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# STRUCTURAL CHANGE AND PPP MEASURES OF INCOME

***Abstract:*** *This paper explores some implications of structural change that is caused by differences in sectoral productivity growth that occur both within and across countries. The main result concerns its impact on measured purchasing power parity exchange rates – there is an endogenous increase in purchasing power parity exchange rates for developing countries. Underlying this result is the tendency of competitive markets to make the price of traded goods roughly equal across countries– after accounting for transportation costs and applicable taxes. On the other hand, non-traded goods and services reflect local incomes and wealth, and are more long-term in adjusting. In a developing country, prices in the non-traded sectors are lower than they are in developed countries. When this observation is combined with differences in sectoral productivity growth – which originate in the exploitation of comparative advantage, and tend to favour tradable goods – one can see a link between productivity growth and pressures on prices in various sectors. Moreover, high productivity growth in sectors that produce tradable goods induce wage increases that extend to 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.*

*From a measurement perspective, differences between countries in purchasing power parity exchange rates capture differences between what consumers pay for a given bundle of goods and services in different countries. Thus they primarily capture differences across countries in the price of locally-produced goods and services. A purchasing power parity measure, therefore, should endogenously change over time as local incomes increase: a result observed in this paper.*

*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.*

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## STRUCTURAL CHANGE AND PPP MEASURES OF INCOME

### Introduction

Recent projections from the United Nations show world population reaching 9 billion by 2050. When 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, but is expected to have more than doubled that rate to 3.9 percent for the period 1995 to 2004.[2]

Rapid world growth, however, not only implies that the absolute scale of economic activity is increasing; it also implies that important structural changes are occurring in the composition of output. Long-term historical data always show that growth across economic sectors is unevenly distributed: aggregate growth is the sum of disparate growth in individual industries. For example, Table 1 provides a long-term perspective on employment in different sectors, and how it has changed over time.

**Table 1. Long term structure of sectoral employment** (% of total employment)

| | | Netherlands | United Kingdom | United States |
|---|---|---|---|---|
| 1700 | Agriculture | 40 | 56 | n.a. |
| | Industry | 33 | 22 | n.a. |
| | Services | 27 | 22 | n.a. |
| 1820 | Agriculture | 43 | 37 | 70 |
| | Industry | 26 | 33 | 15 |
| | Services | 31 | 30 | 15 |
| 1890 | Agriculture | 36 | 16 | 38 |
| | Industry | 32 | 43 | 24 |
| | Services | 32 | 41 | 38 |
| 1998 | Agriculture | 3 | 2 | 3 |
| | Industry | 22 | 26 | 23 |
| | Services | 75 | 72 | 74 |

Source : Maddison (2001). Some data are noted in source tables.

The movement of labour from agriculture to industry was made possible by increases in agricultural productivity – which meant that a smaller number of farmers could feed an increasing number of industrial workers. In a similar vein, modern economies are undergoing structural change through increases in productivity in manufacturing, which leads to a shifting of the labour force out of manufacturing and into various service sectors – that are generally higher in value but lower in productivity. In manufacturing, as

2. It has it has been even faster during the latest 4 years, see IMF (2004). Global growth during 2004 was anticipated to be 5.0 percent.

with the earlier changes in agriculture, the net result is expected to be an expansion of overall economic output.

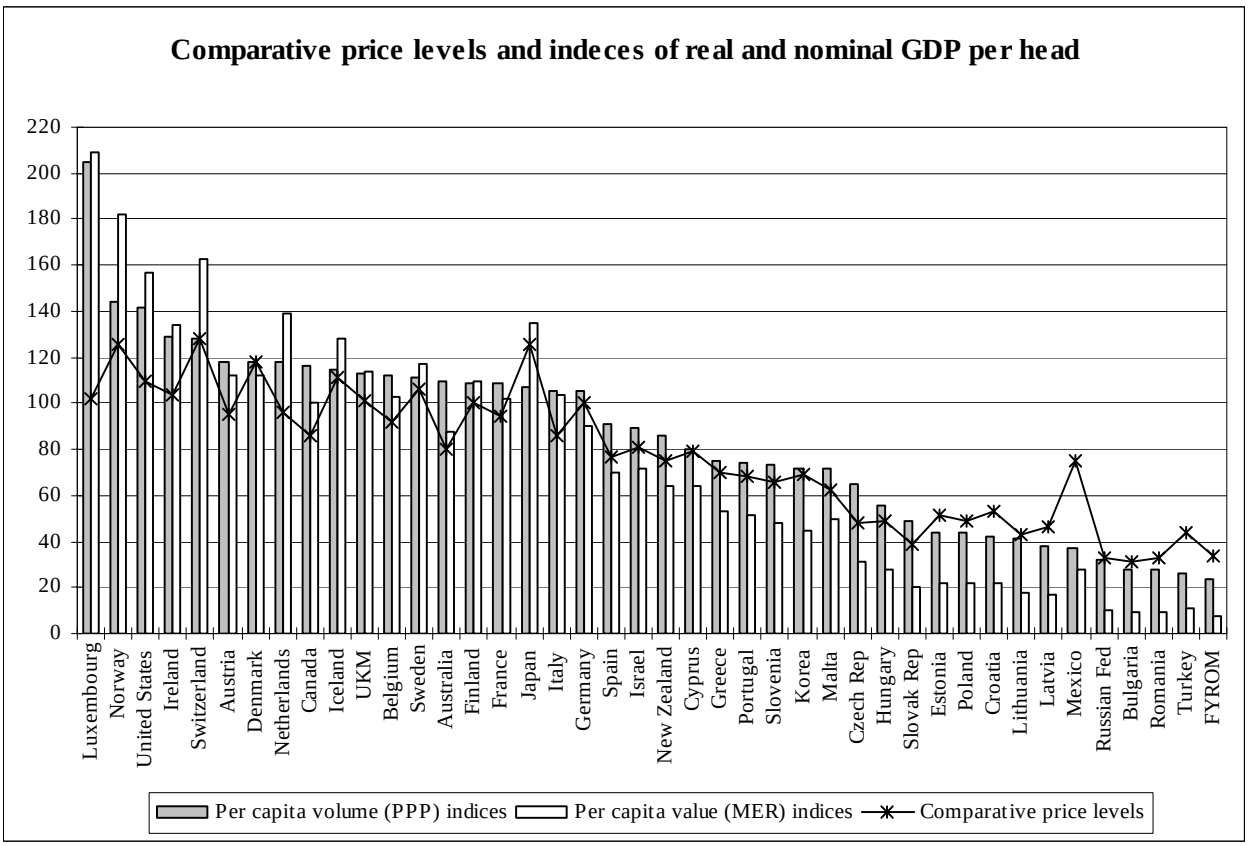
This document explores some implications of growth that is associated with structural change. In particular, it focuses on change that is induced by differences in sectoral rates of productivity growth. It does so by looking at historical trends in productivity growth, and uses that information to create a *general equilibrium* forwarding-looking scenario. That scenario is then examined for some of the endogenous changes that are brought about by the sectoral productivity growth. Earlier work (e.g. Bagnoli, McKibbin and Wilcoxen, 1999) looked at the implication of sectoral productivity growth in accounting for de-coupling economic growth from environmental impacts. The present work explores its role in the observation that purchasing power parity (PPP)-based measures of income change over time at a rate that is different from market exchange rate (MER)-based measures of income. Being able to account for such differences endogenously in an analytical framework will make it less necessary to adopt ad hoc measures that reproduce the empirical regularity without a theoretical foundation. Moreover, by obtaining numerical results in a general equilibrium scenario that link sectoral productivity growth to changing PPP exchange rates, the disparate elements of various theoretical models that lead one to suspect such an outcome are confirmed.

