balanced through the adjustment of the income tax on consumer income.

International trade is based on a set of regional bilateral flows according to the GTAP database. The model adopts Armington assumptions that domestic and imported products are not perfectly substitutable. Moreover, total imports are also imperfectly substitutable between regions of origin. Bilateral exports are modelled in a parallel manner (except that CET functions and not CES are used for imports). Allocation of trade between partners then responds to relative prices at the equilibrium.

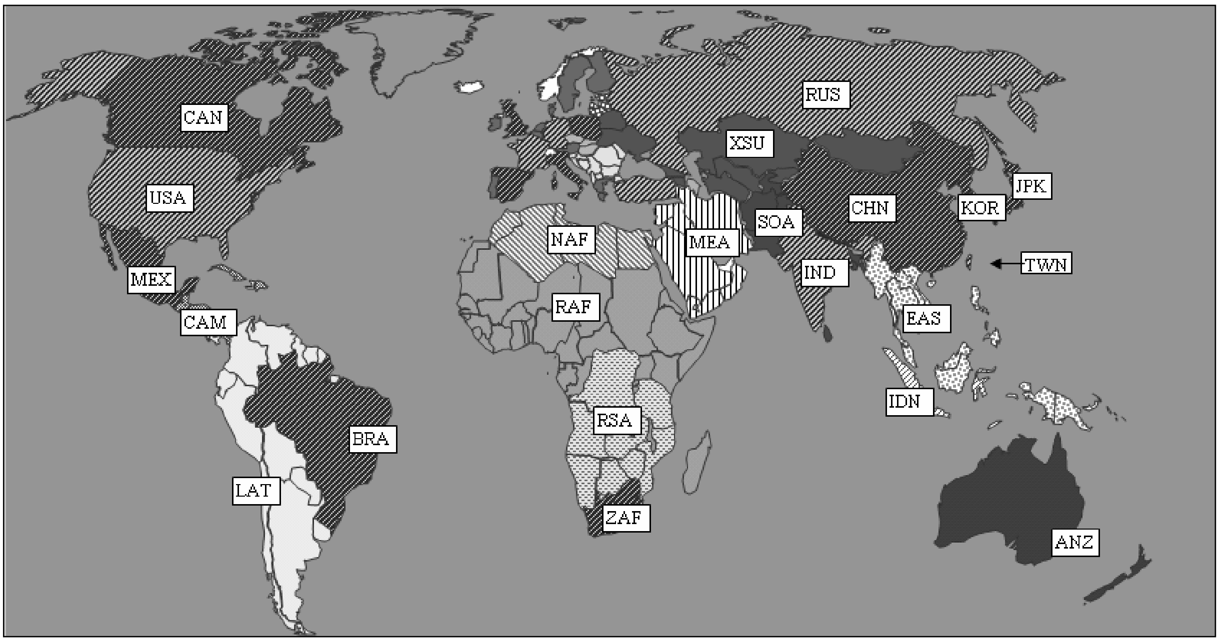
The JOBS model also adopts some original features: characterization of a full set of region-specific CO2 emissions coefficients, for different kinds of energy demand, both imported and domestic; differences in labour productivity growth across the sectors and regions; and the possibility of non-market policy instruments (e.g. regulatory requirements) associated with environmental policy. A number of addition developments are also being implemented.

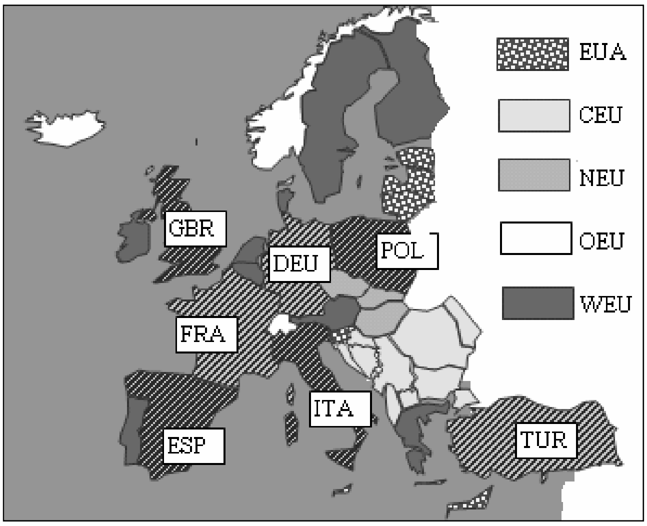
Database, regions and sectors

Given the global coverage of OECD policy issues, maximum regional and sectoral disaggregation is an explicit target. The GTAP database is a useful starting point for empirical work – it provides a ready-made disaggregation of some 87 global regions with national data that are comparable. The methodology for developing a baseline that is described below is thus applied to the full GTAP Version 6 regional disaggregation. For computing reasons this regional disaggregation cannot be maintained in the JOBS model[3], therefore, the 87 regions included in GTAP were aggregated to 34 model regions, shown in Figure 1.

3 . As most of CGE models associated with GTAP database the JOBS model is implemented in GAMS software. GAMS is a modelling system for mathematical programming problems that consists of a language compiler and a set of different solvers. As GAMS functions well only when all variables and derivatives are scaled close to unity, in practice in the interval [0.001 , 1000]. For this reason all sector and region des-aggregation are not really feasible. For example choosing a largely aggregated "service sector" and a very detailed sector like "raw milk" together with regions of very different size like "North America" and "Luxemburg" will imply inextricable numerical problems (as long as for instance the range between North America "raw milk" import from Luxemburg and North America total production of domestic service will be out of the range of [0.001 , 1000]).

Figure 1: The 34 Regions used in the Jobs Model – World and Europe Details





For the results reported below, within the OECD regions, a number of databases exist which provide high quality data (for example, the OECD STAN database, Groningen Growth and Development Centre)[4]. Those data give a reasonable degree of confidence that the empirical foundation on which the baseline rests is informative and relevant to policy-making. Outside of the OECD, however, the coverage is less complete. Other international organisations provide data for non-OECD regions that are comparable across countries, and in some cases of very high quality, but consistency in quality and coverage can not be assured. Data for non-OECD are thus more aggregated in regional coverage.

4. OECD Structural Analysis Database, Industry Vol. 2005 release 02; Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Since Version 6 of the GTAP database is built around data for 2001, some effort is needed to ensure that developments since the base year are incorporated into the projections. For all regions, therefore, historical data and medium-term projections through 2005 (or 2006) from OECD, IMF and Africa Development Bank have been incorporated into the baseline.

For sector dis-aggregation, the level of detail in the GTAP database (57 sectors) is difficult to maintain for both modelling purposes and consistency[5]. The sectors were, therefore, aggregated to 26 sectors (see Table 11 in the Annex for details). Since debate remains concerning comparability of sectoral productivity growth (Sorenson and Schjerning, 2003), the results reported below will focus on 7 sectors so as to minimise potential problems (including a dearth of data in non-OECD). The results that are obtained from historical data on the 7 aggregated sectors will then be applied uniformly to the component sectors in the baseline.

Exogenous drivers for the Baseline

The baseline is being developed for potential future use in JOBS model simulations. This is an ongoing exercise so revisions to this baseline are likely. However these changes will not fundamentally alter the central messages developed in this paper.

