

Recent Productivity Developments in the World Economy: An Overview from The Conference Board Total Economy Database

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ABSTRACT

The recession left its mark on global productivity, which fell in 2009. The productivity growth differential between the United States and Europe increased dramatically in 2009. Average long-term growth of labour productivity in advanced economies has stalled since 2000. The gradual improvement in world productivity is due to emerging and developing economies. In particular the long-term increase in TFP growth reflects a strengthening of the efficiency with which emerging and developing economies use labour and capital in productive economic activity.

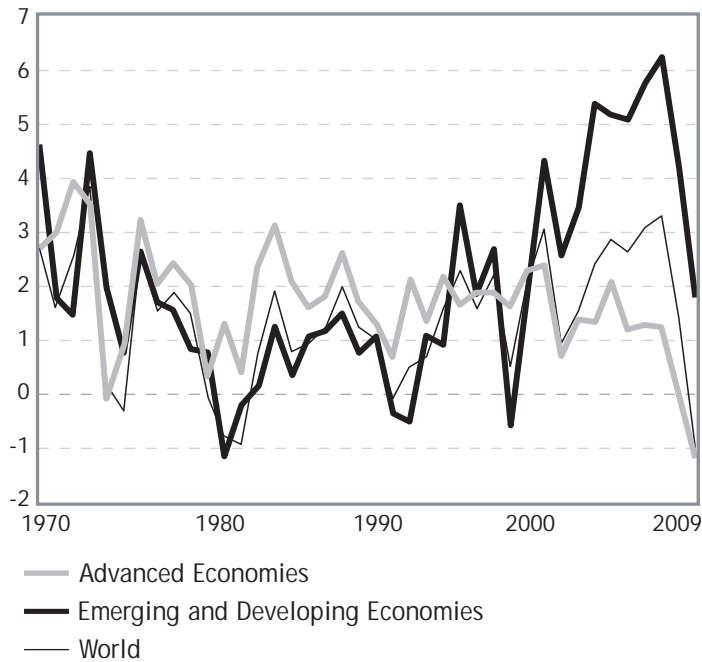
AGAINST THE BACKDROP OF the recession, global productivity, measured as output per person employed, fell 1.0 per cent in 2009 according to preliminary estimates published as part of The Conference Board Total Economy Database in January 2010. This decline in world productivity is the first significant contraction of that benchmark since the early 1980s (Chart 1). The current productivity slowdown has hit countries across the world. Still there remains a large diversity between advanced econo-

mies, on the one hand, and emerging and developing economies, on the other. When measured as a group, advanced economies saw the growth rate of labour productivity fall from 1.3 per cent in 2007 to -1.2 per cent in 2009. In emerging and developing economies it dropped from 6.3 per cent in 2007 to 1.8 per cent in 2009.² Between the advanced economies themselves there has also been high diversity, with the United States performing at considerably higher labour productivity growth rates than most

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2 Advanced economies include United States, EU15, Japan, Canada, Switzerland, Norway, Israel, Iceland, Cyprus, Korea, Australia, Taiwan, Hong Kong, Singapore and New Zealand. Emerging and developing economies include China, India and countries in developing Asia, Latin America, Middle East, Africa, Central & Eastern Europe, Russia and other Commonwealth of Independent States countries.

Chart 1
Growth of GDP per Person Employed, 1970-2009
 (Per Cent per Year)



Note: Growth rates are based on the difference in the log of the levels of each variable. Advanced economies includes North America, the EU-15 (pre-2004 membership), and the following countries in the Asia-Pacific: Australia, Hong Kong, Japan, Korea, New Zealand, Taiwan and Singapore. Also Cyprus, Iceland, Israel and Switzerland are included in the advanced category. The rest of the world relates to emerging and developing economies.

Source: The Conference Board Total Economy Database, January 2010.

European countries during 2009. Also Asian economies have generally performed better than other emerging economies.

While short-term productivity movements are highly volatile during peaks and troughs, the long-term trend worldwide over the past three decades has been toward faster productivity growth (Chart 2). This is mainly due to emerging and developing economies that have rapidly taken over leadership in productivity growth since the early 2000s. In contrast, the average long-term growth of labour productivity in advanced economies has stalled since 2000, even though the trend in the United States started slowing after 2004 only. How-

ever, levels of productivity in emerging and developing countries are still much lower than in the advanced economies, leaving substantial scope for catching up and a strengthening of competitiveness relative to advanced economies.

Total factor productivity (TFP) growth, which measures the change in GDP growth over the compensation-share weighted growth of combined factor inputs (labour and capital inputs, adjusted for change in their quality), has weakened in advanced countries, dropping from 0.4 per cent per year in the period between 1995 and 2005 to -0.1 per cent from 2005 to 2008. TFP growth in emerging and developing economies, on the other hand, has strongly improved from 1.0 per cent in 1995-2005 to 2.2 per cent in 2005-2008 (Chart 3). During the most recent years (2007-2009), total factor productivity has remained at much higher growth rates in emerging and developing economies than in advanced economies.

The above summary of measures of productivity, output and input is based on The Conference Board Total Economy Database. It is a detailed dataset that provides output, input and productivity for 123 countries around the world since 1950. The purpose of this database is to facilitate international comparisons of productivity performance at the macroeconomic level by providing consistent and reliable data; to support empirical and theoretical research in the area of productivity and growth accounting; to examine long term growth trends; and to provide a basis for growth forecasts and projections.

In this overview article, we first discuss the key characteristics of the database. We then introduce the growth accounting methodology and the construction of the variables. In the final section we present a brief analysis of some of the major results observed from the January 2010 release of the database.

Organization, Data Sources and Methodology of the Total Economy Database

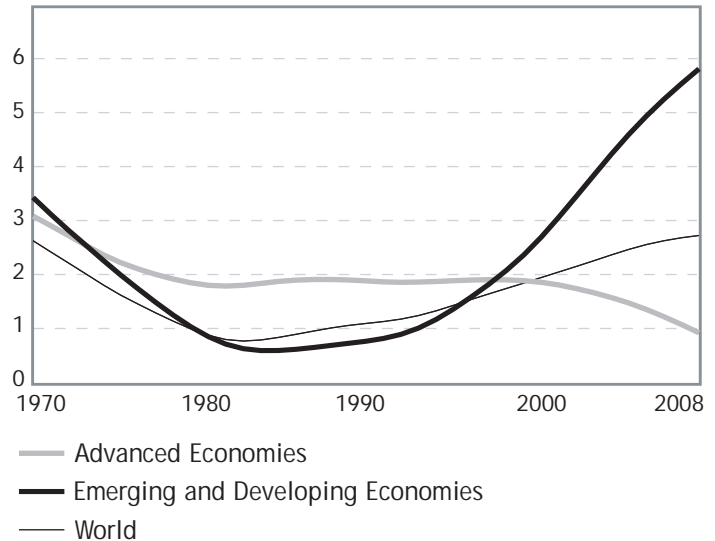
Organization of the database and public access

The Conference Board Total Economy Database was originally developed by the Groningen Growth and Development Centre at the University of Groningen in the Netherlands in the early 1990s. Since the late 1990s, it has been produced in partnership with The Conference Board, and as of 2007 the database was transferred from the University of Groningen to The Conference Board in New York, which has maintained and extended the database since then.

