Technology, TFPG and Employment: A Panel Data Analysis

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Abstract
This paper based on the United Nations Industrial Development Organization (UNIDO) panel data set makes an attempt to estimate total factor productivity growth (TFPG) across countries. Productivity convergence over time is evident when countries are divided across regions which could be attributed to a greater degree of association of countries in a given region pursuing joint efforts for infrastructural development, ICT coverage and advancement, trade negotiations, technology acquisition and innovation, and inflow of FDI. In terms of efficiency estimates for select years, most of the countries are seen to be operating much below the frontier. This is indicative of the fact that countries are keen to pursue resource-driven growth in an attempt to maximize it. Based on the inter-temporal data, we observed that a number of countries registered either a negative or a positive but low correlation between labour productivity growth and TFPG. Evidently, countries are engaged in greater mechanization which may be raising labour productivity without ushering in much success in terms of TFPG. From panel data regression, the impact of technology perceived in terms of TFPG, on employment, is seen to be negligible though it is important to note that none of the groups, income or region-wise, recorded a statistically significant negative effect except the least developed countries (LDCs), while the significant cases (howsoever scanty) reveal a positive association. Appropriate incentives may motivate firms to experience technological progress and employment growth both.

Keywords Technology · Innovation · Productivity · Growth · Employment

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1 Analytical Framework

Non-resource-driven growth is the key to sustainable development in the long run, else resource intensive economic growth can result in crisis in the future years. Technological advancement is endemic to economic growth, and growth in output which is more than proportionate increase in inputs is attributed to total factor productivity growth (TFPG), after controlling for returns to scale. Therefore, decomposing growth in terms of resource-driven and non-resource-based components, the endogenous growth models can be relooked to identify the major determinants of the latter part, i.e. TFPG. Endogenous growth models urge that research and development (R&D) expenditures taken as a broad proxy for innovative moves contribute directly to firms’ productivity enhancement, and indirectly through their industry-wide spill-over effects (see Grossman & Helpman 1990; Romer; 1986). Similarly, import of technology and foreign direct investment (FDI) can also result in technological advancement, contributing to TFPG.

At the global level, TFPG has witnessed a deceleration in the recent past which is a matter of serious concern. In the light of Kuznets’ (1966) modern economic growth, while the developing countries may be trying to catch up with the developed countries by investing in factors that contribute to productivity and growth, the gap between the two sets of countries may not actually disappear. This is likely to happen only when the developed countries are able to pursue technological progress in a continuous manner, translating into shifts in higher levels of productivity. However, the productivity decline in the recent past is indicative of poor performance both from the point of view of the developed as well as developing countries. Investment growth has slowed down in both developed and developing countries with implications on innovation, skills and infrastructure, and through these factors on productivity (Das 2018). The technological progress among the leaders has decelerated, while the developing countries are not able to raise their performance in terms of productivity. Even when factor input contributions remained relatively strong, TFPG declines occurred in the emerging market economies (Erumban & Ark 2018). The contribution of ICT has reached a saturation point (Erumban & Ark 2018) as the cost of capital for the price of IT capital input is very large relative to the cost of capital comprising non-IT input (Jorgenson 2018). Though the labour share is on the decline, the share of intangible capital is on the rise and the globalization process with its consequent effect on value chain has possibly resulted in productivity declines in the developed countries without commensurate increase in productivity growth in the developing countries as their growth is resource intensive. Besides, the cost of knowledge workers using ICT might have been on the rise, reducing the TFPG (Jorgenson 2018).

The other issue relates to the effect of technology on employment. A large number of studies have argued that new technology, particularly when it is imported from the labour scarce developed countries, is capital and skill intensive, which may be reducing the pace of employment creation, particularly from the point of view of the unskilled variety of labour (Berman and Machin 2004; Acemoglu 2003). The import of capital and skill intensive technology from the
developed to the developing world results in sluggish employment growth though UNIDO (2005) urged that such technology mobility should be facilitated by other means of reforms on the macro-front. Globalisation and the economic reforms pursued by most of the countries at the behest of World Bank-IMF initiation did witness a sharp decline in the effective rate of protection and other trade barriers all of which encouraged import of technology. The adoption and adaptation of these international technologies are indeed costly because of tacit knowledge and circumstantial sensitivity of technology (Evenson & Westphal 1995). Further, unless an importing country has significant technological capability, it cannot fully utilize the imported technology. Besides, imported technology may require more skilled than unskilled workers, while developing countries usually have an abundant supply of the latter type. Acemoglu and Zilibotti (2001) argued that due to the difference in skill scarcity, technology in developed countries tends to be skill intensive and is inappropriate for developing countries. Though UNIDO (2005) argues that it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel, there can be serious implications in terms of employment loss.

On the other hand, a number of reasons are cited to suggest that new technology in developing countries can still create new employment opportunities. Vivarelli (2013) for example argues that the new technology may enhance profitability, resulting in new investment with job avenues. The displacement and compensation mechanisms which are at work have been discussed with great details by Vivarelli (2013). He reminds that labour-saving and deskilling effects of capital-intensive technology have been a concern since the Luddite movement of the early 19th century. However, he also draws attention to the theoretical debate, which identifies a range of compensation mechanisms that may alleviate such concerns. Labour-saving effects of technology can be offset through: (i) additional employment in industries producing the new machines; (ii) higher demand for goods/services due to lower prices; (iii) new investments made using extra profits; (iv) decreases in wages resulting from price adjustment mechanisms; (v) higher income resulting from redistribution of innovation gains; and (vi) new products created using new technologies. Mitra and Jha (2015) further noted that innovation of new technology may lead to an expansion in the activities of firms such as processing of by-products, without any proportionate increase in capital. All this is expected to raise employment in absolute terms though labour to value added ratio may not increase in comparison with its pre-innovation magnitude.

The paper uses the UNIDO data for the organized manufacturing across 132 countries for the period ranging from 1990 to 2010. The definition of the organized sector may be different across the countries, and hence, the interpretation needs to be made carefully. The study proposes to estimate TFPG and technical efficiency (TE) for several countries (relatively more number of developing countries) and decipher patterns, if any. It also examines the relationship between TFPG and labour productivity growth (LPG) in order to throw light on the dampening effect of TFPG. The effect of technology perceived through changes in TFPG/TE and the number of patents, on employment, comprises another important dimension of the paper.
Information on patent and per capita income in constant prices is taken from the World Bank data set. The variables such as value added, wage rate and capital in different countries are given in nominal terms by UNIDO, and they are subjected to the influence of foreign exchange movement and domestic inflation. In order to convert them into real terms, we have considered the figures in international currency (dollar) based on the average exchange rate prevailing over 1990–2010 and then deflating the figures by the country-specific implicit price deflator. The methodology adopted to estimate TFPG and TE from panel data is due to Cornwell et al. (1990), where TFPG is estimated as a combination of technological progress (regress) and the change in technical efficiency. From the production function estimated on the basis of the panel data (across countries and over time), the coefficient of time trend is taken as the pace of technological progress (regress).