Consistent with recent work in the OECD Economics Department, the underlying presumption of the baseline is that it is the “quantity and quality” of labour, and labour-augmenting technical change, that are the central determinants of economic growth. To quantify these concepts, we begin by presenting population projections which are then refined into labour supply, through the projection of labour-force participation rates. The productivity of labour is then projected by using the results of past trends to conjecture future changes in productivity. With both of these projections, an underlying assumption is that the amount of capital available to each worker (i.e. the capital/labour ratio) is increasing over time, and determines economic output (GDP) endogenously.

This latter assumption can be justified on the apparent empirical regularity that the returns to most increases in productivity accrue to labour, and not to capital. This is an important difference in comparison to the previous JOBS application for the OECD Environmental Outlook to 2020. In the previous study GDP growth rates trends were assumed to be exogenous in the baseline and the regional capital to labour ratios (both measured in efficiency units) were supposed to be constant over the baseline period – so that capital efficiency also evolved with time as did labour efficiency. In other words, a “balanced growth” assumption was made whereas in the present work the model accounts for change in factor compositions in the baseline.

Economic growth

The level of output in an economy has always been understood to depend primarily upon the skills and resourcefulness of its population. Most OECD countries, for example, have similar levels of material well-being (per hour worked). In developing baselines of future economic and environmental outcomes, this somewhat obvious observation has importance for the manner in which economic well-being will evolve over time. Scientific and other advances are the main drivers of improvements in skills, and thus are

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5 In a long run perspective, the detail in the sector des-aggregation is necessarily limited by the consistency of specialization patterns because as long as some products and some technology will may change a lot in the future some statistical classifications may loose sense. Think for an example about “telecommunication” largely furnished by wire in the past and largely by satellites now.

also the main drivers of changes in economic output per hour worked. Combining such productivity increases with changes in the number of hours worked is a determining factor for projecting future economic output.

Labour supply

Labour supply is primarily determined by two factors, one of which is almost (but not entirely) exogenous to economic policy. The other is more directly influenced by both economic policy and some specific economic trends. Greater responsiveness to policy measures is seen, for example, in the decision of members of the working-age population (particularly women) to participate in the labour force (e.g. Dex, *et al*., 1995).

To gain an understanding of the potential evolution of labour supply, a first step is to understand how populations might evolve over the period of interest. The United Nations regularly publishes data that incorporate factors that influence that evolution. For the purposes of this paper, the "medium variant" has been used. In this variant, the global population stabilises around 9 billion, but is still al most 50 percent higher than the current population. As Table 1 summarises, almost all of the increase is in the non-OECD regions, so most of the interesting socio-economic and environmental changes/pressures will also occur there.

Table 1: Regional populations

	Population (millions)	
	2005	***2050***
Africa	906	1937
Asia	3905	5217
Europe	728	653
Latin America and the Caribbean	561	783
Northern America	331	438
Oceania	33	48

Source: United Nations (2005).

This version of the UN population projection incorporates some, but not all, recent trends in population growth. For example, while explicit assumptions regarding migration have been incorporated[6], the increases in life-span longevity that have been recently pointed out (Oeppen and Vaupel, 2002) are only partially represented.

The UN also reports the proportion of the population that is adult and thus more likely to be economically active (i.e. those who are 15 years of age or older). Given demographic changes that are expected to occur, this represents an adjustment to current proportions (of adult populations) that should be incorporated into the baseline. To show the magnitude of the changing demographics, Table 2 below contrasts population growth of 0-14 year-olds to regionally-aggregated totals (more complete statistics are given in document ENV/EPOC/GSP(2005)2)..

6 . In the 2004 revisions, the UN projections assume that international migration occurs on the basis of past trends, supplemented by an assessment of the policy stance of countries with respect to international migration flows. See Table IV-1 of United Nations (2005) for more detail.

Table 2 : Average annual rate of change of population

Major area	Ages 0-14	Total population
World	0.01	0.75
More developed regions	-0.14	0.05
Less developed regions	0.03	0.89
Least developed countries	1.02	1.84
Other less developed countries	-0.29	0.68
Africa	0.87	1.69
Asia	-0.29	0.64
Europe	-0.36	-0.24
Latin America and the Caribbean	-0.38	0.74
Northern America	0.23	0.62
Oceania	0.09	0.81

Source : United Nations (2005).

Participation rates

The next element in determining labour supply is the participation of the adult population. The participation rate is generally defined as the percentage of the adult population that considers itself part of the labour force (i.e. those who are either working, or looking for work).

Participation rates are influenced by a number of economic factors that impact on the decisions of individuals to either join or stay in the work force. At the margin, for younger workers it is mainly the decision of female workers in OECD countries to stay or leave the work force following childbirth that is the key factor explaining changes in the participation rate. For older employees, it is the incentives that impact on the choice between remaining in the work force and retiring that mainly affect the participation rate.

OECD (2003b) looked at the trends in these factors for OECD countries and found that, for the most part, government policies were complementing demographic changes in exerting downward pressures on participation rates. (In Table 3 the participation rate expected to be achieved in 2025 is projected forward, unchanged, to 2030.).

For non-OECD countries, a slow convergence to the 2001 OECD average (60%) is assumed here to be largely attained by 2030. For many of those countries, this will imply a lowering of their current rate (fewer people work as incomes increase – similar to post-war Europe), while for others, the target leads to an increase in the number of workers (more opportunities – similar to post-war North America).

Together, the population and participation rate estimates give some basis for estimating labour supply. The next step in determining economic growth is to examine the likely productivity of that labour force in providing goods and services.

Table 3 : Participation rate changes*

	Change 2000-25	Participation rate % in 2030		Change 2000-25	Participation rate % in 2030
Australia	-5.6	57	Austria	-8.9	49
Belgium	-2.2	50	Canada	-6	60
Czech Republic	-7.5	53	Denmark	-7	59
Finland	-8.2	58	France	-6.7	48
Germany	-3.5	62	Greece	4.1	54
Hungary	-7.8	45	Ireland	5.1	64
Italy	-1	47	Japan	-6.8	56
Korea	-10	51	Luxemburg	-2.7	51
Mexico	4.2	64	Netherlands	-4.4	
New Zealand	-6.9	58	Norway	-2.5	71
Poland	-7.8	49	Portugal	0	61
Slovakia	-7.8	52	Spain	-0.8	53
Sweden	-9.1	62	Switzerland	-3.1	64
Turkey	-10.9	39	United Kingdom	-4.5	59
United States	-5.6	61			

Source: OECD (2003b).

Note *: Participation rate refers to labour force as a percentage of population aged 15+.

Labour productivity

Scarpetta *et al*. (2000) present data showing that the capital/output ratio tends to be relatively stable in many OECD countries, while at the same time the capital/labour ratio is increasing. These trends are consistent with the notion that productivity growth is primarily labour-augmenting, and that much of the return to increasing output per hour worked goes to labour (in countries with well-functioning product and labour markets).

In developing a baseline that is consistent with these observations, it is useful to have some view of how that trend is likely to evolve over the long-term. For OECD countries, a considerable amount of data exist to inform that view. Table 5 reports on historical experience and projections. These results (based on a “growth accounting” framework) are used in developing the baseline. Recent experience has differed from those trends and needs to be reflected in a transition period.