Two distinguishing features of the database are its wide country coverage and its timeliness. The scant and inconsistent data in emerging and developing economies is the bottleneck for most international comparisons. The Total Economy Database makes use of information from the latest national accounts, labour force surveys, and other employment statistics available for individual countries. In order to maximize international consistency, the figures are largely derived from the most reliable international sources, such as the Organization for Economic Cooperation and Development (OECD); the Statistical Office of the European Union (Eurostat); the International Monetary Fund (IMF); the International Labour Organization (ILO); and the World Bank. However, for many countries data from international sources have been supplemented with those from national statistical offices to increase timeliness when possible. Hence in most cases the estimates are updated to the year $t-1$, where t is the current year (in this case 2010), using a combination of forecasts and estimates up to the third quarter of the year.

The database provides annual estimates of the levels and growth rates of GDP, total population, employment, hours, labour quality, capital

Chart 2
Labour Productivity Growth Trend, 1970-2008
(GDP per Person Employed)



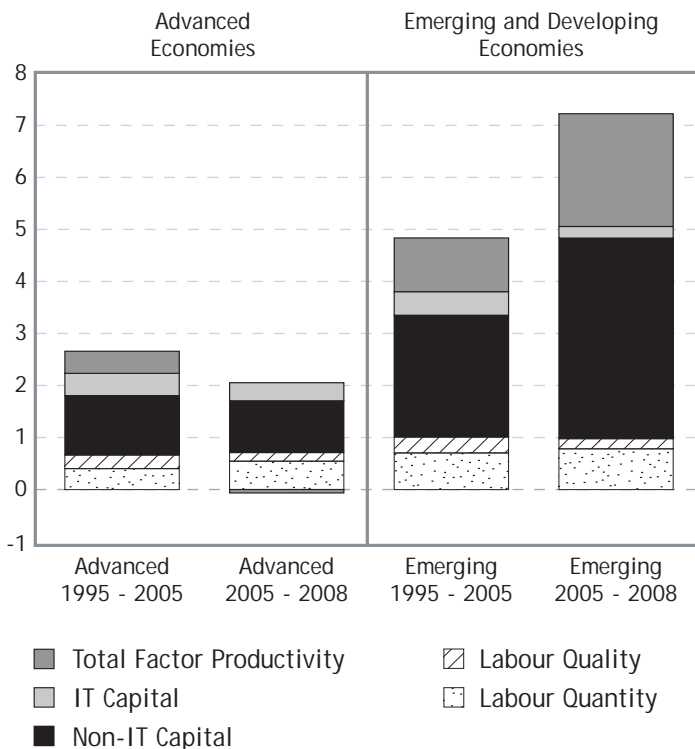
Note: The trend was obtained from the annual estimates in chart 1a using a Hodrick-Prescott filter with a $\lambda = 100$. The trend runs only to 2008, as the observations for 2009 are regarded as too volatile to determine the long-run trend at this point in time. See also Chart 1

Source: The Conference Board Total Economy Database, January 2010.

services, labour productivity, and total factor productivity starting from 1950 for 123 economies in the world, representing 97 per cent of the world's population and 99 per cent of global output. The level estimates are expressed in 2009 U.S. dollars, and converted at purchasing power parity to adjust for differences in relative price levels between countries. The database is publicly released every year in January, with series covered up to year $t-2$ (2008 in the current version), preliminary estimates for the year $t-1$ (i.e. 2009) and projections for the current year t (i.e. 2010).

With the latest release (January 2010), the database has been extended with a module on sources of growth, including labour quantity and quality, capital services (non-ICT and ICT), and total factor productivity. The extended module aims to integrate two previous data sets: the world economy productivity data set created

Chart 3
Decomposition of Sources of Output Growth, 1995-2008
 (Average annual percentage point contributions)



Note: Growth rates for 1995-2005 and 2005-2008 are the averages of yearly growth rates. See also Chart 1

Source: The Conference Board Total Economy Database, January 2010

by Dale Jorgenson and Khuong Vu of Harvard University (Jorgenson and Vu, 2009)³ and the Total Economy Growth Accounting Database of the Groningen Growth and Development Centre (Ypma, Timmer and van Ark, 2003; Timmer and van Ark, 2005).⁴

The data series are publicly available without charge from The Conference Board Total Economy Database website (<http://www.conference->

[board.org/economics/database.cfm](http://www.conference-board.org/economics/database.cfm)). The main results have been discussed in a short publication for members of The Conference Board in January, *The Productivity Brief* (The Conference Board, 2010), which is a prelude to The Conference Board's annual Performance Report to be released in the Fall with an updated version of the database.

Below we provide a brief description of data sources and methodology including the latest changes, in particular to the use of PPPs, the aggregation to regional and world averages and the introduction of TFP estimates. More detail on the methodology can be found in the document *Methodological Notes* and detailed source descriptions are given in *Detailed Sources*. These files are all downloadable from the database website.

Output: GDP and Purchasing Power Parities

The most frequently used measures of efficiency of an economy is labour productivity, which is the average output produced per unit of labour. Labour productivity estimates are obtained by dividing the real output measure (Gross Domestic Product) by the total labour input used to produce that output. Two measures of labour productivity are included: output per person employed and output per hour for countries with total hours data available.

The output measures in the database represent Gross Domestic Product at market prices, which are obtained from national accounts sources from international organizations and national statistical institutes.⁵ The post-1990

3 See also Dale Jorgenson's website: <http://www.economics.harvard.edu/faculty/jorgenson>.

4 See also The Groningen Growth and Development Centre website: http://www.ggdcc.net/databases/ted_growth.htm

5 Our focus here is on the aggregate economy, which includes non-market and semi-public services such as health and education services, as well as public administration and defense. Measurement problems in these industries are substantial, and in several cases (in particular for government), output growth is measured using input growth which is affecting the aggregate productivity numbers. Another problem case is real estate where output mostly reflects imputed housing rents rather than sales of firms. Productivity measures of the market economy, excluding these industries, are not available for as many countries as in this study.

measures are obtained from a variety of sources, including the National Accounts and Economic Outlook of the OECD, national accounts data from Eurostat, and the IMF World Economic Outlook Database. Pre-1990 measures are mostly obtained from historical series, collected by Angus Maddison (2007).⁶