To understand the distinction between MERs and PPP-based exchange rates, consider that MERs balance the demand and supply for currencies that result from: international trade in goods and services, international investments and various types of remittances, and speculation in anticipation of exchange rate movements caused by the previous two. Purchasing power parity exchange rates, however, are intended to capture the differences between the cost of a given bundle of goods and services in different countries. They primarily capture the differences that exist across countries in locally-produced goods and services that do not compete strongly with imports – the prices of traded goods and services vary less between countries. Since PPP-measured incomes reflect consumption potentials, they actually give a better representation of material well-being.

Figure 1 below shows GDP per capita as measured with market exchange rates, and a corresponding measure based on PPP exchange rates.[3] The line illustrating relative prices quantifies the difference between the PPP- and MER-based measures (where 100 implies that the two are equal). The countries are ordered by decreasing PPP-based per capita GDP. The high regularity in the downward trend of the relative price line suggests that being relatively poor implies having a lower MER to PPP income ratio. This is evidence of the point made above concerning the differences between relative prices of trades and non-tradables. That is, where non-tradables are inexpensive in comparison to tradables, the PPP-based measure is expected to be higher than the MER-based measure. It is interesting to note that, on the basis of this interpretation, Figure 1 shows that richer countries actually have domestically produced non-tradables that on average have higher value than goods that compete in international markets.

[3] The data for Luxemburg need to be considered carefully since a "frontier worker" phenomenon implies that up to a quarter of its GDP is produced by people not residing in that country (and thus not counted in population totals).

**Figure 1. Purchasing Power Parities, 2002 Benchmark Year.**




*Source* : OECD (2004b)

The regularity in the downward-sloping comparative price schedule also suggests that there is an endogenous process that changes the relationship between PPP and MER exchange rates. By implication, the process of development itself engages economic changes that lead to a closing, and even reversing of the gap. Since an important part of the difference between PPP and MER exchange rates is the gap between the prices of tradables and non-tradables, and since the price of tradables is, more or less, set in the international market, one would expect that the price of non-tradables will be the main source of changes in the gap. To see what might be driving this process it is worth considering the Balassa-Samuelson theoretical result.

## Interpreting the Balassa-Samuelson effect

Sustained growth over a long period of time engages processes that exploit comparative advantage at many levels, ranging from local individuals to international economies. Among individuals, it leads to a deepening specialisation of skills; that is, factors of production. Among countries, it leads to specialisation that exploits endowments of natural, physical and human capital – even at the level of individual sub-industries where the advantage is tenuously held. Increasing specialisation among countries is often accompanied – most likely caused by – the lowering of natural and political barriers to trade.

Within a country, growth in areas of comparative advantage is expected to be beneficial for everyone – not just for those fortunate enough to be in the expanding sectors. This is most easily understood in a

general equilibrium context. That is, exploiting comparative advantage leads to rapid productivity growth in some sectors but not in others. This then leads to an increase in wages in the expanding sectors as the demand for labour increases, whereas the necessary skills take time to develop. Since, over a long enough period of time, labour is fairly mobile within a country, wages in the growing sectors will come under pressure from people acquiring the necessary skills and competing for the high productivity jobs. On the other hand, the shrinking labour supply in the slow-growing sectors will cause wage pressures to increase there as the departure of workers causes shortages of labour to develop. In the end, wages of people with similar skills should be made equal across sectors – where skill levels are separated by innate ability and are not acquirable. Notice also that the average wage will rise with greater specialisation since more numerous jobs will be found in the high-productivity high-wage sector.

The relationship between economic growth and increases in wages within a country also applies in an international context. This implies that if two countries exploit their respective comparative advantages, then overall wages should increase in both countries – though this does not necessarily imply that they should become equal. 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.[4]

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 developed country. Lack of tradability and labour mobility will maintain those differences until incomes in the developing country move closer to 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.

**Exploring structural change**

While the issues outlined above are relatively intuitive, their relevance for policy formulation would be enhanced by observing them in a rigorous framework. Since the main driver implied within a Balassa-Samuelson context is that non-tradables have lower productivity growth than tradables, it is worth looking into the empirical validity of that proposition. Ideally, this would be done by looking at very detailed historical sectoral productivity data in a country that underwent rapid development, and constructing a corresponding time series of its PPP exchange rate. Unfortunately, such data is not readily available and would take considerable time (if at all possible) to construct. At this stage, an acceptable approach would be use a general equilibrium framework to look forward at the potential for differential sectoral productivity growth to induce changes in the PPP exchange rate. Basing the projection on historical data would give the analysis some empirical relevance for policymakers.