Productivity and its rate of growth, however, are not uniform across countries. For the purpose of building a baseline, some notion of how they might evolve needs to be developed. A significant literature has been created concerning economic convergence. It can be characterised by two main threads which are relevant for the development of a baseline. The first is that there is relatively little evidence for convergence to occur in levels of income per capita between countries. This finding, however, does not imply a strong divergence in incomes – which is the where the second thread becomes evident. Countries differ in ways that are likely to impact on their long-term income levels, but not their growth rates, i.e. there is a convergence in growth rates. This *conditional* convergence has been empirically validated and is a relatively robust finding (see Sala-i-Martin, 2002, or de la Fuente, 2002, for overviews of the theory and evidence for convergence).

The central underpinning of the baseline developed here follows from these observations regarding labour productivity and convergence. It begins by looking at the potential for future productivity growth, and for future changes in the supply of labour, to determine economic growth. Historically-observed *labour-augmenting technical change* will then automatically link increases in labour productivity to output increases; to reflect this, a functional form for economic output is specified in mathematical terms, and long-term stability is imposed.

For OECD countries, this primary force for long-term growth has been reported in earlier work as a 1.76 percent per annum improvement in labour productivity per hour (Dang, Anatolin and Oxley, 2001). This has been incorporated into the baseline described here by having countries move toward that trend (from their historical averages) at a rate that is empirically consistent with the findings of Sala-i-Martin (1996): the rate of adjustment closes the *growth rate gap* by 2 percent per year (implying that half the gap is closed in about 35 years). That adjustment rate has been found to be fairly robust across a number of regions – and even within countries – where significant growth disparities exist on a large geographical scale.

For the results reported here, the historical trend of productivity growth is based on experiences between 1980 and 2001 (actual estimates for OECD countries are taken from OECD Economics Department Studies, eg. Ahmad, *et al.*, 2003, and Dang, Anatolin and Oxley, 2001). Moving from that historical trend to the long-term trend of 1.76 required a number of steps (that also took account of the recent, post-2001, experience):

1. Adjustment from the historical trend begins gradually after 2001[7]. There is a 2 percent per year closing of the growth rate gap between the historical trend (1980 to 2001) and the long-term trend (1.76 percent productivity growth).

2. Super-imposed on that path are: (a) the actual experiences of economies after 2001; and (b) short-term projections from the OECD, IMF and African Development Bank[8].

3. This post-2001 information must be reconciled with the process outlined in (1). The assumption that is made here is that actual experience after 2001 differs from the process of (1) as a result of economic, and other, "shocks". The period after 2001, therefore, is considered to reflect processes that are more medium-term.

4. Economies return to the path outlined in (1) by 2011, so there is an adjustment process that occurs from 2005/2006 to 2011.

The period chosen to underpin the long-term productivity trends can be crucial in determining the relevance of the baseline. As a general principle, statisticians believe that the more data that are available, the more reliable is likely to be the resulting inference: it captures a greater range of changes to determinant variables. While some data sources are available for observations prior to 1980, aggregate and sectoral productivity numbers are not as readily available for many OECD (and especially non-OECD) countries. In attempting to balance the desire for long data series against the paucity of the data in many regions, much of the empirical work reported below is based on the 1980-2001 period.

7. Countries/regions with negative productivity growth between 1980 and 2001 are adjusted to zero growth for the beginning of the trend rate.

8. This super-imposition is necessary because the database (Global Trade Analysis Program of Purdue Universtiy, more detail below) used for compiling internationally comparable data has "real" data only for 2001 (this is the year on which models using that database are calibrated). Projections for modelling purposes, therefore, begin after 2001. However, since data from alternative sources are available for the period after 2001, they should be used.

Non-OECD countries also have historical trends that were obtained (predominantly from empirical results of the International Labour Organisation and World Bank) for the 1980-2001 period. Given the comments above regarding conditional convergence, those trends also move toward the OECD average productivity growth rate of 1.76. As with OECD countries, super-imposed on that trend rate in the period after 2001 is the actual experience of economies, which again moves back to the underlying trend by 2011. This procedure was, therefore, identical to the procedure for OECD countries outlined in (1) to (4) above, except for one important change. For countries whose historical productivity growth rate turned out to be negative, a zero percent rate of growth for the historical trend was imposed.

As discussed earlier, long-term labour productivity growth tended toward a mean of 1.76 for OECD countries. All countries moved toward that level from their long-term historical average – the trend rate. Data for both the period after 2001 and various medium-term projections were super-imposed on the trend rate, but adjustment back to the trend rate was assumed by 2011. In other words, current productivity growth was used as a starting point for the return to the long-term trend – where the long-term trend was itself moving from the historical average to 1.76. The adjustment of the long-term trend toward 1.76 was made to be consistent with the work of Sala-i-Martin (1996) by closing the gap at two percent per year. Table 5 provides a sampling of some annual results from those calculations.

Table 4 : OECD Labour productivity growth (output per hour)

	1980-2001	**Average to 2050†**		**1980-2001**	**Average to 2050†**
Australia	1.8	1.76	Austria	2.0	1.88
Belgium	2.2	1.82	Canada	1.2	1.58
Czech Republic	1.8	2.47	Denmark	1.7	1.67
Finland	2.7	2.07	France	2.5	1.72
Germany	2.2	1.76	Greece*	1.7	
Hungary	2.3	3.12	Ireland*	4.2	
Italy	2.0	1.82	Japan	2.8	1.67
Korea	5.5	2.73	Mexico*	0.1	
Netherlands	1.6	1.67	New Zealand	0.9	1.72
Norway	2.7	1.10	Poland	4.7	2.00
Portugal	2.1	3.21	Slovak Republic*	4.1	
Spain	2.2	1.95	Sweden	1.6	1.76
Switzerland*	0.7		Turkey*	2.7	
United Kingdom	2.2	1.82	United States	1.4	1.84

Source: Ahmad, *et al.* (2003) and Dang, Anatolin and Oxley (2001), and ILO (2002). Historical data derived from OECD productivity database.
Note: For Eastern European countries, the historical data begin during the 1990s.
* No projections given for these countries.
† The source-data projections to 2050 have been retained for illustrative purposes.

It should be noted that there is some discrepancy in the measurement of labour productivity when it is measured as output per hour worked, versus measurement per worker. The United States, for example, has experienced increases in the numbers of hours that each employee works, and thus the growth in productivity per hour is lower than growth in productivity per worker.

For non-OECD countries, labour productivity growth is more difficult to gauge. Important sources for this kind of information exist in the International Labour Organisation, the World Bank, and the Groningen Growth and Development Centre. Estimates of labour productivity from these sources for the 1980 to 2001 period are shown in Table A3 in the Annex. As is reflected in these estimates, a number of those regions went through troubled economic times. The important question is how to use this data for looking forward. More recent results, for Africa in particular, give a more optimistic view than Table A3 would suggest (e.g. World Bank, 2004; OECD, 2004). The historical instability in that region, however, would be difficult to dismiss in any projection of future outcomes – especially one that was intended to be policy-relevant.

For the work presented here, labour productivity growth in non-OECD countries is conjectured to move from the individual historical averages to the OECD average. Using the same convergence criteria as above, the gap between the OECD average and the individual country average is closed at a rate of two percent per year. For countries where the historical average was negative, the convergence begins from a zero productivity growth level and moved toward the OECD rate.