In the second stage using the residuals as a quadratic function of time for each country separately, TE and the change in TE (dTE/dt) have been estimated. Then, the estimated values of the residual from all the country specific regressions, using the inter-temporal data, have been pooled and relative to the maximum value the efficiency index for each country and for every year has been generated: \( \exp(residual - max\ residual) \). Thus, though the technological progress is perceived to be common for all countries over a given time period, which in a globalizing world is quite a realistic assumption, the change in technical efficiency over time is perceived to be different across countries. Hence, TFPG over time and across countries is likely to have considerable variations (for details on the methodology see appendix).

The rest of the paper is structured as follows: Section 2 focuses on the TFPG estimates across countries over different time constellations and tries to verify if the cross-sectional variations in productivity estimates are converging in a broad sense. Section 3 turns to the relationship between labour productivity and TFPG in order to reflect on whether the contribution of non-resource-driven growth is driving the factor productivity or whether the rise in productivity of one factor (labour) is mainly related to capital accumulation without improvement in the overall performance. Section 4 turns to the relationship between technology and employment. Improvements in technology may raise productivity which in turn tends to reduce the utilisations of all factors including labour. Alternately, technological progress makes technology cheaper, improves the accessibility of all types of firms, expands the scale of production and encourages the processing of by-products, all resulting in rise in employment. Finally, Section 5 summarizes the major findings.

### 2 TFPG Estimates

Though the year-to-year estimates of TFPG and TE have been derived for the period 1990–2010 depending on the availability of data, in the appendix table 2, we present the estimates for a few select years only, which is again not available uniformly for each of the countries due to missing information. In Table 1, we have tried to present a summary of TFPG estimates based on the figures for the 1990s and the 2000s. The number of countries in Table 1 has dropped considerably in comparison with the table in the appendix due to the lack of data. However, the pattern suggests that
Table 1  Total Factor Productivity Growth over the Years

|         | 1990’s                         | 2000’s                         |
|---------|--------------------------------|--------------------------------|
|         | Negative                      | Low                            | Medium                        | High                           |
| 2000s   | Cyprus                         | China, Macao SAR               | China, Hong Kong SAR           |                                |
|         | Ethiopia                       | Japan                          | Luxembourg                     |                                |
|         | Iran (Islamic Republic of)     | Morocco                        | Republic of Korea              |                                |
|         | Kuwait                         |                                |                                |                                |
|         | Philippines                    |                                |                                |                                |
|         | Spain                          |                                |                                |                                |
|         | Turkey                         |                                |                                |                                |
|         | Uruguay                        | Low                            | Austria                        | Ecuador                        |
|         |                                |                                | Norway                         |                                |
|         |                                | Low                            | India                          |                                |
|         |                                | Norway                         | Israel                         |                                |
|         |                                | Medium                         | Malaysia                       |                                |
|         | Germany                        | Finland                        | Belgium                        |                                |
|         | Italy                          | Oman                           | Netherlands                    |                                |
|         | Malta                          | United States of America       |                                |                                |
|         | Portugal                       |                                |                                |                                |
|         | Romania                        | High                           | Denmark                        | United Republic of Tanzania    |
|         |                                |                                | Ireland                        |                                |
|         |                                | High                           |                                |                                |
|         | Eritrea                        | Sri Lanka                      |                                |                                |
|         | Hungary                        | Sweden                         |                                |                                |
|         | Jordan                         | United Kingdom                 |                                |                                |
|         | Latvia                         |                                |                                |                                |
|         | Malawi                         |                                |                                |                                |
|         | Mexico                         |                                |                                |                                |
|         | New Zealand                    |                                |                                |                                |
|         | Poland                         |                                |                                |                                |
|         | Singapore                      |                                |                                |                                |
|         | Slovakia                       |                                |                                |                                |
|         | Slovenia                       |                                |                                |                                |
|         | Viet Nam                       |                                |                                |                                |

Low, medium and large refer to range of values in terms of growth rates. Low (0–2%), Medium (2–5%), High (5% & above)

Source: Based on UNIDO Data
quite a few countries, many of which belong to the developed world, experienced a rise in TFPG in the 2000s, while they had recorded either a negative or a low TFPG in the 1990s (Table 1).

Based on the year-to-year estimates, the cross-sectional variations are measured after dividing the countries into various income groups. From the results, for all countries combined, a significant decline is evident in the standard deviation of TFPG estimates, which may be interpreted as a sign of sigma convergence. Across various groups of countries, however, such a pattern is not evident. For example, among the least developed countries (LDCs), the long-term pace of decline in the variation is mild though the humps of the early nineties and late nineties and early 2000s were not repeated thereafter. Similarly, in the case of low-income countries, again the cross-country variation in TFPG seems to have become less volatile in the 2000s though the extent of long-term decline in the sigma is mild. Among the lower middle income, upper middle income and high-income countries, the drop in the sigma magnitude is prominent though, for the last group, the country experiences tend to widen sharply during 2007–2010 (Fig. 1).

Looking at the sigma value (the standard deviations) after dividing the countries across regions East Asia and Pacific, Europe and Central Asia and Latin America and Caribbean, countries seem to have registered a steady fall, indicating convergence in the productivity growth experience of the countries. Middle East and North Africa on the other hand unfold a rising tendency in the productivity growth witnessed across countries within the group. South Asia, with missing data for the years between 2002 and 2005, reveals a rise in the country-wide variation in productivity growth towards the end of the 2000s, though between 1990 and 2001, sigma convergence was taking place. Sub-Saharan countries after experiencing a sharp increase in the productivity growth variation during the nineties witnessed a major decline in the sigma value which is also less fluctuating on year-to-year basis. On the whole, in several regions in the world, there is a tendency of productivity convergence, though the value around which countries in each region are converging may itself vary from region to region. This could be attributed to a greater degree of association of countries in a given region pursuing efforts jointly for infrastructural development, ICT coverage and advancement, trade negotiations, technology acquisition and innovation, and inflow of FDI.