4. An 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).

### *Sectoral change*

To explore trends in sectoral change, consider empirical data from the period for 1980 to 2001. Table 2 illustrates the sectoral productivity data that can be derived from the OECD STAN and the Groningen Growth and Development Centre databases. As illustrated, significant differences exist in the rates of growth of labour productivity across sectors. Notable is the slow growth of service sector productivity in comparison to the other sectors. 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*).

**Table 2. OECD Sectoral Labour Productivity growth (1980-2001)**

| | Agriculture | Forestry, Fishing | Energy† | Non-durable Manufacturing | Durable Manufacturing | Trade, Transport | Services |
|---|---|---|---|---|---|---|---|
| Australia | 3.2% | 2.9% | 4.9% | 1.9% | 3.2% | 1.2% | 0.3% |
| Austria | 5.2% | 5.1% | 3.9% | 4.1% | 8.4% | 2.8% | 3.0% |
| Belgium | 4.2% | 5.9% | 4.2% | 2.8% | 6.1% | 1.3% | 1.5% |
| Canada | 2.1% | -1.2% | 1.2% | 1.2% | 4.0% | -2.3% | 1.1% |
| Czech Rep.* | 10.3% | 10.5% | 0.8% | 11.3% | 4.8% | 12.4% | -2.7% |
| Denmark | 7.3% | 1.0% | 5.8% | 1.6% | 3.5% | 0.0% | 3.8% |
| Finland | 2.1% | 4.1% | 5.1% | 4.5% | 6.7% | 2.8% | 2.6% |
| France | 5.9% | -1.3% | 2.3% | 0.8% | 5.8% | 3.0% | 1.5% |
| Germany | 5.8% | 2.8% | 2.9% | 1.3% | 2.9% | 3.0% | 1.9% |
| Greece | 1.7% | 2.8% | 3.7% | 3.1% | 1.1% | 1.3% | -2.1% |
| Hungary* | 5.6% | 6.0% | -0.8% | -1.0% | 2.6% | 4.6% | -0.4% |
| Ireland | 4.2% | 3.3% | 7.2% | 6.3% | 15.5% | 2.7% | 1.0% |
| Italy | 5.0% | 5.9% | 1.2% | 2.3% | 4.6% | 1.6% | 0.2% |
| Japan | 3.0% | 1.4% | 3.0% | 0.0% | 8.8% | 3.0% | 2.7% |
| Korea | 7.1% | 4.1% | 9.0% | 4.2% | 15.1% | 3.2% | 0.8% |
| Luxembourg | 5.4% | 6.5% | 4.4% | -0.4% | 5.6% | 3.9% | 0.0% |
| Mexico* | 1.9% | 1.9% | 2.6% | 1.7% | 1.7% | 1.0% | -0.2% |
| Netherlands | 3.4% | 1.6% | 0.9% | 3.7% | 4.4% | 2.7% | 2.4% |
| New Zealand | 5.1% | 5.0% | 2.2% | 1.4% | 1.4% | 4.2% | 2.4% |
| Norway | 4.1% | 6.4% | 4.7% | 0.2% | 2.2% | 4.0% | -2.8% |
| Poland* | -1.6% | 6.0% | 1.6% | 3.0% | 10.8% | 4.1% | -0.1% |
| Portugal | 4.7% | 4.6% | 7.4% | 1.9% | 5.3% | 1.9% | 0.4% |
| Slovak Rep.* | 2.5% | 2.5% | -3.9% | -0.9% | 0.8% | 0.2% | 3.4% |
| Spain | 5.4% | 3.5% | 3.1% | 2.0% | 4.2% | 1.6% | -0.9% |
| Sweden | 2.0% | 5.5% | 2.8% | 2.1% | 4.1% | 2.0% | 0.9% |
| Switzerland | -1.1% | -1.1% | -0.4% | 0.8% | 5.8% | -0.7% | 0.3% |
| UK | 3.0% | 1.5% | 7.8% | 2.5% | 6.6% | 3.6% | -2.0% |
| US | 4.4% | 1.5% | 2.6% | -0.8% | 6.7% | 4.0% | 0.7% |

*Source*: OECD STAN database, Groningen Growth and Development Centre database.
† Data periods for energy are variable
* Periods as follows: Poland (1994-2001), Mexico (1988-2001), Czech (1993-2001), Hungary (1993-2001), Slovakia (1993-2001)

The slow growth of sectors primarily producing services is relevant to the Balassa-Samuelson effect, as already noted. Table 3 shows that in a sample of countries, the output of the service sector is generally not highly traded, whereas the other sectors produce goods that are more likely to compete in international markets – and thus more likely to be exchanged at a world price.

**Table 3. Sectoral import shares (2001)**

| | Agriculture | Forestry, Fishing | Energy† | Non-durable Manufacturing | Durable Manufacturing | Trade, Transport | Services |
|---|---|---|---|---|---|---|---|
| China | 7% | 8% | 17% | 34% | 80% | 17% | 8% |
| Japan | 33% | 22% | 32% | 45% | 31% | 5% | 2% |
| India | 2% | 7% | 25% | 22% | 53% | 5% | 5% |
| USA | 15% | 14% | 17% | 13% | 56% | 4% | 2% |
| France | 25% | 28% | 53% | 47% | 100% | 11% | 4% |
| Germany | 66% | 20% | 57% | 40% | 92% | 17% | 8% |

*Source*: GTAP version 6 database.

Also of interest in Table 2 is the relationship between these data and trends already noted elsewhere – such as declining energy, or material inputs, per unit of output (OECD, 2002). The Table implies a shift of importance away from most of material-producing sectors – which will be observed as a decoupling of growth in material use from aggregate economic growth. That is, an economy where labour productivity is high in an energy-producing sector will 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 – as observed prior to recent demand-induced oil price increases.

Tables 2 and 3 show that some of the primary conditions for observing the Balassa-Samuelson effect are present in the data. The next step will be to look into whether forward projections embodying similar trends can lead to observed changes in PPP-based exchange rates. To explore that possibility, the conditions underlying future economic growth are explored below in a general equilibrium framework – where other factors impacting on the channels of transmission can be accounted for. This will allow us to draw conclusions regarding future evolution of PPP-based exchanged rates.

In the following sections, a dataset is developed that outlines the sources of aggregate and sectoral growth rates on a global basis. This dataset is then used in a computable general equilibrium model to examine changes in PPP-based exchange rates.