Table 5 : Sample baseline labour productivity growth*

	2002	2007	2010	2020	2030		2002	2007	2010	2020	2030
Argentina	-11.5	2.4	0.9	1.3	1.7	Lithuania	7.0	6.4	5.1	4.5	4.1
Australia	2.9	2.6	2.0	1.8	1.8	Malaysia	2.9	4.3	3.0	2.8	2.7
Austria	1.0	2.3	1.8	1.9	1.9	Mexico	-0.1	2.6	0.9	1.1	1.3
Belgium	0.8	2.5	2.1	1.9	1.8	Netherlands	0.6	2.2	1.8	1.7	1.7
Brazil	1.0	1.9	0.9	1.1	1.2	Norway	2.9	0.0	1.5	1.2	1.1
Canada	2.7	2.2	1.6	1.6	1.6	Peru	3.9	2.5	0.9	1.3	1.7
Chile	1.6	3.3	2.2	2.1	2.1	Philippines	3.1	2.1	0.8	1.2	1.6
China	7.8	6.2	4.9	4.4	3.9	Poland	1.4	4.2	2.9	2.2	2.0
Colombia	0.5	2.3	1.4	1.5	1.6	Portugal	0.1	2.4	2.4	3.0	3.2
Czech Rep.	1.5	3.4	2.3	2.5	2.5	Romania	5.0	3.6	1.5	1.6	1.6
Denmark	-0.1	2.0	1.8	1.7	1.7	Russia	5.0	5.4	3.3	3.1	2.9
EECCA	0.7	2.6	2.6	2.5	2.4	S. Africa	2.9	1.8	0.7	1.1	1.5
Estonia	7.6	5.6	5.3	4.7	4.2	Singapore	2.2	4.0	3.5	3.2	3.0
Finland	2.1	2.8	2.5	2.2	2.1	Slovakia	4.4	3.7	2.9	2.2	2.0
France	0.9	2.0	2.1	1.8	1.7	Slovenia	1.2	2.3	2.8	2.6	2.5
Germany	0.0	2.2	2.1	1.9	1.8	Spain	1.7	2.4	2.2	2.0	2.0
Greece	3.4	3.0	2.1	2.0	2.0	Sri Lanka	3.6	3.8	2.5	2.4	2.4
Hungary	3.6	3.3	2.7	3.0	3.1	Sweden	1.7	2.7	1.9	1.8	1.8
India	4.0	4.8	3.4	3.1	2.9	Switzerland	0.2	1.7	1.4	1.9	2.0
Indonesia	2.8	3.4	2.2	2.1	2.1	Tanzania	4.5	2.2	0.8	1.2	1.6
Ireland	4.9	3.6	3.1	2.2	2.0	Thailand	4.8	5.0	3.9	3.5	3.2
Italy	0.3	2.0	1.9	1.8	1.8	Turkey	6.9	4.3	2.7	2.1	2.0
Japan	-0.4	2.2	2.3	1.8	1.7	UK	1.5	2.1	2.0	1.8	1.8
Korea	6.7	4.7	4.3	3.0	2.7	USA	1.2	2.6	1.8	1.8	1.8
Latvia	6.7	6.1	5.8	5.1	4.5	Venezuela	-10.0	1.7	0.7	1.1	1.5

* note: for non-OECD, medium-term projections incorporate IMF and African Development Bank results.

Sectoral change

Structural change in the baseline is also represented by allowing differences in productivity improvements across sectors. As with the classic case of agricultural output, rapid productivity growth in a given sector leads to labour movement out of that sector and into other sectors, which then results in an overall expansion in economic output in the latter. The baseline projection uses historical trends (again 1980-2001) to gauge the potential for long-term differences in sectoral labour productivity – so future structural change is again informed by long-term trends. For environmental issues, some of the trends already noted elsewhere – such as declining energy, or material inputs, per unit of output (OECD, 2002) –

will be captured by the shifting importance of sectors within the model. That is, an economy where labour productivity is high in an energy-producing sector may find that the use of a particular raw material for producing energy (e.g. oil) will decline relative to GDP, at the same time that the price of that raw material is declining.

This is also an important change relative to the previous JOBS analysis for the OECD Environmental Outlook to 2020. In these applications the efficiency of labour parameter (and hence the labour productivity growth rate) was uniform across non-agricultural sectors. But assumptions regarding autonomous energy efficiency improvements in the use of energy was made. This leads to energy-savings phenomenon whereas in our model energy-saving will be much more the result of sectoral reallocation of resources associated to the differences in labour productivity between sectors. It has to be kept in mind that assumptions about possible exogenous energy efficiency improvements have very strong implications for endogenous CO2 emissions. The reason for our choice is essentially that differences in sector and region labour productivity growth rates are very well supported by empirical evidence whereas sector and region specific autonomous energy efficiency improvements are much more difficult to justify.

Table 6 illustrates the sectoral productivity that can be derived from the OECD STAN, Groningen Growth and Development Centre database, as well as others.

As that Table illustrates, significant differences exist in the rates of growth of labour productivity across sectors.[9] The slow growth of service sectors has long been noted as a source of structural change (Baumol, 1967, first noted it, now commonly referred to as *Baumol's disease*). Since this is a long-standing trend, future growth can reasonably be expected to continue along these lines – so it is clear that the structure of economies will continue to change.

Within an economic model, these differences in sectoral productivity will lead to shifts in the relative prices of inputs and outputs, implying significant compositional changes in the economy that will occur *endogenously*. Similar changes can be observed to be occurring in non-OECD countries – in addition to the shift out of agriculture that was mentioned above.

Table 6 : Sectoral labour productivity growth 1980-2001, % change

	Agriculture	Forest, Fishing	Energy	Non-durable	Durable	Trade, Transport	Services
US, Canada, Australia, New Zealand	4.2	1.0	2.2	0.6	4.6	3.6	0.6
EU-15, other Western Europe	5.0	3.3	2.0	2.0	7.6	2.4	0.3
E. Europe, Central Asia, Russia*	3.9	7.6	8.1	8.1	9.1	3.9	0.7
Japan	3.0	1.0	2.1	0.0	3.8	2.9	2.0
Korea, fast-growing Asia	4.0	3.0	2.6	2.6	4.4	1.9	1.4
China	4.1	4.2	3.0	4.0	4.0	1.0	1.0
India	3.7	4.2	5.6	5.6	5.6	4.3	1.0
Brazil, Central/South America†	2.7	1.9	2.0	1.2	4.9	0.7	1.5
Rest of World‡	3.9	4.1	4.3	4.3	5.2	2.0	1.2

Source : OECD STAN database, Groningen Growth and Development Centre database, ILO (2002), others[10].

9 McKibbin, Pearce, and Stegman (2004) also use differences in sectoral productivity growth in their projections but, since they have services growing more rapidly than manufacturing, they do not capture Baumol's disease in their results.

10. Brazil: http://www.brazil.ox.ac.uk/workingpapers/Bonelli35.pdf; India: http://lisd.delhi.nic.in/AnnualReport2002-03/lab04.pdf; South Africa: http://www.ggdc.net/pub/gd58.pdf; Russia: http://www.delnet.oecd.org/publications/library/acrobatebook/1004111E.PDF, and OECD Economic surveys Russian Federation (2004).

* Based on data from Eastern Europe and Former Soviet Union.
† Based primarily on data from Brazil and Mexico, but also incorporates limited data from other countries.
‡ Average of non-OECD where data was available.