Looking at the efficiency estimates for select years (appendix table), most of the countries are seen to be operating much below the frontier. This is indicative of the fact that countries are keen to pursue resource-driven growth in an attempt to maximize the growth strategy in the wake of globalization. Without bothering to use the resources optimally or to exploit the existing capacity to the maximum possible extent, countries are in a mad rush to raise the growth magnitude which would indeed show up in the future years, resulting in its non-sustainability. The standard deviation computed from the TE magnitudes across countries seems to be declining except in the case of lower middle income countries, high-income countries and region-wise, East Asia and Pacific, South Asia, and Sub-Saharan Africa (Fig. 2). In other words, in some of the groups of countries, the competitiveness is high, and hence, efforts are on to catch up in terms of the utilization of resources. Countries which were lagging behind have tried to get closer
to the relatively better performers though most of them may still be operating much below the frontier. In other words, there is enormous scope to utilize the resources efficiently.
As mentioned in Sect. 1, there has been a productivity decline (in terms of TFPG) across the globe since the advanced countries are not able to raise it steadily while
many developing countries are not able to exploit the productivity advantages in a sustainable manner. In the backdrop of globalization, many of the developing countries are involved in maximizing the growth strategy without exploring the
Fig. 2  (continued)
possibilities of raising the non-resource-driven component. Hence, the growth story and the TFPG trajectories may not match in many countries. Labour productivity growth which is in fact much more directly observable and can be closely related to the overall growth experience of the countries can then be assessed in relation to TFPG. In other words, whether the non-resource-driven growth component is translating itself to labour productivity growth or the latter is growing more independently using up the existing resource base? For example, on a priori basis, increased capital per worker may result in rapid labour productivity growth without any major dent on TFPG.

Based on the inter-temporal data for each of the countries, we observe from Table 2 that a number of countries registered either a negative or a positive though low, correlation between labour productivity growth and TFPG. Relatively fewer countries show a positive and medium/high correlation between the two variables. Evidently, countries are engaged in greater mechanization which may be raising the labour productivity without ushering in much success in terms of total factor productivity that tries to conserve all the resources and not one at the expense of the other.

Dividing the time period into two phases, Table 3 indicates that most of the countries which showed a negative or weakly positive correlation between labour productivity growth and TFPG in the nineties continued to remain so in the 2000s as well. Only a handful of countries graduated to unfold a better association between these variables. Only a few countries like Denmark, Malawi, Malta and Ethiopia moved from negative correlation to medium-/high-correlation category and France, Denmark and Sri Lanka improved from low-to-medium correlation category. So, on the whole, the countries’ strategy to catch up in terms of growth does not seem to be based on resource-saving approach which is indeed a key to sustainable development.

The regression results\(^1\) which in addition to TFPG include the number of patents as a determinant of labour productivity are suggestive of the fact that patents are insignificant in the LDCs and the low-income countries, while it is significant in lower middle income, upper middle income and high-income countries. Region-wise, the Latin American and Caribbean and South Asian countries again unravel a significant impact of patents on labour productivity (Table 4). TFPG, on the other hand, is a significant determinant in a number of groups of countries including the aggregate results (all countries combined). In terms of income, the least developed and low-income countries and region-wise East Asia and Pacific, Middle East and North Africa, North America and Sub-Saharan African countries show TFPG as an insignificant determinant of labour productivity growth. In other words, many of the countries in regions largely corresponding to the developing world are not engaged in resource-saving pursuits. The production processes in these countries adhere to resource intensive growth, which in future can pose serious challenges.

\(^1\) Three sets of estimates—OLS, Fixed Effect (FE) and Random Effect (RE)—were generated, and based on the test statistic, the appropriate model has been retained.
Table 2  Inter-temporal Correlation between Labour Productivity and TFPG in Each of the Country

| Correlation between Annual Growth of Labour Productivity & TFPG (Over the Period 1990–2010) | Negative | Low | Medium | High |
|---|---|---|---|---|
| Albania | Austria | Azerbaijan | Australia |
| Armenia | Bahamas | Denmark | Barbados |
| Bangladesh | China, Hong Kong SAR | Eritrea | Belarus |
| Belgium | Ecuador | Estonia | Botswana |
| Bolivia (Plurinational State of) | Georgia | France | Bulgaria |
| Cameroon | Germany | Hungary | Chile |
| Central African Republic | Indonesia | Kenya | Czech Republic |
| China, Macao SAR | Ireland | Kuwait | Egypt |
| Colombia | Italy | New Zealand | Greece |
| Cyprus | Jordan | Panama | Nigeria |
| El Salvador | Latvia | Poland | Peru |
| Ethiopia | Luxembourg | Slovakia | Romania |
| Fiji | Madagascar | Slovenia | Thailand |
| Finland | Malawi | United Kingdom | The f. Yugosl. Rep. of Macedonia |
| Iceland | Malaysia | Uruguay | Trinidad and Tobago |
| India | Malta | Netherlands | Norway |
| Iran (Islamic Republic of) | Norway | Oman | Portugal |
| Japan | Portugal | Spain | Sweden |
| Lithuania | Sri Lanka | Spain | Sweden |
| Mauritius | Spain | Sweden | Spain |
| Mexico | Sri Lanka | Spain | Sweden |
| Mongolia | Sweden | Spain | Spain |
| Morocco | Venezuela (Bolivarian Republic of) | Spain | Spain |
Table 2 (continued)

Correlation between Annual Growth of Labour Productivity & TFPG (Over the Period 1990–2010)

| Negative | Low | Medium | High |
|----------|-----|--------|------|
| Niger    |     |        |      |
| Philippines |   |        |      |
| Republic of Korea | |        |      |
| Republic of Moldova | |        |      |
| Singapore |     |        |      |
| Swaziland |    |        |      |
| Tunisia  |     |        |      |
| Turkey   |     |        |      |
| Ukraine  |     |        |      |
| United Republic of Tanzania | |        |      |
| United States of America | |        |      |
| Viet Nam |     |        |      |