To allow international comparisons of the levels of labour productivity, output levels are adjusted by purchasing power parities (PPPs) to take into account the differences in price levels. The measures of GDP and productivity levels are expressed in constant U.S.-dollar market prices for 2009, and are adjusted for cross-country differences in the relative prices of goods and services using PPPs. Two measures of GDP in dollars are available from the database, one which is converted at EKS PPPs and the other at Geary-Khamis (GK) PPPs.⁷ The original EKS series, which are measured in constant 2005 U.S. dollars and are extrapolated to 2009 with GDP deflator changes, are unpublished estimates from Penn World Tables (PWT). These estimates, which were kindly provided by Alan Heston and will be used in the upcoming version of PWT 7, are benchmarked on the 2005 PPPs from the International Comparisons Project (ICP) at the World Bank (World Bank, 2008), and are available for 111 of the 123 countries in the database.⁸ The adjustments made by PWT reflect:⁹

- 1) an adjustment for global weighting for individual countries using EKS weights over domestic absorption (DA) for all countries

rather than over five main regions as was done in the ICP by the World Bank;

- 2) an adjustment for the net foreign balance using the PPP for domestic absorption (DA) rather than the exchange rate as in the ICP; and
- 3) a downward adjustment in the PPP for China, which originally was based on relatively high prices for 11 cities, in order to better reflect the impact of relatively lower prices in rural areas in China, which were not adequately reflected in the original World Bank estimate.

The effect of the first two adjustments increased GDP (in U.S. dollars) for the global economy (all countries excluding the United States) by 7.6 per cent relative to the U.S. in 2005. The China correction adds another 2 percentage points to global GDP (excluding the United States, which is the benchmark country). For China specifically the first two effects lead to an upward adjustment in GDP of 13 per cent relative to the World Bank measure, and together with the adjustment for prices (the third effect) even to an upward adjustment of 28.5 per cent of the World Bank GDP level for China.¹⁰

Geary-Khamis series of GDP are expressed in 1990 U.S. dollars and are available for all of the 123 countries in the database. The benchmark year estimates were in almost all cases derived from Maddison (2007). Maddison used a PPP for China which was constructed for 1986, and which is much lower than the

6 For the latest Maddison estimates, see: http://www.ggd.net/Maddison/Historical_Statistics/horizontal-file_03-2009.xls

7 "EKS" stands for the originators of this PPP formula, Eltoto, Kovacs and Szulc, which essentially is a multilateral Fisher index. Geary and Khamis are the originators of a PPP formula, which is a multilateral index similar to binary Paasche index, giving relatively large weights to large countries.

8 The following 12 countries in the Total Economy Database are not covered by the PWT PPPs thus do not have GDPEKS series: Algeria, Barbados, Costa Rica, Dominican Republic, Guatemala, Jamaica, Myanmar, St. Lucia, Trinidad & Tobago, Turkmenistan, United Arab Emirates and Uzbekistan.

9 We thank Alan Heston for providing the PWT rework of the ICP PPP data. For a detailed description on the PWT PPPs, see Angus Deaton and Alan Heston (2009).

10 See also Ravallion (2010) who defends the World Bank measures of the China PPP, but admits to an upward bias due to the undercoverage of rural prices in China.

recent PPP obtained by the ICP/World Bank. As a result Maddison's GDP level for China in U.S. dollars is roughly 40 per cent higher than that of the World Bank. We adjusted Maddison's GDP level for China downwards by 22.6 per cent, which brings it closer to the adjustments for China in the PWT PPP index, as described above.

Labour quantity: Employment and hours worked

From the perspective of productivity measurement, it is very important that the measures of employment used are consistent with the measures of output. In this regard, the key concern is that employment figures need to cover all persons engaged in productive activity that fall within the production boundary of the system.¹¹ In terms of production boundary, the domestic concept is adopted which includes all workers employed domestically, but excludes any nationals working abroad. Employment therefore should include employees, self-employed as well as unpaid family members that are economically engaged, apprentices and the military.

The employment data for most advanced countries since the 1990s are from the National Accounts (domestic concept) from the OECD and Eurostat, supplemented by the growth rates mostly from labour force surveys to extrapolate backward the employment levels for earlier years. For many developing countries, the employment figures do not strictly follow the international standard defined above due to the lack of qualified data sources.¹²

Still, output per person employed is a crude measure of labour productivity. Total hours worked measures the quantity of labour input more accurately, and is defined as the aggregate number of hours actually worked during the year in employee and self-employment jobs. Series of hours worked are currently available for 51 countries in the database with OECD and Eurostat National Accounts being the major data sources for recent years. These data sources aim to ensure that the total hours worked is within the production boundary and that it is consistent with the employment data used in the database.

Growth accounting

Output and labour quantity allow for the calculation of labour productivity. Another type of productivity measure is total factor productivity (TFP), which is average output produced by a combination of multiple inputs, including labour and capital input, and with adjustments for changes in the quality of labour and changes in the composition of capital assets. To obtain total factor productivity estimates, a standard growth accounting framework is used to compute the contribution of these inputs to aggregate output (GDP) growth. The growth accounting methodology has been pioneered by Solow (1957) and further developed by Jorgenson and associates (Jorgenson and Griliches, 1967; Jorgenson, Gollop and Fraumeni, 1987).

In the general production function below, output (Y) is produced by an input bundle X , consisting of capital services (K) and labour services (L_0). Capital services are decomposed

11 Employment has been defined by the International Labour Organization (ILO) in the "Resolution concerning statistics of the economically active population, employment, unemployment and underemployment," adopted by the thirteenth International Conference of Labour Statisticians. It is defined consistently in the System of National Accounts 1993 (1993 SNA) and European System of Accounts 1995 (1995 ESA). ILO: <http://www.ilo.org/public/english/bureau/stat/res/index.htm>; 1993 SNA XVII: Population and Labour Inputs: <http://unstats.un.org/unsd/sna1993/toctop.asp>; 1995 ESA Chapter 11 Population and Labour Inputs: <http://circa.europa.eu/irc/dsis/nfaccount/info/data/esa95/en/esa95en.htm>.

12 For example, the employment figures for most African and Mid-East countries are actually labour force data, which are unadjusted for unemployment or underemployment.

into six asset types: computer hardware; software; telecommunications equipment; dwellings, buildings and structures; transport equipment; and machinery. Labour services (L_Q) are the product of labour quantity (L) and labour quality (Q). Input (X) is augmented by a Hicks-neutral total factor productivity (A).

$$1) \quad Y = AX(L_Q, K)$$

Under the assumption of perfect competitive factor markets (where the marginal product of each input equals its price) and constant returns to scale, the above production function can be transformed into the following growth accounting framework:

$$2) \quad \Delta \ln Y = \Delta \ln A + v_L \Delta \ln L + v_Q \Delta \ln Q + \sum_{i=1}^6 v_{K_i} \Delta \ln K_i$$

where $\Delta \ln X$ denotes the growth rate of variable X over two time periods, v 's stand for the average input shares in total factor income and because of constant returns to scale, $v_L + \sum_{i=1}^6 v_{K_i} = 1$. Equation (3) can be arranged to per hour/worker terms:

$$3) \quad \Delta \ln y = \Delta \ln A + v_L \Delta \ln Q + \sum_{i=1}^6 v_{K_i} \Delta \ln k_i$$

where y is labour productivity, defined as $y=Y/L$, the ratio of total output to labour quantity, and k is capital deepening, defined as $k=K/L$, the ratio of capital services to labour quantity. Total hours worked is a preferred measure of labour quantity. When this variable is not available in most developing and emerging economies, total employment is used instead under the assumption that the average hours worked per person do not change and the change in total hours worked equals the change in total employment. Equation (2) and (3) illustrate that the output growth is driven by a share weighted input growth and TFP growth, a residual that captures all sources of growth which are left unexplained by labour and capital services in the production function.