## Economic Growth

Economic development depends primarily on the skills and resourcefulness of a country's population. Most OECD countries, for example, have similar levels of material well-being (per hour worked) – derived from similar educational systems and similar social/governmental institutional arrangements (Lucas, 2000). In developing a perspective of future economic growth, this simple observation has important implications. The population of a country is a primary factor in determining the quantity of labour available to the economy. Scientific and other advances are the primary determinants of skills that increase output per hour worked (productivity). Combining productivity increases with changes in the number of hours worked (i.e. the extent of increases in employment and the intensity of its use) is thus the determining factor for projecting future economic output.

### *Labour supply*

To gain an understanding of the potential evolution of labour supply, a first step is to understand how populations might evolve. 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. It is characterised by a global population that stabilises around 9 billion – which is still almost 50 percent

higher than the current population. As Table 4 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 4. 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, of the recent trends in population growth. For example, while explicit assumptions regarding migration have been incorporated[5], 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 analysis. To show the magnitude of the changing demographics, Table 5 contrasts population growth of 0-14 year-olds to regionally-aggregated totals.

**Table 5. 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).

5. 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.

***Participation rates***

The next element in determining labour supply is the decision of members of the adult population to work. 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 in, or leave, the work force following childbirth that is the key factor explaining changes in the participation rate.[6] 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 (Table 6).

**Table 6. Participation rate changes***

| | Change 2000-25 | Participation rate % in 2025 | | Change 2000-25 | Participation rate % in 2025 |
|---|---|---|---|---|---|
| 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 | 63 |
| 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+.

For non-OECD countries, data on participation rates are less readily available over a long enough period to draw conclusions. An examination of historical OECD data, however, suggests there is evidence for a long-term average of 60 percent, which is more or less constant since the 1960's. This observation could be used to underpin a conjecture of slow convergence in non-OECD country participation rates to 60 percent. For many of those countries, this will imply a lowering of their current rate (fewer people work as

6 . Other policy measures, while less important, also influence the decision of members of the working-age population (particularly women) to participate in the labour force. For example, Dex, *et al.* (1995) discuss the impact of means-testing in unemployment insurance systems.

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.

### *Labour productivity*

For OECD countries, a considerable amount of data exists to inform a view of how labour productivity might evolve. Table 7 reports on historical experience and projections. These results (based on a "growth accounting" framework) are used in developing a baseline.[7]

**Table 7. 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, Antolin 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.

As is clear, productivity and its rate of growth are not uniform across countries. Moreover, some notion of how they might evolve needs to be developed for exploring the implications of future trends. A significant literature has been created concerning economic convergence. It can be characterised by two main threads. 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 necessarily imply a strong divergence in incomes per capita – which is the where the second thread becomes evident. There is some evidence for convergence in growth rates to occur across countries. This distinction between convergence in levels of income (per capita) and convergence in growth rates means that countries differ in ways that are important to the allocative efficiency of market economies, but not in ways that impede their ability to exploit technological advance. Convergence in growth rates is termed *conditional* convergence and has been

7 . Recent experience has differed from those trends and needs to be reflected in a transition period.

empirically validated. It is thus a relatively robust finding, see Sala-i-Martin (2002), or de la Fuente (2002), for overviews of the theory and evidence for convergence.

To understand more deeply the distinction between convergence in income per capita and convergence in growth rates, consider that convergence in income levels per capita would imply that social institutions and even government policies would have no impact on differences between countries. The reason is that any differences in policies across countries should, in principle, be reflected in income levels per capita – those policies reflect differences in social or market tradeoffs that countries are willing to make. On the other hand, convergence in growth rates implies that government policies do not impact on the ability of competitive firms to acquire and use new technologies.

***Growth and convergence***

These observations – underpinning convergence and productivity growth – are key for the sections that follows. Future productivity growth, and future changes in the supply of labour, determine economic growth. 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). This means that the link between increases in labour productivity and output growth is tightly established: one needs only specify a functional form for economic output that features labour-augmenting technical change and impose long-term stability. This will then endogenously determine GDP.

Estimates of the historical trend in productivity growth for OECD countries are readily available for the period from 1980 to 2001, e.g. Ahmad, *et al*. (2003), and Dang, Antolin and Oxley (2001). Historical trends for non-OECD countries can be obtained from the International Labour Organisation, the World Bank, and the Groningen Growth and Development Centre – again for the 1980-2001 period. Table I.3 in Annex I compiles these data.

Looking forward, for OECD countries long-term potential productivity growth has been conjectured to be 1.76 percent (per annum, per hour, see Dang, Antolin and Oxley, 2001). For analytical work, this forward-looking conjecture can be reconciled with the historical data by asserting that, after accounting for recent data, countries move toward 1.76 annual productivity growth 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.

Historical data for non-OECD countries are sparse but some data are available from, among others, OECD, IMF, African Development Bank, and the World Bank. Given earlier comments, labour productivity growth in non-OECD countries is conjectured to also move toward the OECD average. Table 8 provides a sampling of some annual results from those sources. For countries where the historical average was negative, the convergence begins from a zero productivity growth level and moves toward the long-term OECD rate.