Low is less than and equal to 0.3; medium is greater than 0.3 and up to 0.6, and high is greater than 0.6
In the previous section, we noted that the contribution of TFPG to labour productivity growth is not substantial and much of the labour productivity growth has accrued due to capital accumulation. In this section, we turn to a more fundamental question: is the modern technology itself averse to employment creation? In other words, effect of technology on employment is an important concern. Whether technological growth tends to reduce employment or it can be conducive to employment growth is a pertinent issue. If technological development means lesser utilization of all the factors of production for the same level of output, then naturally, it tends to reduce employment per unit of output as well. But, if it reduces the utilization of some of the factors of production and not labour, then both technology and employment can go hand in hand. In support of this view, it may be argued that output growth is faster than the growth of some of the inputs such as capital but not labour because the

| Table 3 Correlation between Labour Productivity and TFPG in the 1990s and 2000s |
|-----------------------------------------------|
| Correlation between Annual Labour Productivity Growth & TFPG:                  |
| 1990s                                                                 |
| Negative | Low | Medium | High |
|-----------|-----|--------|------|
| Austria   |     |        |      |
| Belgium   |     |        |      |
| Cameroon  |     |        |      |
| China, Macao SAR | | | |
| Hungary   |     |        |      |
| Iran (Islamic Republic of) | | | |
| Oman      |     |        |      |
| Slovakia  |     |        |      |
| Sweden    |     |        |      |
| United States of America | | | |
| Low       |     |        |      |
| Estonia   |     |        |      |
| India     |     |        |      |
| Latvia    |     |        |      |
| New Zealand |   |  | |
| Norway    |     |        |      |
| Singapore |     |        |      |
| Medium    |     |        |      |
| Denmark   |     |        |      |
| Malawi    |     |        |      |
| Malta     |     |        |      |
| High      |     |        |      |
| Ethiopia  |     |        |      |

Low is less than and equal to 0.3; medium is greater than 0.3 and up to 0.6, and high is greater than 0.6

4 Technology and Employment

In the previous section, we noted that the contribution of TFPG to labour productivity growth is not substantial and much of the labour productivity growth has accrued due to capital accumulation. In this section, we turn to a more fundamental question: is the modern technology itself averse to employment creation? In other words, effect of technology on employment is an important concern. Whether technological growth tends to reduce employment or it can be conducive to employment growth is a pertinent issue. If technological development means lesser utilization of all the factors of production for the same level of output, then naturally, it tends to reduce employment per unit of output as well. But, if it reduces the utilization of some of the factors of production and not labour, then both technology and employment can go hand in hand. In support of this view, it may be argued that output growth is faster than the growth of some of the inputs such as capital but not labour because the
Table 4  Regression Results for Annual Labour Productivity Growth (Dependent Variable)

| VARIABLES          | All Countries (RE) | LDC Low Income | Lower Middle Income (RE) | Upper Middle Income (RE) | High Income (RE) | East Asia & Pacific | Europe & Central Asia | Latin America & Caribbean (RE) | Middle East & North Africa | North America | South Asia (RE) | Sub-Saharan Africa (RE) |
|--------------------|---------------------|----------------|--------------------------|--------------------------|------------------|---------------------|----------------------|--------------------------|---------------------------|----------------|----------------|------------------------|
| TFPG               | 1.104***            | − 1.051        | 0.166**                  | 2.166***                 | 0.769***         | − 0.0568            | 1.889***             | 1.160***                 | 0.167                      | − 1.505        | 0.258***        | 0.228                  |
|                    | (0.342)             | (1.741)        | (1.843)                  | (0.0654)                 | (0.339)          | (0.220)             | (0.358)              | (0.453)                  | (1.046)                    | (9.687)        | (0.0812)       | (0.264)                |
| Patents            | 2.20e–05            | − 0.134        | − 0.553                  | 0.00218**                | 0.00166**        | 7.60e–06***         | 1.29e–05             | 0.000284                 | − 0.0544***                | 0.00126        | 1.49e–05       | 0.00183***              |
|                    | (1.65e–05)          | (0.193)        | (0.339)                  | (0.000997)               | (0.000742)       | (2.73e–06)          | (3.36e–05)           | (0.00290)                | (0.0193)                   | (0.00103)      | (0.000207)     | (0.000124)              |
| Constant           | − 4.676**           | − 24.10        | − 26.01                  | − 4.734                  | − 8.683**        | 0.183               | − 1.614              | − 1.823                  | − 3.228                    | − 4.417        | 1.375          | − 6.748***              |
|                    | (2.088)             | (10.47)        | (14.72)                  | (4.644)                  | (4.411)          | (0.645)             | (1.870)              | (9.688)                  | (4.653)                    | (2.985)        | (19.01)        | (0.569)                 |
| Observations       | 854                 | 25             | 23                       | 149                      | 162              | 520                 | 149                  | 460                      | 81                        | 85             | 14             | 37                     |
| R-squared          | 0.048               | 0.050          | 0.000                    | 0.194                    | 0.019            | 0.042               |                     |                          |                           |                |                |                        |
| Number of id       | 79                  | 4              | 3                        | 19                       | 17               | 40                  | 13                   | 36                       | 13                        | 7              | 4              | 5                      |

Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1
labour contracts may involve rigidity. Labour might have been hired on a long-term basis, which can be treated as a sunk cost (fixed or variable)—a retrospective cost that has already been incurred and cannot be recovered. Besides, the operation of the new technology is not necessarily automated which involves labour displacement.

A related point is also of great interest. Even if technology leads to lesser utilization of all the factors (including labour) for a given level of output, the rise in the quantum of production certainly contributes to employment generation, i.e. the scale effect. Modernization of technology may lead to its large-scale application in various sectors of the economy, and hence, the quantum of production and employment both may increase simultaneously even when the new technology gets more capital intensive. Though labour per unit of output may be declining in absolute terms, the increase in employment can still be substantial. These issues of employment increase at the aggregate level due to wider application of the advanced technology prompted by the profit motive and are certainly of great relevance, particularly in the context of the developing economies confronted with the compulsion of maximizing growth and generating employment opportunities for the vast supplies of labour.

Nevertheless from another angle, there can be a negative effect of technology on employment. Since technological innovations largely take place in developed countries, they are made to suit these economies and their factor endowments. Incidentally, these countries are primarily labour scarce, and thus, the new technology tends to become increasingly labour saving (Pack & Todaro 1969). In other words, the developed countries are faced with a severe shortage of labour ready to pursue mechanical jobs, and thus, the innovations relating to technical progress are usually pursued with an objective of reduction in labour requirement in the production process. So technical progress and rising capital intensity proceed synonymously, which do not conflict with the labour market situation in the developed countries. However, with import liberalization if the developing countries import this sort of technology at a cheaper cost, it restricts their employment growth particularly in the high productivity formal sector. Thus, the labour-saving technical change is a definite disadvantage to developing economies (Kelley et al. 1972) though UNIDO (2005) argues that it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel. Similar is the case with innovation which is believed to be highly capital intensive.