Labour quality

The labour input, whether in terms of total employment or hours worked, represents a series of labour quantity. In order to measure labour's contribution to output growth, an adjustment for changes in the quality of labour is needed. The labour quality index, which is constructed from a weighted summation of the percentage of labour force in low, medium and high skill levels using relative wages as weights for three skill levels respectively, ranges between 1 and 2.8 for developing economies and between 1 and 2.25 for advanced economies.¹³ Thus a labour quality index of 1 indicates that all working force population is of low skill and an index of 2.8/2.25 shows that all is of high skill. These measures are calculated on an annual basis to determine trends in the labour quality index.

The labour force skill level distribution is compiled from three databases: (1) Barro and Lee (2000), (2) EU KLEMS Growth and Productivity Accounts (Timmer *et al.*, 2007), and (3) projections by the International Institute for Applied System Analysis (IIASA, 2010). Both Barro and Lee and the IIASA projection paper classify the population of 15+ into no schooling, primary, secondary and tertiary schooling for 5-year intervals, whereas EUKLEMS categorizes the percentage of total hours worked into low, medium and high skill level on an annual basis. There are discrepancies between the three datasets in terms of both coverage (i.e. population vs. hours worked) and definitions, and we lack information to consolidate the three datasets into a unified one due to these data limitations. Instead we have used a statistical relationship among these three datasets to construct an annual labour quality index for 104 countries from 1960 onwards divided into three skill levels for the labour force. The weights for three skill levels are calculated based on the EUKLEMS

13 The following weights are used: 1 for low skill, 1.42 (1.36) for medium skill, 2.8 (2.25) for high skill for developing (advanced) economies.

data, and reflect average relative wages for the aggregate of advanced and for that of emerging and developing countries, and subsequently allocated to each country belonging in one of the two country groups.¹⁴

Capital services: ICT and non-ICT

We obtained measures of capital services for two major asset groups, each including three asset types: non-ICT capital, including non-residential construction, transport equipment and machinery; and ICT capital, including IT hardware, telecommunication equipment and software. For each type of asset, a capital stock series, $K_{i,t}$, is constructed from the investment data, $I_{i,t}$. The perpetual inventory method with a geometric depreciation rate is used as follows:

$$4) \quad K_{i,t} = (1 - \delta_i) \times K_{i,t-1} + I_{i,t}$$

All values in the above equation are in real terms (quantities). The initial capital stocks $K_{0,i}$ are obtained by assuming initial values equal to $\frac{I_{i,0}}{(g + \delta_i)}$, where g is the average GDP growth rate and $I_{i,0}$ is the investment in asset type i in the initial period. The same set of depreciation rates, δ_i , is used for all countries:

- for non-ICT capital: construction – 0.03, Transport – 0.2, Machinery – 0.13
- for ICT capital: IT Hardware – 0.3, Telecom Equipments – 0.12, Software – 0.46

Growth in capital services flow is measured by the weighted sum of growth in different types of capital stock.

$$\Delta \ln K = \ln K_t - \ln K_{t-1} = \sum_i \bar{v}_{i,t} \Delta \ln K_{i,t}$$

The weights in the above equation are two-period average shares (that is, the average of the shares in period t and period $t-1$) of each asset type in the value of total capital compensation.

$$6) \quad \bar{v}_{i,t} = \frac{[V_{i,t} + V_{i,t-1}]}{2}$$

$$7) \quad \bar{v}_{i,t} = \frac{p_{i,t} K_{i,t}}{\sum_i p_{i,t} K_{i,t}}$$

The rental price $p_{i,t}$ of capital services from asset type i in period t is defined as

$$8) \quad p_i = r_t + \delta_i - \pi_{i,t}$$

In the above rental price equation, r_t is the nominal rate of return and $\pi_{i,t}$ is the asset price inflation (or capital gains). The asset price inflation is calculated using *current* price and *constant* price investment series. The *ex-post* or internal rate of return is calculated by estimating the capital revenue for each time period from the labour compensation share data:

$$9) \quad (1 - LabShare_t) \times GDP_t^{Current} = \sum_i p_i \times K_{i,t}$$

If labour share data are not available or the estimated internal rates of return are negative or very large, *ex-ante* rates of return are taken from the IMF International Financial Statistics series on central bank discount rate, government bond yield and lending rate.

The aggregated growth rates of capital services (ICT and non-ICT) are calculated as the weighted sum of growth rates of individual capital stocks, using the shares in capital compensation obtained from equation 6, 7 and 8 as weights. The total compensation share of capital input in output is derived as the residual, i.e. one minus the share of labour compensation in total factor income.

The data on non-ICT investment by asset type is based on the Penn World Tables investment dataset, as described and reworked by Erumban (2008). For OECD countries, the Penn World Tables dataset is extended by linking it with OECD investment series from the year 2004 onwards. For non-OECD countries, data are available only for aggregate gross fixed capital formation from United Nations National Accounts, and we used the 2004 distribution from Penn World Tables for later years. The asset-specific investment price deflators are obtained by using the rates of asset-price inflation in 2004 for individual

¹⁴ See Bonthuis, 2009, for a more detailed explanation.

countries obtained from PWT for the later years as well.

The Jorgenson & Vu (2009) dataset is used to integrate the data for ICT investment with non-ICT investment. These datasets are extended to more recent years using *WITSA Digital Planet Report 2008*, published by the World Information Technology and Services Alliance (WITSA). Since WITSA only reports total expenditure on ICT, the purchases made by consumers need to be removed to obtain the estimates for the investments in ICT assets. The estimation of business investment (out of the total reported in WITSA) is based on the latest values in the Jorgenson & Vu dataset for the year 2005. These series also need to be converted to constant prices or volume series. The price deflators for the years 2006–2008 are estimated by assuming the same rate of ICT asset-price inflation as in 2005 for the later years as well.

Labour share

The labour share, defined as the ratio of total labour compensation to gross value added at basic prices, is used to assign weights to labour and capital inputs in the growth accounting equation. The labour shares from EUKLEMS are used whenever the data are available. OECD and Eurostat also report data on labour compensation for employees, which are used to fill the gaps. In those cases we assume that the compensation for self-employed can be imputed from the average compensation for employees by adjusting the employee labour compensation share for the employee share among total employment to obtain the total labour compensation share among GDP.