Full data for all non-OECD countries are not available, given the lack of collection and processing of data in many countries. An obvious question then becomes whether it is better to make assumptions of no structural change, versus making some estimation of how structural change might evolve based on the experience of "similar economies". For most analytical issues, more insight is assumed here to be gained by including trends that are commonly part of the development experience. A "similar economies" approach will therefore be used to provide the basis for trends in their respective regions.

Evolution of trade

Future trade patterns are themselves both indicative of structural change and a source of them. For OECD countries changes in the trade share have slowed considerably. The non-OECD regions are still experiencing substantial structural change.

Achieving these shifts can be accomplished in a number of ways. General equilibrium studies of past tariff reductions do not support the proposition that tariff changes alone explain the shifts (Kehoe, 2003). Other work, however, suggests that tariffs are only a small part of the obstacles to trade that firms face (McCallum, 1995). Reductions in those barriers offer potential explanations for why trade shares increase in regions where the reductions in tariffs themselves are inadequate. Recent work exploring this link shows promise in quantifying that relationship (Hertel and Walkenhorst, 2005).

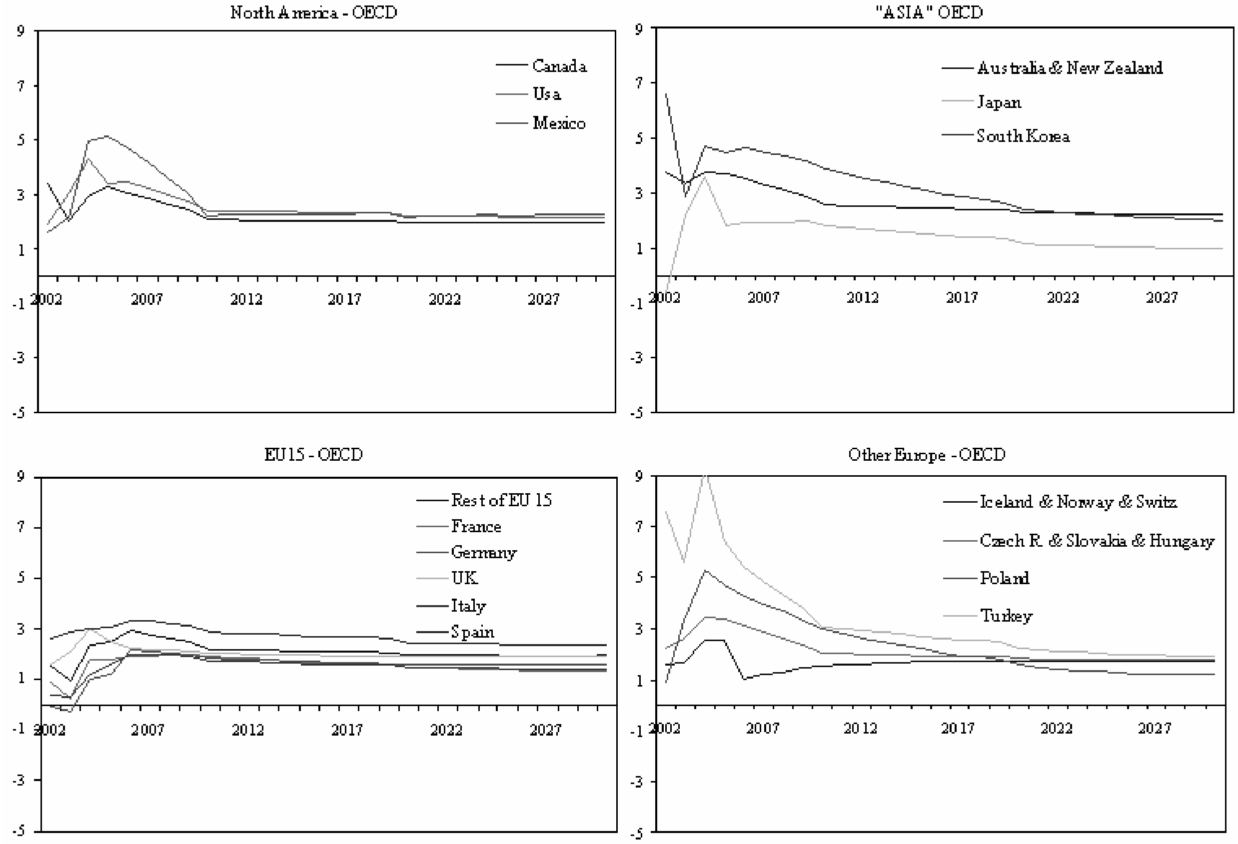
One way of dealing with trend changes in these barriers within the baseline is to have them reflected in "trade and transport margins". These margins reflect *extra* costs related to buying a particular good or service from abroad, compared to buying it from a domestic supplier (longer transport, customs clearance procedures, language barriers, etc.) – but not import tariffs in themselves, as they are reflected in other parameters of the model. Similar techniques have also been employed in an earlier application of the OECD GREEN model, where a uniform decrease of 1% per year in each region was assumed. In the present work, the same uniform margin reduction is imposed. Next step in our work will be to use the trends in trade to provide us a basis for conjecturing the future evolution of barrier reductions.

Simulation of the model with the baseline

In the baseline scenario then, GDP growth rate will evolve in the near future almost as forecasted by OECD (Figure 2) or by the IMF (Figure 3). After 2010 and because of our assumptions on convergence, trends in GDP growth will linearly converge towards long-run trends.

As it is clear from these two figures there is a general slowdown in growth because the active population growth rate diminishes in all regions but Africa after 2005. However because rate of growth of active population remain dispersed among regions so will do the GDP growth rates. Nevertheless convergence in labour productivity growth rates has an impact since the dispersion in the growth rates of the labour force is substantially higher in 2030 than in 2000 (particularly between older OECD countries and less developed countries like Africa or Middle East) , while the dispersion in the GDP growth rates is slightly lower.