So one hypothesis in this section is that the import of technology and innovation both being capital intensive may reduce employment. Alternately, technological progress and employment both can be positively associated due to the scale effects prompted by the reductions in technology price. This may lead to a greater accessibility and adoption of the technology and also processing of by-products which may not result in proportionate increase in capital but require greater magnitude of labour in absolute sense.

In order to test this, hypothesis log of employment is taken to be a function of log of value added and log of wage rate and the number of patents. The performance

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2 Different mechanisms of technological change and effects on jobs emerge in the work of Bogliacino and Pianta (2010).
indicator (TFPG/TE) is included to test if productivity growth or better utilization of resources results in higher output growth relative to input growth including labour or alternately and does not affect employment though reduces the use of other inputs.

Based on panel data across countries, it is observed that the elasticity of employment with respect to value added is positive across regions and various income groups though there are considerable variations in the magnitude (Table 5). The same is true in relation to wage elasticity of employment.

TFPG is an omnibus measure of technological change. It incorporates productivity growth arising from all kinds of technological change (could involve modern technologies such as robotics, artificial intelligence, or earlier generations of technologies). The concern about employment has been with reference to modern technologies. Our results show that the impact of performance indicator (TFPG) is negligible (statistically insignificant) in most of the cases except in the low and lower middle income countries and region-wise, North America. It is important to note that none of the groups, income or regions, recorded a (statistically significant) negative effect of TFPG on employment, except the LDC, while the significant cases (howsoever scanty) reveal a positive association. However, the effect of patents, wherever statistically significant, is seen to reduce employment when countries are divided as per income. On the other hand, different regions decipher differential impact: East Asia & Pacific, North America and South Asia are indicative of a negative effect, while Europe & Central Asia, Latin America & Caribbean and Middle East & North Africa show a positive impact of patents on employment.

5 Conclusion

This paper based on UNIDO panel data makes an attempt to estimate TFPG across countries and over time. Though inter-temporal comparison was not possible for a number of countries, among the ones for which a comparison could be made, many belonged to the developed world and experienced a rise in TFPG in the 2000s, while they had recorded either a negative or a low TFPG in the 1990s. However, in the case of the developing countries, such improvements were rather limited.

Productivity convergence is not evident among some of the groups of countries. For example, among the least developed countries, the long-term pace of decline in the variation is mild though the humps of the early nineties and late nineties and early 2000s were not repeated thereafter. Similarly in the case of low-income countries, again the cross-country variation in TFPG seems to have become less volatile in the 2000s though the extent of long-term decline in the sigma (standard deviation) is mild. On the other hand, among the lower middle income, upper middle income and high income countries, the drop in the sigma magnitude is prominent. Looking at the sigma value after dividing the countries across regions, East Asia and Pacific, Europe and Central Asian and Latin America and Caribbean countries seem to have registered a steady fall, indicating convergence in the productivity growth

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3 As we replace TFPG by TE (Table 6) the effect of performance index remains mixed: lower middle income and high income countries show a positive and negative effect respectively.
Table 5  TFPG and Employment-Dependent Variable: Log of Number of Employees

| Variables            | (1)          | (2)          | (3)          | (4)          | (5)          | (6)          | (7)          | (8)          | (9)          | (10)         | (11)         | (12)         | (13)         |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Log (value added)    | 0.690***     | 0.483***     | 0.528***     | 0.651***     | 0.335***     | 0.819***     | 0.823***     | 0.733***     | 0.388**      | 0.611***     | 0.571***     | 0.818***     | 0.505***     |
|                      | (0.101)      | (0.0447)     | (0.0177)     | (0.0894)     | (0.113)      | (0.0910)     | (0.0973)     | (0.167)      | (0.151)      | (0.113)      | (0.108)      | (0.107)      | (0.0886)     |
| Log (wage rate)      | −0.698***    | −0.653***    | −0.702***    | −0.629***    | −0.348**     | −0.789***    | −0.855***    | −0.765***    | −0.344*      | −0.583***    | −2.191***    | −0.583***    | −0.649***    |
|                      | (0.103)      | (0.0385)     | (0.0179)     | (0.0885)     | (0.128)      | (0.0827)     | (0.108)      | (0.176)      | (0.172)      | (0.0841)     | (0.175)      | (0.129)      | (0.0658)     |
| Patents              | −1.51e−06*** | −0.00185     | −0.00851     | −4.89e−05*** | −2.79e−05    | −1.63e−06*** | −2.00e−06*** | 2.24e−05**   | 0.00530***   | 4.33e−06*    | −1.56e−06**  | −7.43e−05**  | −0.00376     |
|                      | (2.72e−07)   | (0.00182)    | (0.0128)     | (1.40e−05)   | (1.96e−05)   | (2.09e−07)   | (1.41e−07)   | (9.50e−06)   | (0.00218)    | (2.00e−06)   | (6.94e−07)   | (1.70e−05)   | (0.00918)    |
| TFPG                 | 0.000326     | −0.00210     | −0.00627***  | 0.00321**    | −0.00141     | −0.000303    | −0.000516    | −0.00323     | 0.000728     | −0.0105      | 0.0653*      | 0.00511      | 0.00249      |
|                      | (0.000954)   | (0.000207)   | (0.000812)   | (0.00113)    | (0.00214)    | (0.00237)    | (0.00280)    | (0.00245)    | (0.00190)    | (0.00718)    | (0.0359)     | (0.00483)    | (0.00134)    |
| Constant             | 3.463**      | 6.852***     | 6.036***     | 3.585**      | 8.490***     | 1.422        | 1.793        | 3.127        | 6.289***     | 3.973*       | 23.90***     | −0.325       | 6.241**      |
|                      | (1.507)      | (0.669)      | (0.219)      | (1.346)      | (1.690)      | (1.481)      | (1.403)      | (2.334)      | (1.948)      | (1.826)      | (3.239)      | (1.898)      | (1.377)      |
| Observations         | 920          | 28           | 23           | 172          | 185          | 540          | 164          | 478          | 96           | 91           | 17           | 46           | 28           |
| R-squared            | 0.700        | 0.924        | 0.766        | 0.331        | 0.867        | 0.789        | 0.740        | 0.500        | 0.855        | 0.975        | 0.876        | 0.896        |              |
| Number of id         | 78           | 4            | 3            | 19           | 17           | 39           | 12           | 36           | 13           | 7            | 4            | 5            |              |

Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1

FE/RE model is selected on the basis of LM and Hausman statistic. It may be noted that while TFPG is a flow variable others are not so
Table 6  TE and Employment-Dependent Variable Log of Number of Employees

| VARIABLES                        | (1) All Countries | (2) LDC Low Income (RE) | (3) Low Income (RE) | (4) Lower Middle Income | (5) Upper Middle Income | (6) High Income | (7) East Asia & Pacific | (8) Europe & Central Asia | (9) Latin America & Caribbean | (10) Middle East & North Africa | (11) North America (OLS) | (12) South Asia | (13) Sub-Saharan Africa |
|---------------------------------|-------------------|-------------------------|---------------------|------------------------|------------------------|------------------|-------------------------|--------------------------|---------------------------------|-----------------------------|---------------------------|----------------|---------------------|
| Log (value added)               | 0.679***          | 0.584***                | 0.679***            | 0.363***               | 0.818***              | 0.763***        | 0.740***                | 0.410**                  | 0.544***                        | 0.588***                    | 0.787**                   | 0.521***               |
|                                 | (0.0995)          | (0.0976)                | (0.0995)            | (0.105)                | (0.0837)              | (0.112)         | (0.151)                 | (0.166)                  | (0.0543)                        | (0.0791)                    | (0.153)                   | (0.0622)               |
| Log (wage rate)                 | 0.682***          | 0.653***                | 0.726***            | 0.345**               | 0.698***              | 0.764***        | 0.674***                | 0.345*                   | 0.581***                        | 1.767***                    | 0.622**                   | 0.676***               |
|                                 | (0.0967)          | (0.0233)                | (0.0465)            | (0.124)                | (0.0720)              | (0.132)         | (0.163)                 | (0.171)                  | (0.0477)                        | (0.294)                     | (0.177)                   | (0.0425)               |
| Patents                         | 1.34e–06***       | 0.00114                 | 0.00975             | 5.41e–05***            | 2.93e–05              | 9.37e–05        | 5.77e–07               | 1.87e–05**               | 0.000556**                      | 7.26e–06**                 | 1.57e–07                  | 7.45e–05*             |
|                                 | (2.64e–07)        | (0.00236)               | (0.00979)           | (1.99e–05)            | (2.31e–07)            | (6.08e–07)      | (7.55e–06)            | (0.000235)               | (1.97e–06)                      | (6.53e–07)                 | (2.44e–05)                | (0.0116)              |
| Technical Efficiency            | 0.520             | 3.291                   | 1.974               | 0.145**               | 0.575                 | 2.070***        | 2.697                   | 1.794***                | 0.273                           | 2.837                      | 1.499                     | 0.391                   |
|                                 | (0.390)           | (4.835)                 | (1.947)             | (0.0639)              | (0.517)               | (2.239)         | (0.437)                 | (0.274)                  | (1.578)                        | (1.729)                     | (0.618)                   | (0.166)                |
| Constant                        | 3.202***          | 6.081***                | 5.188***            | 3.253***              | 7.856***              | 0.715           | 2.569                   | 2.226                   | 5.806**                        | 5.282***                    | 19.01***                 | 0.718                  |
|                                 | (1.508)           | (0.867)                 | (1.603)             | (1.466)               | (1.521)               | (1.438)         | (1.624)                 | (2.081)                  | (2.286)                        | (0.934)                     | (2.860)                   | (2.658)                |
| Observations                    | 920               | 28                      | 23                  | 172                   | 185                   | 540             | 164                     | 478                     | 96                             | 91                          | 17                        | 46                      |
| R-squared                       | 0.706             | 0.927                   | 0.746               | 0.340                 | 0.881                 | 0.805           | 0.755                   | 0.502                   | 0.851                          | 0.972                       | 0.863                    | 0.899                  |
| Number of id                    | 78                | 4                       | 3                   | 19                    | 17                    | 39              | 12                      | 36                      | 13                             | 7                           | 4                         | 5                      |

Robust standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
experience of the countries in these regions. This could be attributed to a greater degree of association of countries in a given region pursuing jointly infrastructural ventures, ICT coverage and advancement, trade negotiations, technology acquisition and innovation, and inflow of FDI.

In terms of efficiency estimates for select years, most of the countries are seen to be operating much below the frontier. This is indicative of the fact that countries are keen to pursue resource-driven growth in an attempt to maximize the growth strategy in the wake of globalization. Without being concerned to use the resources optimally or to exploit the existing capacity to the maximum possible extent, countries are in a mad rush to raise the growth magnitude which would indeed show up in the future years, resulting in its non-sustainability.

Based on the inter-temporal data for each of the countries, we observed that a number of countries registered either a negative or a positive but low correlation between labour productivity growth and TFPG. Relatively fewer countries show a positive and medium/high correlation between the two variables, be it developing or developed. Evidently, countries are engaged in greater mechanization which may be raising the labour productivity without ushering in much success in terms of overall productivity (TFP). Even with real technological change, there may not be a rise in TFPG, particularly if tangible capital cost is excessive. From panel data, it is observed that the elasticity of employment with respect to value added is positive across regions as well as various income groups though there are considerable variations in the magnitude. The same is true in relation to wage elasticity of employment. However, the impact of technology perceived in terms of performance indicator (TFPG) is negligible (statistically insignificant) in most of the cases, though it is important to note that TFPG does not necessarily tell us about the kind of technological change. But it is important to note that none of the groups, income or region, recorded a (statistically significant) negative effect of TFPG on employment, except the LDCs, while the significant cases (howsoever scanty) reveal a positive association. On the whole, TFPG has been weak, while capital deepening has been significant. Considering TFPG as a very broad proxy of technological change, we may infer that modern technology is not necessarily employment saving in absolute sense at least. The scale effect and the scope to process by-products resulting in the expansion of activities of firms may contribute to employment creation. Hence, appropriate incentives may motivate firms to experience both technological progress and employment growth.