For a number of large non-OECD, non-EU countries, we estimated the labour share using alternative sources. In the case of China, the

labour share is estimated from input-output tables. For Brazil, India and Russia the labour share is calculated using compensation data from the ILO. For the other emerging and developing economies, we use 0.5 as the labour share. In much of the growth accounting literature, a labour share of 0.7 is widely used across time and countries.¹⁵ However, we decided to use 0.5 as the labour share for emerging and developing economies, because capital is relatively scarce in most of those remaining economies, and thus its return is high, while labour is cheap compared to advanced countries, leading to a lower labour share. Also, the adjustment for the labour share that is allocated to self-employed remains relatively large in many developing economies.

Aggregation of levels and growth rates

Growth rates for individual countries are calculated using the log difference in levels instead of the percentage change in the actual level. We chose this method in order to facilitate aggregation as well as decomposition of the growth for individual countries and components.

With regard to the aggregation to regional country groupings, the following methods are used for GDP, labour input and labour productivity growth respectively:

$$10) \Delta \ln Y_{region} = \sum_i \bar{w}_i \Delta \ln Y_i$$

$$11) \Delta \ln L_{region} = \Delta \ln \sum_i L_i$$

$$12) \Delta \ln y_{region} = \sum_i \bar{w}_i \Delta \ln y_i$$

$$+ (\sum_i \bar{w}_i \Delta \ln L_i - \Delta \ln \sum_i L_i) = \sum_i \bar{w}_i \Delta \ln y_i + R$$

with w_i as the country share in PPP adjusted nominal GDP of the region for each year and a bar denoting the two-period average. Hence aggregate GDP growth is the weighted sum of the country GDP growth. Growth in labour quantity (employment or hours) is simply the

15 For example, Gollin (2002) identified and compared several adjustments for calculating labour shares and concluded that factor shares are approximately constant across time and countries within a range of 0.65 to 0.80.

log difference of the summed total labour quantity values for all the countries in one region. The aggregate labour productivity growth is the weighted sum of country productivity growth rates plus a reallocation term R . This reallocation term is positive if employment shifts from low productivity countries towards high productivity countries.

The levels of regional GDP and labour productivity are calculated by applying the above PPP-adjusted current GDP-weighted growth rates to the benchmark year, 2009.¹⁶ The labour productivity in 2009 is simply calculated as $\sum_i Y_i / \sum_i L_i$.

Aggregate total factor productivity growth rates for different regions are calculated by using the aggregate output, input and labour shares from the growth accounting equation. Aggregate output and input (quality adjusted labour input¹⁷ and capital services) growth rates are calculated by taking the weighted average of individual country growth rates. The weights used are two period averages of the country shares in the PPP-adjusted nominal GDP of the group for each year. The aggregate labour compensation share for each year, i.e., $\bar{v}_{L,region}$, is obtained by summing up the labour compensation (PPP adjusted) of individual countries and then dividing this sum by total nominal GDP (PPP adjusted) of the group. A bar on the regional labour compensation share indicates the two-period average. Thus the regional TFP growth rates are calculated using the formula below:

$$13) \Delta \ln A_{region} = \Delta \ln Y_{region} - \bar{v}_{L,region} \Delta \ln L_{Q,region} - (1 - \bar{v}_{L,region}) \Delta \ln K_{region}$$

A Bird's Eye View of Recent Productivity Measures

Table 1 summarizes the productivity, output and total hours growth rates for a selected group of advanced economies. Despite the deep recession, labour productivity growth in the United States strengthened in “per hour” terms in 2009 to 2.5 per cent, up from 1.4 per cent in 2008. Productivity growth in other advanced economies was much weaker in 2009: 0.3 per cent in Japan, -1.0 per cent in the Euro Area, and as much as -1.9 per cent in the United Kingdom. Hence the productivity growth differential between the United States and the Euro Area in 2009 is 3.5 percentage points, and between the United States and the United Kingdom, it stands at 4.4 percentage points. For comparison, the productivity growth differential between the United States and the Euro Area was only 1 percentage point between 1995 and 2005 and 0.2 percentage points between the United States and the United Kingdom.

While estimates for 2009 are still preliminary, and adjustments are made to both the output and hours numbers once more definitive data from the national accounts and employment statistics are published, the productivity growth differential is so large that some important observations already emerge. First, the differences among advanced countries (or regions) partly reflect differences in output declines during 2009, which were much higher in Japan (-5.6 per cent), the Euro Area (-4.1 per cent), and the United Kingdom (-4.8 per cent) than in the United States (-2.5 per cent). The second factor, however, is the much larger number of hours lost in the United States as a result of a very

16 2009 is set as the benchmark year for the aggregate levels in order to be consistent with other tables in the Total Economy Database (January 2010). Although the choice of benchmark year affects the levels, it does not affect the growth rates of GDP and labour productivity.

17 For countries with missing labour quality data, labour input reflects the change in labour quantity only, i.e., the change in employment or total hours worked. Consequently, total factor productivity growth in those countries is somewhat overstated due to this missing input component. However, because of the generally small contribution of the labour quality in the output growth, the TFP overestimation is relatively low in magnitude.

Table 1
Growth of Labour Productivity, Real GDP and Total Hours Worked
for Advanced Countries, 1995-2009

	United States	Japan	Euro Area	United Kingdom	France	Germany	Italy	Spain	Canada
Labour Productivity Growth (GDP per hour, annual average, per cent)									
1995-2005	2.4	2.1	1.4	2.2	1.8	1.6	0.5	0.5	1.5
2005-2009	1.5	0.8	0.5	0.9	0.8	0.2	-0.8	2.0	0.1
2007	1.4	1.8	1.1	2.3	-0.2	0.7	0.1	1.6	0.4
2008	1.4	0.1	0.1	1.0	0.4	-0.3	-0.5	1.5	-0.7
2009 (estimate)	2.5	0.3	-1.0	-1.9	0.3	-2.2	-3.2	3.8	-0.2
Real GDP Growth (annual average, per cent)									
1995-2005	3.3	1.1	2.2	2.9	2.2	1.3	1.4	3.6	3.6
2005-2009	0.7	-0.5	0.6	0.4	0.6	0.4	-0.6	1.2	0.6
2007	2.1	2.4	2.7	3.0	2.2	2.4	1.4	3.5	2.5
2008	0.4	-0.7	0.6	0.5	0.3	1.0	-1.1	0.9	0.4
2009 (estimate)	-2.5	-5.6	-4.1	-4.8	-2.3	-5.0	-4.9	-3.7	-3.2
Growth in Total Hours Worked (annual average, per cent)									
1995-2005	0.9	-1.0	0.8	0.7	0.4	-0.3	0.9	3.1	1.7
2005-2009	-0.9	-1.3	0.1	-0.5	-0.2	0.1	0.2	-0.8	0.5
2007	0.7	0.5	1.6	0.7	2.4	1.8	1.3	1.9	2.1
2008	-0.9	-0.8	0.4	-0.5	-0.1	1.3	-0.5	-0.6	1.1
2009 (estimate)	-5.1	-5.9	-3.1	-2.8	-2.6	-2.8	-1.7	-7.5	-3.0

Note: Growth rates are based on the difference in the log of the levels of each variable
Source: The Conference Board Total Economy Database, January 2010

sharp reaction of firms to the crisis. Hours worked declined 5.1 per cent in the United States, with 3.6 percentage points caused by job shedding and another 1.5 percentage points attributable to a reduction in the working hours of workers who still had jobs. Labour hoarding in Europe was a much larger factor, as the Euro Area saw total working hours decline 3.1 per cent, of which 1.9 percentage points were related to job losses.