Figure 2 : Real GDP growth rates: OECD Countries

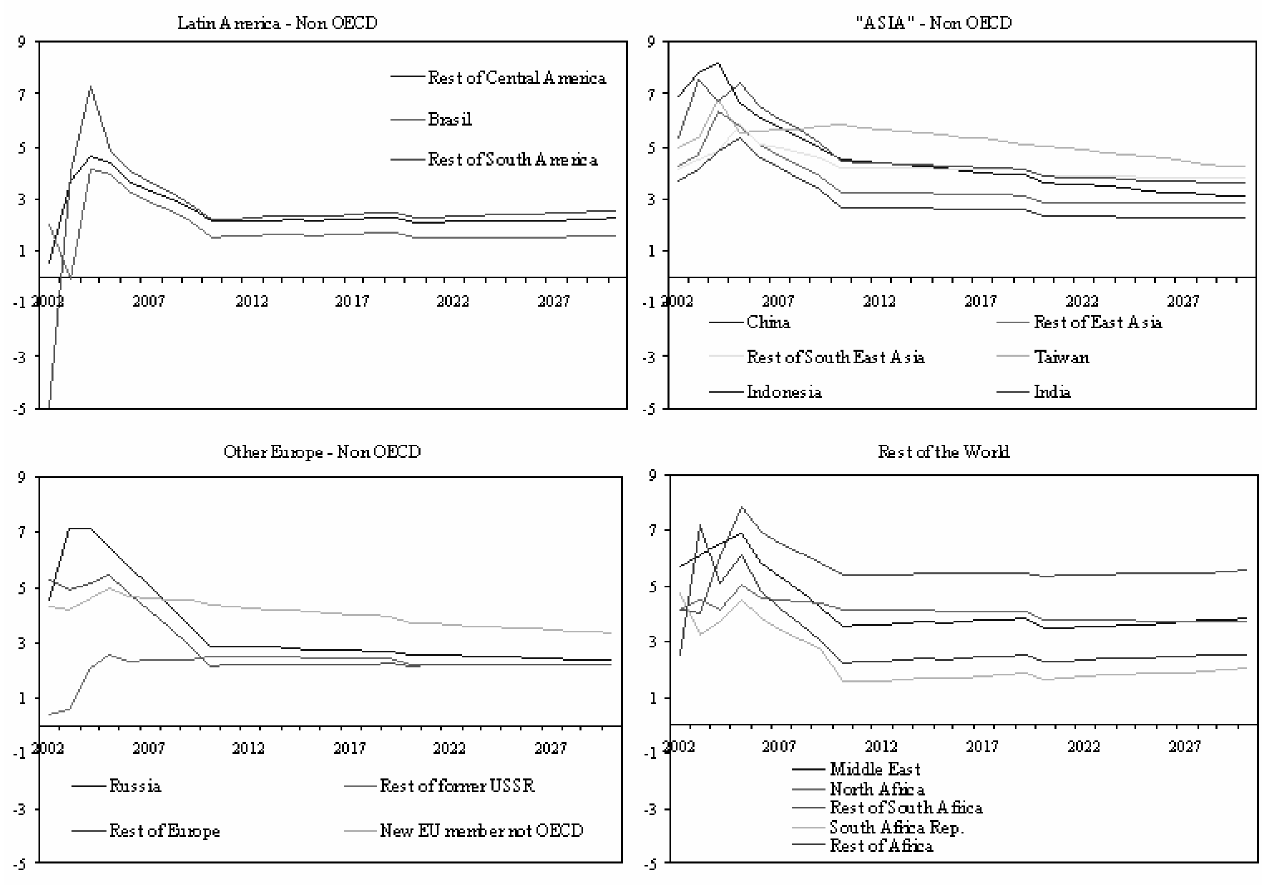


Source : OECD – JOBS Baseline Scenario (May 2005)

The Chinese and Indian regions are the ones where the catching up is the most rapid. There rates of growth in GDP remain high even when population growth begins to level off – even exceeding areas with higher labour force growth like the "Middle East" countries.

North America and western Europe have growth profiles that partly differ from the general pattern. In North America growth decelerates in the latter part of the current decade because demographic forces begin to be felt and productivity growth returns to long-term trends. Implied in the demographics is that the active population stops declining around 2015 and remains stationary thereafter. Europe has a more sombre outlook. Its GDP growth follows the same pattern as North America in decelerating during the latter part of the current decade, but is shifted downward (i.e. slower growth rates) because its active population will decline over the entire period.

Figure 3. Real GDP growth rates: Non OECD countries



Source : OECD - JOBS Central Scenario (may 2005)

Implication of the baseline: The Balassa-Samuelson Effect

Long-term growth engages a process exploiting comparative advantage among individuals within a country that leads to deepening specialisation of skills and factors of production. Long-term growth also leads to specialisation among countries as endowments of natural, physical and human capital are exploited for comparative advantage while natural and political barriers to trade are lowered.

Within a country, growth in areas of comparative advantage is expected to be beneficial for everyone – not just for those working in the expanding sectors. The reasons for this can be explained along the lines of the following. Exploiting comparative advantage will lead to rapid productivity growth in some sectors but not in others. This will lead to an increase in wages in the expanding sectors as the demand for labour increases but the necessary skills take time to develop. Since labour is fairly mobile within a country over a long enough period of time, wages in the growing sectors will come under pressure from people acquiring the necessary skills and competing for those jobs. On the other hand, the shrinking labour supply in the slow-growing sectors will cause wage pressures to increase there as people migrate to the fast-growing sectors. In the end, wages of people with similar skills should be made equal across sectors, but the average wage will rise with greater specialisation and more numerous jobs in the high-productivity sector.

This explanation of the relationship between economic growth and increases in wages within a country also applies in an international context. It implies that if two countries exploit their respective comparative advantages, then the process outlined above will occur in both countries, and wages will increase in both countries. However, if one country is growing more rapidly than the other (it has a more favourable comparative advantage), then it may see faster wage growth.

An important dynamic in moving toward equilibrium is introduced at the international level when labour is immobile and trade barriers, natural and otherwise, impede the complete movement of goods and services. The productivity growth gained from exploiting comparative advantage will be combined with distinctions between tradable and non-tradable goods and services; that is, high productivity growth in sectors that produce tradable goods will also drive wage increases in the slow-growth non-tradable sectors. This phenomenon was noted some time ago by Balassa (1964) and Samuelson (1964) and has come to be known as the Balassa-Samuelson effect.[11]

Competitive markets will tend to make the price of traded goods roughly equal across countries even in the short-run – after accounting for transportation costs and applicable taxes. On the other hand, non-traded goods and services will reflect local incomes and wealth and are more long-term in adjusting as noted above. A haircut, for example, will generally be much cheaper in a developing country than in a European capital. Lack of tradability and labour mobility will maintain those differences until incomes in the developing country approach those of developed countries. The process that increases the price of haircuts in developing countries is the one that was described above as driving economy-wide wage increases.

International comparisons

This discussion of wages and productivity growth touches on issues related to international comparisons of incomes and wealth. Market exchange rates balance the demand and supply of currencies that result from: international trade in goods and services, international investments in short- and long-term projects, and speculation in anticipation of exchange rate movements caused by the previous two. In changing economies, the exchange rate will therefore reflect factors that often have little to do with the income of individuals.

When two economies are undergoing growth then, even in the case where they have achieved relatively similar levels of industrial development, their exchange rate can make it difficult to compare consumer income levels in a meaningful way. This is particularly the case when growth is affecting trade patterns and investment opportunities. More difficult still is the case where two countries are in different stages of development. The observations made above, concerning productivity in different sectors, will imply that any measurement of income will reflect a snapshot of changing economies where the exchange rate itself will be in transition. In that case, the exchange rate (applied to individual income levels) can be a mis-leading indicator of material wealth.

In comparing countries at varying stages of development, therefore, some account needs to be taken of the fact that relative prices of goods and services will be different across countries. The purchasing power parity exchange rate accomplishes that goal by measuring the value of a similar bundle of goods and services in local currencies. It is thus able to capture the gap between the prices of tradables and non-tradables across countries.

11. A little known implication of the Balassa-Samuelson effect in a general equilibrium context is that if trade barriers are reduced to zero, then wages in both countries would actually become equal (implied by Copeland and Taylor, 2003).

In the process of development, a large gap in incomes measured by purchasing power parity should be eliminated, in part, because the relative price of tradables and non-tradables will tend to become roughly equal across countries. Succinctly, the process of development will change the purchasing power parity exchange rate between countries. Driving this process is the Balassa-Samuelson theoretical result.

Changes in purchasing power parity exchange rates

A demonstration of this phenomenon can be seen in the results of the JOBS model. Two regions with substantially different initial levels of wealth and income at the starting point are China and North America. For China, Table 1 shows the proportion of each sector in the model that is traded.