**Appendix**

| Country          | Year | TE  | TFPG | Country                      | Year | TE  | TFPG |
|------------------|------|-----|------|------------------------------|------|-----|------|
| Albania          | 2000 | 0.01| 5.36 | China, Hong Kong SAR         | 1995 | 0.11| 5.05 |
| Albania          | 2005 | 0.02| 9.53 | China, Hong Kong SAR         | 2000 | 0.14| 3.04 |
| Albania          | 2010 | 0.04| 13.70| China, Hong Kong SAR         | 2005 | 0.16| 1.03 |
| Armenia          | 2005 | 0.06| −38.21| China, Hong Kong SAR       | 2010 | 0.17| −0.98|
| Country                     | Year | TE  | TFPG  | Country                  | Year | TE  | TFPG  |
|----------------------------|------|-----|-------|--------------------------|------|-----|-------|
| Australia                  | 1990 | 0.12| −11.84| China, Macao SAR         | 1990 | 0.09| 3.07  |
| Australia                  | 2005 | 0.10| 7.29  | China, Macao SAR         | 1995 | 0.11| 2.03  |
| Austria                    | 1990 | 0.08| 1.34  | China, Macao SAR         | 2000 | 0.13| 0.98  |
| Austria                    | 1995 | 0.09| 1.49  | China, Macao SAR         | 2005 | 0.14| −0.06 |
| Austria                    | 2000 | 0.10| 1.64  | China, Macao SAR         | 2010 | 0.14| −1.11 |
| Austria                    | 2005 | 0.12| 1.79  | Colombia                 | 1990 | 0.10| 27.35 |
| Azerbaijan                 | 2005 | 0.05| 5.98  | Colombia                 | 1995 | 0.30| 16.69 |
| Azerbaijan                 | 2010 | 0.06| 6.16  | Colombia                 | 2005 | 0.60| 4.64  |
| Bahamas                    | 1990 | 0.06| 30.63 | Cyprus                   | 1990 | 0.09| 2.60  |
| Bahamas                    | 1995 | 0.11| −7.88 | Cyprus                   | 1995 | 0.10| 0.77  |
| Bangladesh                 | 1990 | 0.04| 17.97 | Cyprus                   | 2000 | 0.10| 1.06  |
| Bangladesh                 | 1995 | 0.07| −1.68 | Cyprus                   | 2005 | 0.10| −2.89 |
| Barbados                   | 1990 | 0.05| 51.92 | Cyprus                   | 2010 | 0.08| −4.72 |
| Barbados                   | 1995 | 0.11| −19.89| Czech Republic           | 1995 | 0.04| 1.88  |
| Belarus                    | 2005 | 0.01| 0.50  | Czech Republic           | 2005 | 0.06| 8.71  |
| Belgium                    | 1990 | 0.06| 4.47  | Denmark                  | 1990 | 0.12| −7.21 |
| Belgium                    | 2000 | 0.10| 3.25  | Denmark                  | 1995 | 0.10| 3.34  |
| Belgium                    | 2005 | 0.12| 2.64  | Denmark                  | 2000 | 0.09| 0.52  |
| Bolivia                    | 1990 | 0.11| −0.15 | Denmark                  | 2005 | 0.11| 4.39  |
| Bolivia                    | 1995 | 0.09| −10.84| Ecuador                  | 1990 | 0.03| 9.66  |
| Brazil                     | 1990 | 0.90| 36.48 | Ecuador                  | 1995 | 0.05| 8.21  |
| Bulgaria                   | 2000 | 0.02| −7.53 | Ecuador                  | 2000 | 0.07| 6.75  |
| Bulgaria                   | 2005 | 0.03| 14.94 | Ecuador                  | 2005 | 0.11| 5.30  |
| Cameroon                   | 1990 | 0.04| 7.13  | Egypt                    | 1990 | 0.06| −16.90|
| Cameroon                   | 1995 | 0.05| −1.32 | Egypt                    | 1995 | 0.03| −14.49|
| Cameroon                   | 2000 | 0.04| −9.76 | Egypt                    | 2005 | 0.01| −9.68 |
| Central African Republic   | 1990 | 0.07| −10.90| El Salvador              | 1995 | 0.07| −7.10 |
| Chile                      | 1990 | 0.12| −0.67 | Eritrea                  | 1995 | 0.06| −20.31|
| Chile                      | 2005 | 0.17| 2.57  | Eritrea                  | 2000 | 0.03| −6.47 |
| China, Hong Kong SAR       | 1990 | 0.08| 7.06  | Eritrea                  | 2005 | 0.03| 7.37  |
| Eritrea                    | 2010 | 0.07| 21.21 | Indonesia                | 1990 | 0.12| −42.94|
| Estonia                    | 1995 | 0.04| −3.46 | Indonesia                | 1995 | 0.02| −22.75|
| Estonia                    | 2005 | 0.05| 8.03  | Indonesia                | 2000 | 0.01| −2.57 |
| Ethiopia                   | 1990 | 0.11| −1.96 | Indonesia                | 2005 | 0.02| 17.62 |
| Ethiopia                   | 1995 | 0.11| −2.79 | Iran (Islamic Republic of)| 1990 | 0.16| −3.00 |
| Ethiopia                   | 2000 | 0.10| −3.63 | Iran (Islamic Republic of)| 1995 | 0.14| −3.37 |
| Ethiopia                   | 2005 | 0.08| −4.47 | Iran (Islamic Republic of)| 2000 | 0.13| −3.74 |
| Fiji                       | 1990 | 0.04| 19.72 | Iran (Islamic Republic of)| 2005 | 0.11| −4.11 |
| Fiji                       | 2000 | 0.13| −0.11 | Ireland                  | 1990 | 0.16| −5.92 |
| Fiji                       | 2005 | 0.11| −10.03| Ireland                  | 1995 | 0.14| −1.53 |