**Table 8. Sample baseline labour productivity growth***

| | 2007 | 2010 | 2020 | 2030 | | 2007 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Argentina | 2.4 | 0.9 | 1.3 | 1.7 | Lithuania | 6.4 | 5.1 | 4.5 | 4.1 |
| Australia | 2.6 | 2.0 | 1.8 | 1.8 | Malaysia | 4.3 | 3.0 | 2.8 | 2.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Austria | 2.3 | 1.8 | 1.9 | 1.9 | Mexico | 2.6 | 0.9 | 1.1 | 1.3 |
| Belgium | 2.5 | 2.1 | 1.9 | 1.8 | Netherlands | 2.2 | 1.8 | 1.7 | 1.7 |
| Brazil | 1.9 | 0.9 | 1.1 | 1.2 | Norway | 0.0 | 1.5 | 1.2 | 1.1 |
| Canada | 2.2 | 1.6 | 1.6 | 1.6 | Peru | 2.5 | 0.9 | 1.3 | 1.7 |
| Chile | 3.3 | 2.2 | 2.1 | 2.1 | Philippines | 2.1 | 0.8 | 1.2 | 1.6 |
| China | 6.2 | 4.9 | 4.4 | 3.9 | Poland | 4.2 | 2.9 | 2.2 | 2.0 |
| Colombia | 2.3 | 1.4 | 1.5 | 1.6 | Portugal | 2.4 | 2.4 | 3.0 | 3.2 |
| Czech Rep. | 3.4 | 2.3 | 2.5 | 2.5 | Romania | 3.6 | 1.5 | 1.6 | 1.6 |
| Denmark | 2.0 | 1.8 | 1.7 | 1.7 | Russia | 6.1 | 4.9 | 4.41 | 3.9 |
| EECCA | 2.6 | 2.6 | 2.5 | 2.4 | S. Africa | 1.8 | 0.7 | 1.1 | 1.5 |
| Estonia | 5.6 | 5.3 | 4.7 | 4.2 | Singapore | 4.0 | 3.5 | 3.2 | 3.0 |
| Finland | 2.8 | 2.5 | 2.2 | 2.1 | Slovakia | 3.7 | 2.9 | 2.2 | 2.0 |
| France | 2.0 | 2.1 | 1.8 | 1.7 | Slovenia | 2.3 | 2.8 | 2.6 | 2.5 |
| Germany | 2.2 | 2.1 | 1.9 | 1.8 | Spain | 2.4 | 2.2 | 2.0 | 2.0 |
| Greece | 3.0 | 2.1 | 2.0 | 2.0 | Sri Lanka | 3.8 | 2.5 | 2.4 | 2.4 |
| Hungary | 3.3 | 2.7 | 3.0 | 3.1 | Sweden | 2.7 | 1.9 | 1.8 | 1.8 |
| India | 5.0 | 3.9 | 3.6 | 3.3 | Switzerland | 1.7 | 1.4 | 1.9 | 2.0 |
| Indonesia | 3.4 | 2.2 | 2.1 | 2.1 | Tanzania | 2.2 | 0.8 | 1.2 | 1.6 |
| Ireland | 3.6 | 3.1 | 2.2 | 2.0 | Thailand | 5.0 | 3.9 | 3.5 | 3.2 |
| Italy | 2.0 | 1.9 | 1.8 | 1.8 | Turkey | 4.3 | 2.7 | 2.1 | 2.0 |
| Japan | 2.2 | 2.3 | 1.8 | 1.7 | UK | 2.1 | 2.0 | 1.8 | 1.8 |
| Korea | 4.7 | 4.3 | 3.0 | 2.7 | USA | 2.6 | 1.8 | 1.8 | 1.8 |
| Latvia | 6.1 | 5.8 | 5.1 | 4.5 | Venezuela | 1.7 | 0.7 | 1.1 | 1.5 |

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

***Sectoral change***

To fully explore some issues in structural change resulting from productivity growth, it will be useful to have global coverage. However, given the lack of collection and processing of data in many non-OECD countries, data for many non-OECD countries are not available. 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 the analytical issues of interest here, more insight will be gained by including trends that are commonly part of the development experience. A "similar economies" approach is therefore used to provide the basis for trends in some regions.

Sectoral productivity changes have thus been developed into a worldwide dataset to provide full global coverage for analytical work. Table 9 illustrates the results.

**Table 9. Sectoral labour productivity growth 1980-2001, % change**

| | Agriculture | Forest, Fishing | Energy | Non-durable Manufacturing | Durable Manufacturing | Trade, Transport | Services |
|---|---|---|---|---|---|---|---|
| US, Canada, Australia, New Zealand | 4.2 | 1.4 | 2.6 | 0.6 | 6.3 | 3.4 | 0.7 |
| EU-15, other Western Europe | 5.0 | 3.4 | 4.4 | 2.0 | 4.0 | 2.4 | 0.7 |
| E. Europe, Central Asia | 2.4 | 6.6 | 1.2 | 3.6 | 5.4 | 5.5 | -0.4 |
| Russia* | 8.5 | 2.7 | 1.7 | 14.0 | 14.0 | 2.6 | 0.6 |
| Japan | 3.0 | 1.4 | 1.2 | 0.0 | 0.9 | 3.0 | 2.7 |
| Korea, fast-growing Asia | 7.1 | 4.1 | 9.0 | 4.2 | 14.3 | 3.2 | 0.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| China | 4.1 | 4.1 | 3.0 | 4.0 | 4.0 | 1.0 | 1.0 |
| India | 2.8 | 6.6 | 6.3 | 3.0 | 7.5 | 3.5 | 3.2 |
| Brazil, Central/South America† | 2.7 | 2.7 | 2.3 | 1.0 | 4.8 | 0.7 | 1.5 |
| Rest of World‡ | 3.4 | 4.6 | 3.5 | 3.1 | 5.1 | 1.9 | 1.5 |

*Source* : OECD STAN database, Groningen Growth and Development Centre database, ILO (2002), others[8].
* Based on data from 1999 to 2003.
† Based primarily on data from Brazil and Mexico, but also incorporates limited data from other countries.
‡ Average of non-OECD where data was available.

Exploring the link between productivity growth at a sectoral level and changes in PPP-based measures of income will require a general equilibrium framework if it is to be consistent with economic theory. Introducing all the trends noted above into a fully-specified economic framework would give policy-makers a rigorously-based expectation of changes that may occur if no major shocks arise in national economies. The next section outlines a computable general equilibrium (CGE) model that will be used to implement these trends.

### *The ENV-LINKAGES Model*

The ENV-Linkages model has a number of similarities to the LINKAGE model of van der Mensbrugghe (2004). It was first developed at the OECD for the Linkages II project and has continued to be used and further developed 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 deal with climate change (undertaken during the early 1990's).

ENV-Linkages 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.[9]

**ENV-Linkages model**

*Model Specification*

Among the important characteristics of ENV-Linkages worth noting are the technological representation of production: modelled using a nested sequence of CES functions. Four factors are specified: 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) are also specified.

All production is assumed to operate under cost minimization with an assumption of perfect markets and constant return to scale technology. The production technology is specified as nested CES production functions in a branching hierarchy. The top node thus represents an output – using intermediate goods combined with value-added. This structure is replicated for each output, where the parameterisation of the

8. 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, OECD Economic surveys: Russian Federation (2004); and Ahrend (2004).