Greater flexibility in labour markets may be seen as one cause for the divergent patterns between the United States and the Euro Area, but it probably does not tell the whole story as Japan, which does not have a particularly flexible

labour market either, also saw a large decline in total hours worked (-5.9 per cent), which reflected a loss of 3 per cent in workers and almost 3 per cent in hours worked per worker. In contrast, the United Kingdom which has among the most flexible labour markets in the European Union, showed a pattern that was not all that different from the Euro Area. In the United Kingdom hours fell 2.8 per cent, of which 2.0 percentage points were due to a decline in employed persons.

While productivity growth in 2009 was negative in most European countries, there were significant variations between major countries. Germany performed far worse than France (-2.2

Table 2
Growth of Labour Productivity, Real GDP and Persons Employed
for Major Emerging Economies, 1995-2009

	Major Emerging Economies	Brazil	Russia	India	China	Mexico	Indonesia	Turkey
Labour Productivity Growth (GDP per persons, annual average, per cent)								
1995-2005	4.1	0.3	3.7	4.2	6.7	1.4	1.5	3.6
2005-2009	5.9	2.6	3.7	5.2	9.6	0.5	2.1	1.0
2007	7.6	3.5	7.0	6.2	11.5	1.6	3.6	3.1
2008	5.3	4.0	4.7	4.0	8.6	-0.9	1.0	-1.2
2009 (estimate)	3.6	1.5	-3.8	3.9	8.2	-0.3	-0.3	-3.2
Real GDP Growth (annual average, per cent)								
1995-2005	5.5	2.4	3.8	6.3	7.8	3.6	3.1	4.2
2005-2009	7.1	3.8	4.2	7.6	10.0	2.0	5.5	1.9
2007	9.1	5.5	7.8	8.6	12.2	3.2	6.1	4.6
2008	6.8	5.7	5.4	6.5	9.2	1.4	5.9	0.9
2009 (estimate)	4.1	0.0	-3.8	5.8	7.7	-1.5	4.7	-4.5
Growth in Persons Employed (annual average, per cent)								
1995-2005	1.4	2.0	0.1	2.0	1.1	2.2	1.6	0.7
2005-2009	1.3	1.2	0.5	2.3	0.4	1.5	3.4	0.9
2007	1.5	2.0	0.8	2.4	0.8	1.7	2.5	1.5
2008	1.6	1.7	0.8	2.4	0.6	2.2	5.0	2.1
2009 (estimate)	0.5	-1.5	0.0	2.0	-0.5	-1.2	5.0	-1.3

Note: Growth rates are based on the difference in the log of the levels of each variable

Source: The Conference Board Total Economy Database, January 2010

per cent in Germany and 0.3 per cent in France) due to a deeper contraction in output in Germany (-5.0 per cent) than France (-2.3 per cent). Interestingly, Germany lost no jobs in net terms, as all the loss in working hours (-2.8 per cent) was due to shortening of working hours of employees who stayed in employment. France's more moderate decline in output and slight increase in productivity relates to the smaller impact of exports on the economy, which was severely hit in Germany, and the sustained growth of the public sector. While both Italy and Spain suffered strong output declines (-4.9 per cent in Italy and -3.7 per cent in Spain), Spain shed hours five times as rapidly (-7.5 per cent) as Italy (-1.7 per cent). Much of the employment losses were in construction and

tourism, which is characterized by a large share of temporary, less well-protected jobs. Consequently, labour productivity increased by 3.8 per cent in Spain while it declined by 3.2 per cent in Italy.

Table 2 provides a summary of the growth rates for seven leading emerging economies: Brazil, China, India, Indonesia, Mexico, Russia and Turkey. On average, labour productivity growth of these major emerging economies group was 3.6 per cent in 2009, which was down by 1.7 percentage points from the 5.3 per cent rate in 2008. But there were large differences among the emerging economies. China showed the strongest output and productivity performance in 2009 at 7.7 per cent and 8.2 per cent respectively.¹⁸ This was largely the result of a boom in bank loans and

rapid investment in infrastructure, which stimulated output growth and at least temporarily boosted the investment-intensive activities of state-owned enterprises (SOEs). Although employment estimates are extremely difficult to obtain, the evidence from a variety of partial sources suggests that employment growth in China stalled as a result of layoffs by private companies, especially export-oriented firms. Hence, while overall productivity increased, there may have been important underlying structural changes that may impact China's productivity trend ahead. For example, SOEs and infrastructure construction probably occupied a larger footprint in the economy in 2009 than before.

While Brazil and Mexico have been among the weakest productivity performers historically, their performance diverged as Brazil's output, employment, and productivity performance strengthened in recent years. Productivity growth in Brazil stood at 1.5 per cent in 2009, down from 4.0 per cent in 2008, whereas productivity growth in Mexico continued to be negative in 2009 (-0.3 per cent in 2009 following a 0.9 per cent decline in 2008). In contrast, in addition to China, Indonesia and India strengthened their performance in recent years; as they were relatively shielded from the global crisis because of moderate exposure to exports and the global financial world, their performance remained reasonably strong during the recession. Labour productivity in India grew at 3.9 per cent in 2009 as a result of 5.8 per cent GDP growth and 2.0 per cent employment growth. The negative productivity growth in Indonesia (-0.3 per cent) is a result of faster growth in employment than GDP (4.7 per cent for GDP growth and 5.0 per cent for employment growth). In contrast, Russia and Turkey, which were both strongly exposed to the global crisis, suffered most in terms of output (-

3.8 per cent and -4.5 per cent respectively), employment (0 per cent and -1.3 per cent respectively), and productivity (-3.8 per cent and -3.2 per cent respectively).

While the short-term improvements in productivity help countries position themselves to exploit their growth potential, the actual trigger for sustainable growth is the long-term productivity trend (see also Chart 2), which is also the main source for improvements in living standards. To accelerate the long-term productivity trend, growth needs to come from not only investment in inputs, which equip workers with higher skills and better tools to produce, but also from an increase in the efficiency with which these inputs (such as labour, workforce skills, machinery, and technology inputs) are used, i.e., the total factor productivity growth.