Table 7 : Trade and consumption

Sector	Trade relative to consumption (%)
Rice	0
Other Crops	9
Livestock	4
Forestry	12
Fishing	2
Coal	18
Crude oil	54
Electricity	1
Gas distribution	7
Natural gas	120
Refined oil	20
Minerals	9
Meat	13
Other Food	7
Pulp, paper and publishing	15
Wood products	19
Ferrous metals	14
Non-Ferrous metals	34
Motor vehicle	24
Chemicals	26
Other Manufactures	34
Water	1
Construction	1
Trade and transport	8
Services	5
Dwellings	0

Source : GTAP database

As the table shows, many of the service sectors have low rates of trading. Services have lower levels of trading so their prices are more likely to reflect local incomes and wealth. **Table 8** now illustrates the relative size of each sector in the Chinese and North American economies.

Table 8 : Relative sector size in 2001

Sector	Share of sector in consumption (%)	
	North America	China
Rice	0.000	0.173
Other crops	0.546	8.929
Livestock	0.167	7.251
Forestry	0.064	0.093
Fishing	0.056	2.165
Coal	0.001	0.119
Crude oil	0.000	0.000
Electricity	0.854	0.901
Gas distribution	0.088	0.028
Natural gas	0.008	0.004
Refined oil	0.743	1.042
Minerals	0.002	0.037
Meat	1.535	1.997
Other food	5.805	13.780
Pulp, paper and publishing	1.086	0.550
Wood products	0.662	0.588
Ferrous metals	0.001	0.025
Non-ferrous metals	0.007	0.090
Motor vehicle	2.621	0.741
Chemicals	2.436	2.637
Other manufactures	7.396	20.353
Water	0.520	0.244
Construction	0.005	0.001
Trade and transport	24.463	18.290
Services	40.078	13.663
Dwellings	10.857	6.298

Source: GTAP database

As the table shows, the relative sizes of various sectors differ considerably between regions. Sectoral productivity growth leads to changes in these proportions over time. For reason's outlined in Baumol (1967) it can be expected that the services sectors will experience slower productivity growth over time, and thus become a continually larger share of the overall economy. This was borne out in the empirical work outlined above, which indeed showed historical patterns of slow productivity and increasing shares of the services sectors. Table 9 shows the impact that these trends will have on relative shares. In a general equilibrium framework, however, these trends will also result in price responses as consumers react to changes in the supply of various goods (induced by productivity changes making goods cheaper to produce).

The price changes imply a growing dominance of the sectors exhibiting slow productivity growth. Moreover, the price changes that are induced by that growth have implications for measured improvements in income – as a result of changes in the composition of sectors. That is, measuring the value of a consumption bundle in China in 2001 will combine low-value non-traded goods with high-value traded ones. Productivity changes in China, however, are more rapid than in North America. Because the non-traded components of that bundle are appreciating in value more rapidly than the traded components, the consumption bundle in China should be evolving to look more like its North American counterpart. That is, the purchasing power parity exchange rate should be increasing in China relative to North America.

Table 9 : Productivity-induced changes in China to 2030

Sector	Change from 2001 to 2030 (%)	
	Change in consumption share	Price
Rice	-43.9	-19.8
Other crops	-43.8	-19.0
Livestock	32.3	-16.1
Forestry	36.6	-16.5
Fishing	20.0	15.0
Coal	29.4	7.3
Crude oil	1.4	-5.7
Electricity	37.3	-8.9
Gas distribution	25.6	14.5
Natural gas	30.4	1.3
Refined oil	29.2	-2.2
Minerals	12.2	34.3
Meat	24.2	-10.7
Other food	-20.6	-14.3
Pulp, paper and publishing	11.7	-11.4
Wood products	19.5	-8.3
Ferrous metals	25.0	1.8
Non-ferrous metals	-12.4	9.6
Motor vehicle	24.8	-9.2
Chemicals	23.5	-8.6
Other manufactures	5.3	-8.2
Water	41.6	-16.4
Construction	3.2	77.4
Trade and transport	2.5	74.1
Services	-2.1	104.2
Dwellings	32.7	-11.6

Source : OECD – JOBS Baseline Scenario (May 2005)

Calculating the price of consumption bundles in China in both 2001 and 2030 gives results that are consistent with this intuition. In fact, the purchasing power parity exchange rate for China increases by 25% vis-à-vis that of North America.

This result suggests that correctly accounting for differential productivity growth between traded and non-traded goods can explain to a significant degree the changing purchasing power parity exchange rate that is observed in developing countries. Under-pinning that phenomenon is the Balassa-Samuelson effect of relative price changes.

Sectoral versus aggregate growth in labour productivity

The way that labour productivity is spread among sectors will also matter for assessing developments such as CO2 emissions in each region. If changing labour productivity was uniform across sectors, then emissions could be expected to differ from results obtained with non-uniform growth. Productivity in the energy sector would be a key factor in CO2 emissions (even without changing fossil fuel prices). Table 10 illustrates relative differences in emissions between uniform and non-uniform growth of productivity across sectors. In both cases, the overall economy-wide rate of productivity growth is the same. The positive numbers suggest that emissions in the uniform case are higher than in the non-uniform case.

Table 10 : CO2 emissions with uniform labour productivity growth (percentages changes from non-uniform case)

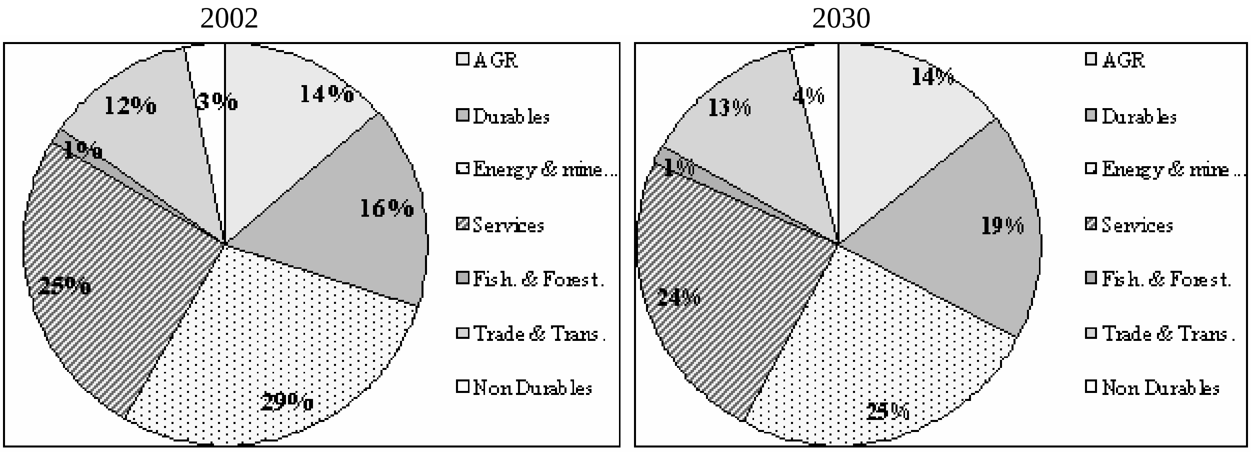
Year	Anz*	China	East Asia	Mea*	Japan & Korea	Sth. America	Nafta	South Asia	EU15	other oecd Eur.	Rest of Eur.[µ]	ex-Ussr#	Afr.	Total
2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	1.3	-0.2	-0.1	-1.2	2.5	0.5	0.1	3.9	1.0	3.7	2.9	3.7	0.1	1.0
2020	5.7	-1.3	2.9	-2.6	6.7	1.8	1.2	19.8	3.4	16.1	11.1	18.1	4.1	4.6
2030	12.6	-5.2	9.1	-2.9	10.9	4.3	2.8	49.9	6.5	35.2	24.6	46.7	15.2	10.4

* see Figure 1. for the definition of this region. # region "RUS" plus region "XSU" in Figure 1. µ region "CEU" plus region "EUA" in Figure 1.