9 In other applications at OECD, some inferences – both within and outside the model -- are made regarding environmental impacts as well.

CES functions may differ across sectors.

Total output for a sector is actually 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 words, 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 model.

The valued-added bundle is specified as a CES combination of labour and a broad concept of capital. In the "crop" production sector, this broad capital is itself a CES combination of fertilizer and another bundle of capital-land-energy. The intention of this specification is to reflect the possibility of substitution between extensive and intensive agriculture. 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 similar 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 a sector-specific factor for primary resources).

Household consumption demand is the result of static maximization behaviour which is formally implemented as an "Extended Linear Expenditure System". A representative consumer in each region – who takes 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 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. The 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 given in 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.

*Database, regions, and sectors*

The GTAP database is used as a starting point for empirical work but is aggregated to 34 model regions, shown in Table I.1 in Annex I.

For OECD regions, a number of databases exist which provide high quality data (for example, the OECD STAN database, Groningen Growth and Development Centre)[10]. Those data give a reasonable degree of confidence that the empirical foundation, underlying model results, 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

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

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.

The sectors used were aggregated to 26 sectors (see Table I.2 in Annex I for details). Since debate remains concerning comparability of sectoral productivity growth (Sorenson and Schjerning, 2003), the results reported below focus on 7 sectors so as to minimise potential problems (including a dearth of data in non-OECD regions). The results that are obtained from historical data on the 7 aggregated sectors are applied uniformly to the component sectors in the model.

**Changes in purchasing power parity exchange rates**

The evolving trends in labour supply and labour productivity were implemented in the ENV-Linkages model. Annex II reports on some general results. Of principle interest is the impact of differential sectoral productivity growth on purchasing power parity exchange rates. Understanding this impact can be facilitated by looking at two regions with substantially different initial levels of wealth and income: China and the United States. For China, Table 10 shows the proportion of each sector in the model that is traded relative to what is consumed domestically.

**Table 10. Trade and consumption in China**

| Sector | Trade relative to consumption (%) |
|---|---|
| Rice | 0.0 |
| Other Crops | 6.8 |
| Livestock | 3.2 |
| Forestry | 9.9 |
| Fishing | 1.3 |
| Coal | 3.0 |
| Crude oil | 21.3 |
| Electricity | 0.7 |
| Gas distribution | 4.8 |
| Natural gas | 29.1 |
| Refined oil | 16.5 |
| Minerals | 7.6 |
| Meat | 12.2 |
| Other Food | 5.7 |
| Pulp, paper and publishing | 13.1 |
| Wood products | 13.3 |
| Ferrous metals | 11.9 |
| Non-Ferrous metals | 21.0 |
| Motor vehicle | 17.5 |
| Chemicals | 19.5 |
| Other Manufactures | 22.7 |
| Water | 0.7 |
| Construction | 0.8 |
| Trade and transport | 7.8 |
| Services | 5.3 |
| Dwellings | 0.0 |

Source : GTAP database

As the Table shows, many of the service sectors have low rates of trading. Table 11 now illustrates the share of each sector in total consumption in the Chinese and North American economies (these sectors represent an aggregation of those shown in Table 10).[11]

11 . These sectors represent consumption in the GTAP database. They reflect goods that are produced and go to final consumption, without being bundled into more traditional consumer goods and services.

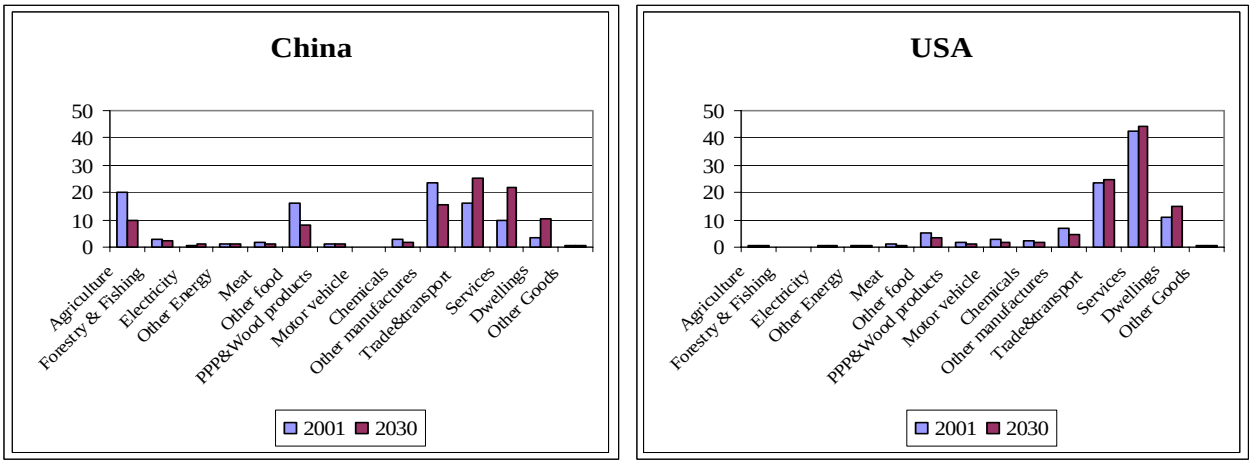
**Table 11. Relative sector size in 2001**

| Sector | Share of sector in consumption (%) | |
|---|---|---|
| | China | North America |
| Agricultural Products | 20.4 | 0.6 |
| Forestry & Fishing | 2.6 | 0.1 |
| Electricity | 0.7 | 0.8 |
| Other Energy | 1.3 | 0.8 |
| Meat | 1.8 | 1.2 |
| Other food | 16.0 | 5.3 |
| Pulp, paper and publishing & Wood products | 1.2 | 1.7 |
| Motor vehicle | 0.1 | 2.6 |
| Chemicals | 2.7 | 2.4 |
| Other manufactures | 23.4 | 7.0 |
| Trade and transport | 16.2 | 23.4 |
| Services | 9.9 | 42.5 |
| Dwellings | 3.3 | 11.0 |
| Other Goods | 0.4 | 0.6 |

Source: GTAP version 6 database

As the Table shows, the relative sizes of various sectors differ considerably between the two regions. Sectoral productivity growth is expected to lead 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. Figure 2 illustrates the changes in sector shares in the USA and China that ENV-Linkages suggests will occur between 2002 and 2030. Notice that since there is overall growth in both economies, a decreased share does not necessarily imply decreased output.