Table 3 and Chart 4 show the sources of output growth for major regions and countries. For the world economy, the output growth of 4.4 per cent from 2005 to 2008 was partly due to an increase in labour input, which contributed 0.7 percentage points to output growth. Another 0.2 percentage point was due to an improvement in the quality of the labour force, measured as the skill level of the labour force according to their level of educational attainment. Most of the output growth in the world, however, has been due to a rise in non-ICT capital: it accounted for half (2.2 percentage points) of total output growth (4.4 per cent). ICT capital contributed 0.4 percentage points to output growth from 2005-2008, leaving a residual growth (TFP) of 0.9 per cent. In contrast, during the earlier period 1995-2005, ICT capital contributed 0.5 percentage points to output growth, leaving a TFP residual of only 0.6 per cent. The acceleration of TFP growth after 2005 might represent a more efficient use of capital, which may relate to either ICT or non-ICT capital.

18 Note that growth rates are based on the difference in the log of the levels of each variable. For example, China's GDP growth rate in 2009 changed from 8.0 per cent, when calculated in percentage terms, to 7.7 per cent when using log differences.

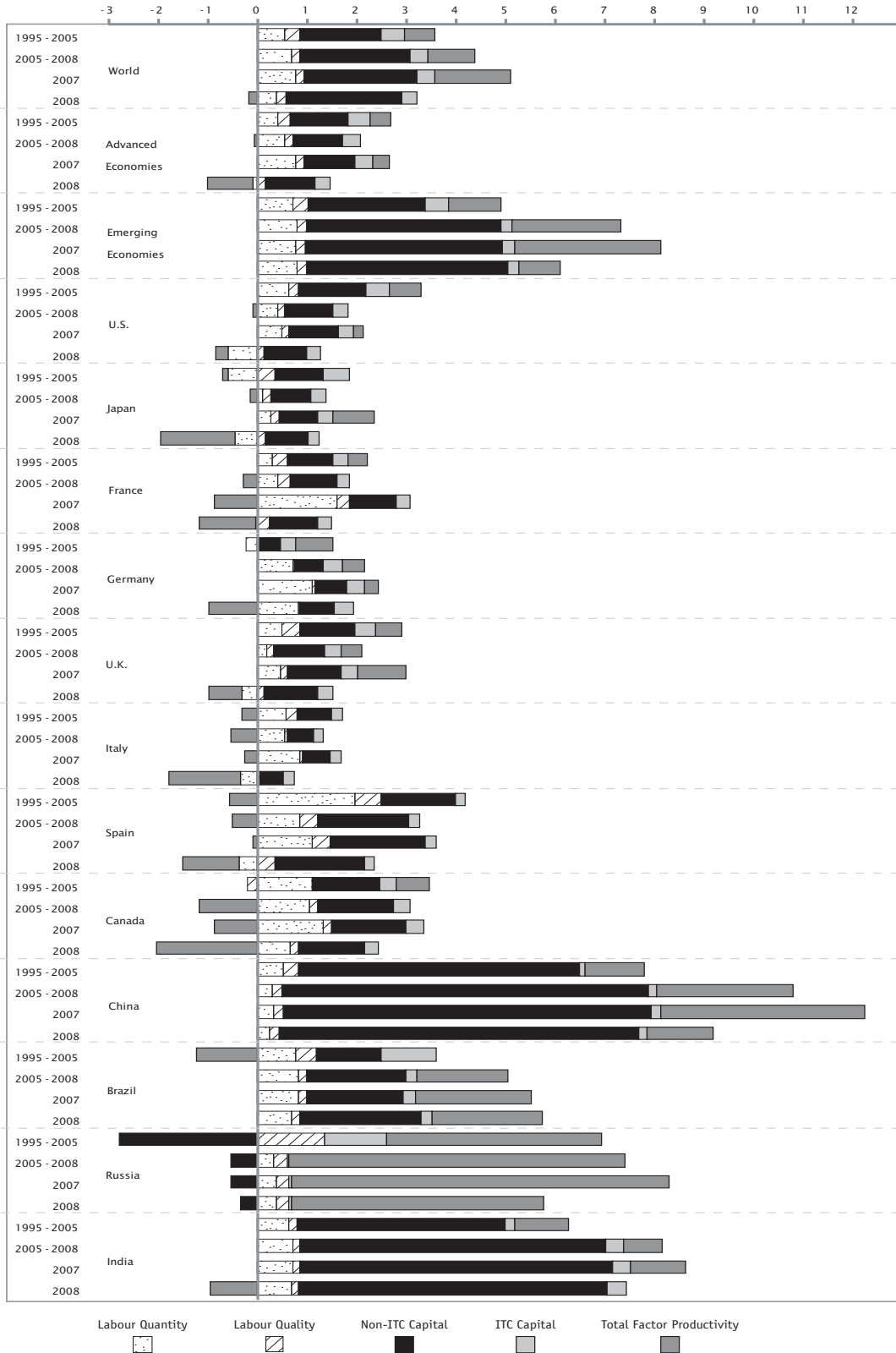
Table 3

Contribution of the Change in Inputs and TFP to Average Annual Output Growth by Country and Region, 1995-2005, 2005-2008, 2007, 2008
(percentage points per year)