Source : OECD – JOBS Simulations (May 2005).

The largest changes are found in former USSR countries. The assumption of uniform productivity growth gives the result that CO2 emission are more than double that of the non-uniform case in 2030. Though illustrative, the results underline that the way productivity growth is manifests itself can matter considerably for environmental outcomes. Moreover, with uniform growth of labour productivity across sectors, decomposition of the total real value-added does not show much change between 2002 and 2030 (Figure 5), while non-uniform sectoral productivity implies large structural changes (Figure 4).

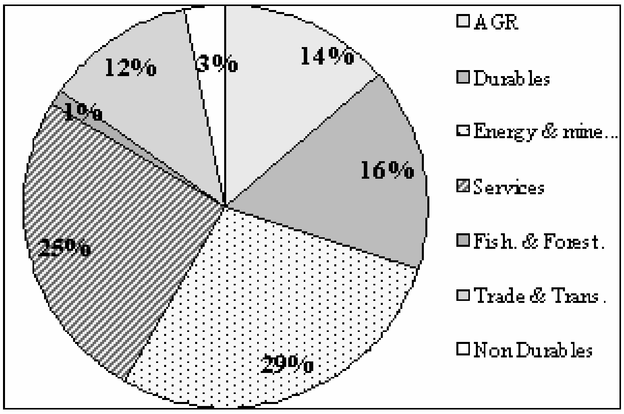
Figure 4 : Baseline Scenario - Structural Change in former USSR



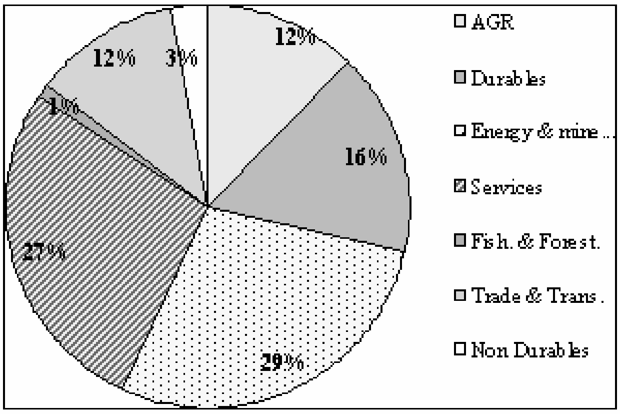
While in value terms the energy sector share will rise in the former USSR, during that period in the baseline scenario this sector will shrink in real terms. However, in the uniform productivity scenario the share will remain almost constant over that period. Because CO2 emissions are ultimately a function of the demand for fossil energy and because energy demand in the former USSR is entirely satisfied by domestic production, growth in CO2 will be slower when labour productivity is higher in energy production than in the overall economy (which is the case in the central scenario as reported in Table 6).

Figure 5 : Uniform Productivity Scenario - Structural Change in former USSR

2002



2030



Source : OECD – JOBS Simulations (May 2005)

Conclusion

Given ongoing discussions in various fora regarding development of baselines for long-term analysis, the work reported in this document contributes insights relevant to many policy issues. In particular, it is shown that differences in sectoral productivity allow a representation of structural change that is necessary for policy analysis over the long term. Issues that have recently become controversial, such as economic convergence in purchasing power parity versus market exchange rates (UNIPCC, 2005) are more easily understood within the context of structural changes in the economy. For example, since the purchasing power parity exchange rate is endogenously increasing in response to structural changes, there is less need in a model with sector productivity growth for mechanisms outside the model to enforce empirically desirable properties on the growth process.

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Table 11 : Model sectors

	Sector composition
1	Paddy rice
2	Wheat, cereal grains nec, vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops nec.
3	Live animals, raw milk, wool, silk-worm cocoons, etc.
4	Fisheries
5	Forestry
6	Manufacture of non-metallic mineral products, except products of petroleum and coal
7	Coal
8	Crude oil
9	Natural gas extraction
10	Petroleum, coal products
11	Gas manufacture and distribution
12	Electricity generation and distribution
13	Meat from all types of animals
14	Vegetable oils and fats, dairy products, processed rice, sugar, food products nec, beverages and tobacco.
15	Chemical, rubber, plastic products
16	Iron and steel
17	Non-ferrous metals
18	Wood products
19	Pulp Paper Publishing
20	Motor vehicle manufacturing including parts
21	Textiles, wearing apparel, leather products, metal products, transport equipment nec, electronic equipment,
22	Construction
23	Water supply
24	Trade and transport services
25	Finance, business, recreational services, public administration, defence, education, health.
26	Dwellings

Table 12 : Labour productivity in non-OECD countries, 1980-2001 (per worker)

Albania†	2.0	Rest of Central America‡	-0.6
Argentina**1**	-0.1	Rest of East Asia‡	0.0
Bangladesh	1.5	Rest of FTA Americas‡	0.1
Bolivia, Ecuador	1.3	Rest of North Africa‡†	1.7
Botswana	4.6	Rest of North America‡	0.9
Brazil**1**	0.2	Rest of Oceania‡	0.5
Bulgaria	1.1	Rest of SADC‡	-4.3
Chile**1**	1.8	Rest of South Africa Customs Union‡†	0.9
China	5.2	Rest of South America‡	-0.8
Colombia**1**	1.0	Rest of SouthAsia‡	3.0
Croatia†	0.2	Rest of SouthEast Asia‡	1.8
Cyprus†	4.1	Rest of Sub-Saharan Africa‡	-0.4
Estonia*	6.0	Romania*	0.5
Hong Kong	3.5	Russian Federation*	2.8
India	3.2	Singapore**1**	3.8
Indonesia	1.8	Slovenia	3.3
Latvia*	6.7	South Africa	-0.8
Lithuania*	5.4	Sri Lanka	2.2
Madagascar	-1.5	Taiwan	5.2
Malawi	-0.4	Tanzania, United Republic of	-0.3
Malaysia	2.8	Thailand	3.9
Malta*	2.5	Tunisia†	3.6
Middle East	-0.1	Uganda	2.1
Morocco	0.6	Uruguay	2.3
Mozambique	1.3	Venezuela**1**	-1.2
Peru	-1.5	Viet Nam	1.5
Philippines	-0.6	Zambia	-1.6
Rest Eastern Europe and Caucasus‡*	2.8	Zimbabwe	-0.4
Rest of Caribbean‡*	3.2		

Source: ILO (2002), World Bank (2003)
* Data begin in 1995.
† Income per capita is used to measure productivity
1 Output per hour is used to measure productivity
‡ In some cases data was not available for all countries. Result is representative of at least 75% of PPP-based GDP of region.