**Figure 2: Changing sector shares, USA and China**




A more detailed view is provided in Table 12 where data on price changes is also given. In a general equilibrium framework differential productivity growth 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).

**Table 12. Productivity-induced changes in China to 2030**

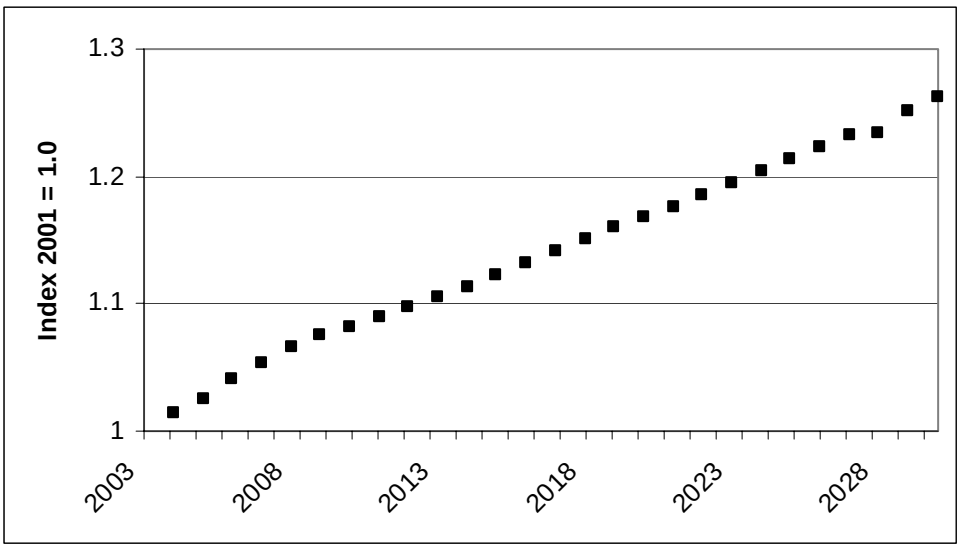
| Sector | Change from 2001 to 2030 (%) |
|---|---|

| | Change in consumption share | Price |
|---|---|---|
| Rice | -54.5 | 21.6 |
| Other crops | -61.5 | -2.0 |
| Livestock | -41.3 | 2.6 |
| Forestry | -11.7 | 56.9 |
| Fishing | -8.9 | 153.1 |
| Coal | 37.2 | 2.0 |
| Crude oil | 0.0 | -20.0 |
| Electricity | 38.6 | -25.5 |
| Gas distribution | 39.2 | -7.5 |
| Natural gas | 29.4 | -23.7 |
| Refined oil | -9.4 | -22.6 |
| Minerals | -11.7 | 62.2 |
| Meat | -45.1 | -6.6 |
| Other food | -49.1 | -3.7 |
| Pulp, paper and publishing | -27.6 | -29.0 |
| Wood products | -26.5 | -21.6 |
| Ferrous metals | -25.4 | -17.4 |
| Non-ferrous metals | -25.3 | -12.1 |
| Motor vehicle | -28.7 | -29.6 |
| Chemicals | -28.1 | -26.1 |
| Other manufactures | -33.3 | -30.7 |
| Water | 40.8 | -28.0 |
| Construction | 36.7 | 7.5 |
| Trade and transport | 55.6 | -8.6 |
| Services | 122.0 | 14.5 |
| Dwellings | 215.4 | -42.9 |

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.

Calculating the price of consumption bundles in China from 2001 to 2030 gives results that are consistent with this intuition. In fact, the purchasing power parity exchange rate for China increases by 26% vis-à-vis that of North America.

**Figure 3. Purchasing Power Parity Exchange Rate, China**




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.

### *Representation of consumption*

A caveat to the result presented here is found in the representation of consumption. In this version of the model, preferences are specified using a utility function that exhibits homotheticity. This implies that only changes in relative prices affect the consumption bundle. Since this assumption is at odds with empirical results (Theil and Clements, 1987), the analysis presented here will likely change with better representation of consumer behaviour. Interestingly, since the impact of increasing incomes is expected to favour the demand for services, the likely result of changes to the representation of consumer preferences will be to magnify the results presented above.

## 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 (IPCC, 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 – such as convergence between countries in PPP-measured growth rates – on the growth process.

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## ANNEX I: REGIONS, SECTORS AND PRODUCTIVITY GROWTH

**Table I.1 Model regions**

| | **Region composition** |
|---|---|
| 1 | Australia, New Zealand |
| 2 | American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, Federated States of, Nauru, New Caledonia, Norfolk Island, Northern Mariana Islands, Niue, Palau, Papua New Guinea, (Western) Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna |
| 3 | China, Hong Kong |
| 4 | Japan |
| 5 | Korea |
| 6 | Chinese Taipei |
| 7 | Macau, Mongolia, DPR of Korea, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Brunei Darussalam, Cambodia, Lao PDR, Burma, (East)Timor Leste |
| 8 | Indonesia |
| 9 | Bangladesh, Sri Lanka, Afghanistan, Bhutan, Maldives, Nepal, Pakistan |
| 10 | India |
| 11 | Canada |
| 12 | United States of America |
| 13 | Mexico |
| 14 | Bermuda, Greenland, Saint Pierre and Miquelon, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Antigua & Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Virgin Islands - U.S., Anguilla, Aruba, Cayman Islands, Cuba, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos, Virgin Islands, British |
| 15 | Colombia, Peru, Venezuela, Bolivia, Ecuador, Argentina, Chile, Uruguay, Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Suriname |
| 16 | Brazil |
| 17 | Austria, Belgium, Denmark, Finland, Greece, Ireland, Luxembourg, Netherlands, Portugal, Sweden |
| 18 | France |
| 19 | Germany |
| 20 | United Kingdom |
| 21 | Italy |
| 22 | Spain |
| 23 | Switzerland, Iceland, Liechtenstein, Norway |
| 24 | Andorra, Bosnia and Herzegovina, Faroe Islands, Gibraltar, the former Yugoslav Republic of Macedonia, San Marino, Serbia and Montenegro (Yugoslavia), Monaco, Albania, Bulgaria, Croatia |
| 25 | Czech Republic, Slovakia, Hungary |

| | |
|---|---|
| 26 | Cyprus, Malta, Romania, Slovenia, Estonia, Latvia, Lithuania |
| 27 | Poland |
| 28 | Russian Federation |
| 29 | Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Republic of, Tajikistan, Turkmenistan, Ukraine, Uzbekistan |
| 30 | Turkey |
| 31 | Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen |
| 32 | Morocco, Tunisia, Algeria, Egypt, Libya |
| 33 | Botswana, Lesotho, Namibia, Swaziland, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, Angola, Democratic Republic of Congo(Zaire), Mauritius, Seychelles |
| 34 | Madagascar, Uganda, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Mayotte, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Sudan, Togo |
| 35 | South Africa |

**Table I.2 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 I.3 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.