Country	Period	Labour Quantity	Labour Quality	Non-ICT Capital	ICT Capital	Total Factor Productivity	Total GDP Growth
World	1995-2005	0.55	0.29	1.64	0.47	0.62	3.6
	2005-2008	0.68	0.18	2.23	0.35	0.94	4.4
	2007	0.76	0.18	2.26	0.36	1.53	5.1
	2008	0.40	0.18	2.32	0.32	-0.18	3.0
Advanced Economies	1995-2005	0.41	0.26	1.16	0.43	0.43	2.7
	2005-2008	0.55	0.17	1.01	0.35	-0.07	2.0
	2007	0.77	0.17	1.04	0.35	0.34	2.7
	2008	-0.09	0.17	0.98	0.32	-0.92	0.5
Emerging Economies	1995-2005	0.71	0.31	2.37	0.46	1.04	4.9
	2005-2008	0.79	0.20	3.90	0.23	2.19	7.3
	2007	0.77	0.20	3.96	0.24	2.95	8.1
	2008	0.79	0.19	4.06	0.22	0.85	6.1
United States	1995-2005	0.63	0.19	1.37	0.48	0.63	3.3
	2005-2008	0.41	0.13	0.97	0.30	-0.09	1.7
	2007	0.50	0.13	1.01	0.30	0.18	2.1
	2008	-0.59	0.13	0.87	0.26	-0.24	0.4
Japan	1995-2005	-0.58	0.35	0.97	0.53	-0.14	1.1
	2005-2008	0.12	0.16	0.82	0.29	-0.15	1.2
	2007	0.28	0.16	0.78	0.31	0.84	2.4
	2008	-0.44	0.15	0.85	0.23	-1.50	-0.7
France	1995-2005	0.29	0.31	0.92	0.30	0.39	2.2
	2005-2008	0.41	0.24	0.94	0.28	-0.29	1.6
	2007	1.61	0.24	0.95	0.27	-0.86	2.2
	2008	-0.03	0.24	0.99	0.27	-1.14	0.3
Germany	1995-2005	-0.23	0.02	0.44	0.31	0.75	1.3
	2005-2008	0.71	0.04	0.59	0.38	0.46	2.2
	2007	1.11	0.04	0.64	0.38	0.27	2.4
	2008	0.82	0.04	0.70	0.39	-0.98	1.0
United Kingdom	1995-2005	0.49	0.36	1.12	0.41	0.52	2.9
	2005-2008	0.19	0.14	1.03	0.33	0.42	2.1
	2007	0.47	0.14	1.07	0.34	0.96	3.0
	2008	-0.31	0.13	1.08	0.32	-0.67	0.5
Italy	1995-2005	0.57	0.22	0.71	0.20	-0.32	1.4
	2005-2008	0.55	0.06	0.52	0.21	-0.54	0.8
	2007	0.87	0.06	0.55	0.21	-0.24	1.4
	2008	-0.34	0.05	0.47	0.21	-1.45	-1.1
Spain	1995-2005	1.98	0.53	1.49	0.19	-0.57	3.6
	2005-2008	0.85	0.36	1.84	0.22	-0.50	2.8
	2007	1.11	0.36	1.90	0.22	-0.09	3.5
	2008	-0.36	0.35	1.80	0.21	-1.15	0.9
Canada	1995-2005	1.12	-0.19	1.34	0.34	0.67	3.3
	2005-2008	1.06	0.16	1.51	0.35	-1.18	1.9
	2007	1.33	0.16	1.51	0.35	-0.87	2.5
	2008	0.67	0.16	1.32	0.30	-2.03	0.4
China	1995-2005	0.52	0.32	5.63	0.13	1.20	7.8
	2005-2008	0.30	0.19	7.37	0.18	2.74	10.8
	2007	0.32	0.19	7.41	0.18	4.12	12.2
	2008	0.25	0.19	7.23	0.18	1.32	9.2
Brazil	1995-2005	0.77	0.42	1.29	1.13	-1.23	2.4
	2005-2008	0.82	0.17	1.99	0.23	1.84	5.1
	2007	0.82	0.17	1.96	0.23	2.34	5.5
	2008	0.69	0.17	2.45	0.22	2.21	5.7
Russia	1995-2005	0.01	1.34	-2.78	1.26	4.33	4.2
	2005-2008	0.34	0.26	-0.55	0.05	6.77	6.9
	2007	0.37	0.26	-0.53	0.05	7.60	7.8
	2008	0.38	0.26	-0.32	0.05	5.10	5.4
India	1995-2005	0.62	0.19	4.18	0.19	1.09	6.3
	2005-2008	0.71	0.14	6.15	0.37	0.76	8.1
	2007	0.71	0.14	6.29	0.36	1.12	8.6
	2008	0.70	0.14	6.21	0.38	-0.94	6.5

Chart 4

Contribution of the Change in Inputs and TFP to Output Growth by Country and Region, 1995-2005, 2005-2008, 2007, 2008



The panels for the aggregate advanced and emerging economies show the diverging developments in TFP growth especially since 2005. While Germany and the United Kingdom still generated some TFP growth, largely related to the peak of the business cycle, TFP growth stalled in Japan and even somewhat declined in France — reflecting the greater inefficiency of the growth process.

The faster output growth rates of emerging and developing economies (at 7.3 per cent, relative to 2.0 per cent in advanced economies from 2005 to 2008) is largely due to the faster increase in non-ICT capital, especially in China and India, and a much higher efficiency by which the inputs are being used, especially in China. In 2008, the overall TFP growth rates for emerging and developing economies was still at 0.85 per cent, although lower than the average of 2.2 per cent from 2005-2008. This was mainly due to the start of the recession and the cooling of the Chinese and Indian economies. However, even among emerging economies there are substantial differences: China showed an increase of 1.3 per cent in TFP growth in 2008, which was modest compared to 2.2 per cent in Brazil and 5.1 per cent in Russia, but much better than the -0.9 per cent decline in India. The Brazilian and Russian economies probably received a TFP bonus from the price boom in natural resource production in 2008, while in India, the contribution of capital to growth remained at the same level despite a significant deceleration in output growth in 2008. The rise in the long-term TFP trend puts the emphasis for future growth even more strongly on the emerging economies. This raises their competitive strength, as it helps these countries to match higher costs, such as rising wages, by their ability to lower costs and prices through efficiency gains.

Conclusion

It should be stressed again that there are substantial uncertainties concerning the productivity estimates for recent periods. National statistical offices often make significant adjustments to their output and employment estimates as the measures from a range of surveys and administrative sources come in with a delay of several months, and are sometimes adjusted significantly during the process of reconciliation of the various sources. Annual GDP growth estimates can be adjusted by as much as one per cent upward or downward for advanced countries and sometimes more for emerging economies while the adjustments for employment are usually much smaller.

Nevertheless, we believe that “real time” productivity figures provide useful insights as they provide signals on how the direction of the productivity trend may be affected by the latest estimates, and how the differences between countries can play out. For example, while the post-1995 productivity growth differential between the United States and the EU-15 (i.e. the EU member state constellation before 2004) has been adjusted following several statistical revisions, the productivity growth differential remained at roughly 1 percentage point with the United States showing an approximately 2.5 per cent increase in GDP per hour in 1995-2005 vis-à-vis one and a half per cent in the European Union. The semi-annual updates in The Conference Board Total Economy Database, however, keep track of ongoing revisions in the data.

Projections of productivity growth are surrounded by even more uncertainties, particularly in times of structural shifts such as in current times. However, on the basis of GDP forecasts and assumptions on the degree of procyclicality of productivity growth, the following projections may be seen as plausible given the current economic situation in various countries.

Following its dismal performance in 2009, global productivity is expected to improve sharply to 2 per cent or even more in 2010. This increase will be the result of the combination of a projected recovery in world GDP of more than 3 per cent and a modest increase in world employment. Advanced economies will mostly see jobless productivity growth as labour markets recover slowly, although limited technology and innovation gains could lead to higher than expected job growth in less productive (in several non-market) service industries. Most emerging and developing economies will experience a combination of productivity and employment growth in 2010. This not only reflects their growing contribution to world output growth, but also a strengthening of their global competitiveness based not only on their low relative cost, but also on increasingly higher productivity.

A long-term improvement in the productivity trend will depend on a revival of global demand, stimulated by technological change and innovation. The growth accounting approach, which is now integrated in The Conference Board Total Economy Database, provides the framework for the next step which is to develop medium term projections of the sources of growth to strengthen the forecasts of GDP growth in international comparative perspective. This sets the agenda for the next version of the database, which will also include an increase in the number of countries included.

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