## ANNEX II: GDP RESULTS

Long-term productivity growth has been assumed to converge to a rate of 1.76 per annum. In moving toward that rate, however, the historical trend has to be distinguished from the recent trend. Recent data, for example, are more likely to reflect business cycle and other short- to medium-term phenomenon than an economy's underlying potential.

Historical trends for productivity growth are taken from period 1980 to 2001. Since estimates of productivity growth for the period after 2001 are not widely available for non-OECD economies, 2001 was used to maintain comparability. Actual estimates for OECD countries are taken from OECD Economics Department Studies, eg. Ahmad, *et al.* (2003), and Dang, Antolin 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[12]. There is a 2 percent per year closing of the growth rate gap (see Sala-i-Martin, 1996) 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[13,14].

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.

Non-OECD countries 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 made earlier in this paper regarding conditional convergence, those trends also move toward the OECD average productivity growth rate of 1.76. The steps described in (1) to (4) are therefore applied to OECD countries as well.

As is clear from Figures II.1 and II2, high current growth rates are not sustained in the long run. An important source of this change is in the declining population growth rate in all regions except Africa.

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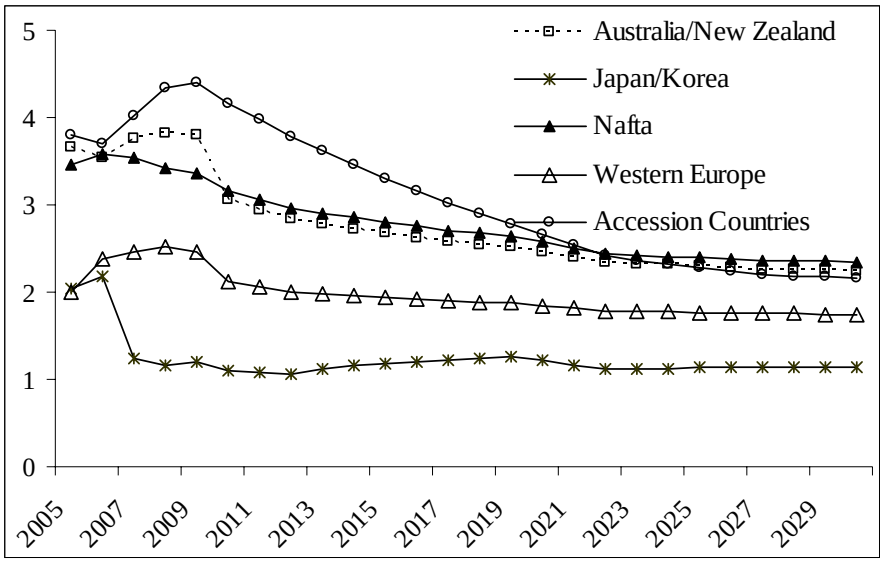
12 . Countries/regions with negative productivity growth between 1980 and 2001 are adjusted to zero growth for the beginning of the trend rate.

13. If the expertise embodied in short-term forecasts is to be used, then those forecasts will also have to be super-imposed on the trend rate.

14 . This super-imposition is necessary because the database (Global Trade Analysis Program of Purdue University) used for the model is calibrated to 2001 data.

Because the rate of growth of the active population remains dispersed among regions, so will the growth of GDP be uneven. The convergence of labour productivity growth rates is thus masked by the impact of dispersed growth rates of the labour force (particularly between more industrialised OECD countries and less developed countries like Africa or Middle East).

**Figure II.1 Real GDP growth rates: OECD Countries**

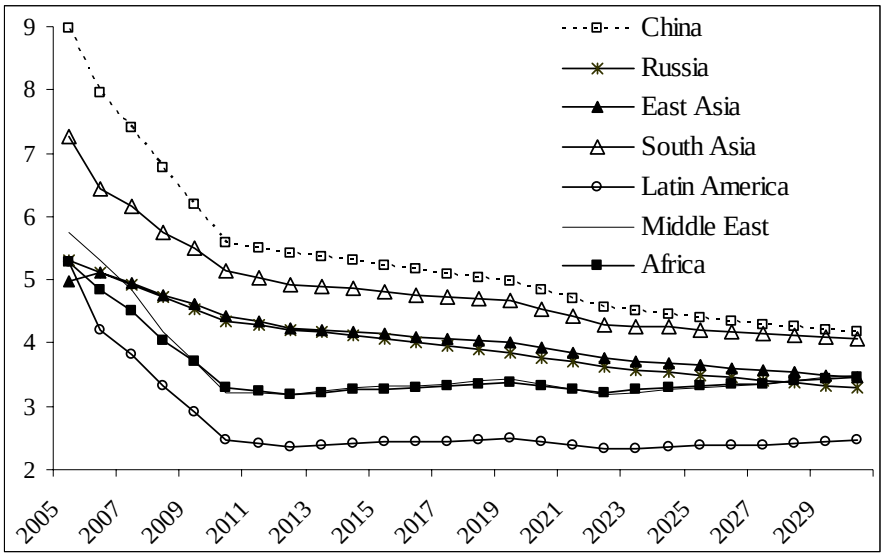



*Source* : OECD – ENV-Linkages Central Scenario (December, 2005)

China and India 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 II.2 Real GDP growth rates: Non OECD countries**




*Source* : OECD – ENV-Linkages Central Scenario (December, 2005)