| Country   | Year | TE  | TFPG | Country    | Year | TE  | TFPG |
|-----------|------|-----|------|-----------|------|-----|------|
| Finland   | 1990 | 0.08| 0.47 | Ireland   | 2000 | 0.15| 2.85 |
| Finland   | 1995 | 0.09| 1.29 | Ireland   | 2005 | 0.20| 7.24 |
| Finland   | 2000 | 0.10| 2.11 | Israel    | 1995 | 0.07| 2.49 |
| Finland   | 2005 | 0.12| 2.93 | Israel    | 2000 | 0.08| 1.96 |
| France    | 1990 | 0.08| 0.49 | Italy     | 1990 | 0.09| -2.44|
| France    | 2005 | 0.11| 0.67 | Italy     | 1995 | 0.08| -1.10|
| Georgia   | 2000 | 0.00| 21.88| Italy     | 2000 | 0.08| 0.23 |
| Georgia   | 2005 | 0.01| 12.84| Italy     | 2005 | 0.09| 1.56 |
| Germany   | 1990 | 0.11| -4.38| Japan     | 1995 | 0.12| 1.87 |
| Germany   | 2000 | 0.10| 0.14 | Japan     | 2000 | 0.13| 0.62 |
| Germany   | 2005 | 0.11| 2.39 | Japan     | 2005 | 0.14| -0.64|
| Greece    | 1990 | 0.10| -4.36| Japan     | 2010 | 0.14| -1.90|
| Greece    | 1995 | 0.09| -2.03| Jordan    | 1990 | 0.13| -9.68|
| Greece    | 2005 | 0.10| 2.64 | Jordan    | 1995 | 0.09| -5.74|
| Hungary   | 1995 | 0.05| -7.15| Jordan    | 2000 | 0.08| -1.81|
| Hungary   | 2000 | 0.04| -0.44| Jordan    | 2005 | 0.08| 2.13 |
| Hungary   | 2005 | 0.05| 6.28 | Jordan    | 2010 | 0.11| 6.06 |
| Iceland   | 2000 | 0.14| 4.98 | Kenya     | 1995 | 0.10| 49.77|
| Iceland   | 2005 | 0.08| -28.78| Kuwait   | 1995 | 0.15| -1.30|
| India     | 1990 | 0.02| 4.10 | Kuwait    | 2000 | 0.13| -5.94|
| India     | 1995 | 0.03| 3.14 | Kuwait    | 2005 | 0.09| -10.59|
| India     | 2000 | 0.03| 2.18 | Kuwait    | 2010 | 0.05| -15.23|
| India     | 2005 | 0.04| 1.22 | Latvia    | 1995 | 0.05| -9.78|
| Latvia    | 2005 | 0.03| 0.60 | Morocco   | 2010 | 0.05| -2.72|
| Latvia    | 2010 | 0.04| 5.80 | Nepal     | 1990 | 0.02| -5.06|
| Lithuania | 2000 | 0.04| -3.83| Netherlands| 1990 | 0.08| 1.97 |
| Lithuania | 2005 | 0.04| 5.65 | Netherlands| 1995 | 0.09| 2.23 |
| Lithuania | 2010 | 0.07| 15.13| Netherlands| 2000 | 0.11| 2.48 |
| Luxembourg| 1995 | 0.08| 6.54 | Netherlands| 2005 | 0.13| 2.74 |
| Luxembourg| 2005 | 0.11| -0.31| New Zealand| 1995 | 0.11| -4.66|
| Madagascar| 2005 | 0.00| -17.36| New Zealand| 2000 | 0.10| 0.14 |
| Malawi    | 1990 | 0.08| -22.80| New Zealand| 2005 | 0.12| 4.94 |
| Malawi    | 1995 | 0.03| -11.18| Niger      | 2000 | 0.05| 53.76|
| Malawi    | 2000 | 0.03| 0.44 | Nigeria    | 1995 | 0.10| -7.54|
| Malawi    | 2005 | 0.04| 12.05| Norway     | 1990 | 0.11| -0.76|
| Malaysia  | 1990 | 0.03| 7.43 | Norway     | 1995 | 0.11| -0.14|
| Malaysia  | 1995 | 0.04| 5.92 | Norway     | 2000 | 0.12| 0.48 |
| Malaysia  | 2000 | 0.06| 4.40 | Norway     | 2005 | 0.13| 1.10 |
| Malaysia  | 2005 | 0.08| 2.89 | Oman      | 1995 | 0.02| 0.59 |
| Country       | Year | TE  | TFPG | Country       | Year | TE  | TFPG |
|---------------|------|-----|------|---------------|------|-----|------|
| Malaysia      | 2010 | 0.09| 1.38 | Oman         | 2000 | 0.02| 1.75 |
| Malta         | 1990 | 0.10| −6.79| Oman         | 2005 | 0.02| 2.90 |
| Malta         | 1995 | 0.08| −3.56| Oman         | 2010 | 0.02| 4.06 |
| Malta         | 2000 | 0.07| −0.33| Panama       | 1990 | 0.13| −32.81|
| Malta         | 2005 | 0.08| 2.89 | Panama       | 2000 | 0.07| 19.52|
| Mauritius     | 2005 | 0.06| −22.12| Peru       | 1990 | 0.41| −57.80|
| Mauritius     | 2010 | 0.10| 38.64| Peru         | 1995 | 0.12| 7.05 |
| Mexico        | 1990 | 0.17| −13.41| Philippines | 1990 | 0.07| −1.27|
| Mexico        | 1995 | 0.11| −7.01 | Philippines | 1995 | 0.07| −0.92|
| Mexico        | 2000 | 0.09| −0.60 | Philippines | 2005 | 0.07| −0.22|
| Mexico        | 2010 | 0.18| 12.21| Poland       | 1990 | 0.09| −9.93|
| Mongolia      | 1990 | 0.04| −12.36| Poland      | 1995 | 0.06| −5.64|
| Mongolia      | 1995 | 0.02| −25.67| Poland      | 2000 | 0.05| −1.35|
| Mongolia      | 2000 | 0.00| −38.97| Poland      | 2005 | 0.06| 2.94 |
| Morocco       | 1990 | 0.04| 3.44 | Portugal     | 1990 | 0.06| −2.89|
| Morocco       | 1995 | 0.05| 1.90 | Portugal     | 2000 | 0.06| 0.30 |
| Morocco       | 2000 | 0.05| 0.36 | Portugal     | 2005 | 0.06| 1.89 |
| Morocco       | 2005 | 0.06| −1.18| Republic of Korea | 1990 | 0.05| 5.98 |

| Country           | Year | TE  | TFPG | Country           | Year | TE  | TFPG |
|-------------------|------|-----|------|-------------------|------|-----|------|
| Republic of Korea  | 1995 | 0.06| 4.00 | Spain             | 1990 | 0.12| −3.97|
| Republic of Korea  | 2000 | 0.08| 2.03 | Spain             | 1995 | 0.10| −3.00|
| Republic of Korea  | 2005 | 0.09| 0.05 | Spain             | 2000 | 0.10| −2.04|
| Republic of Moldova| 2000 | 0.02| −7.85| Spain             | 2005 | 0.09| −1.07|
| Republic of Moldova| 2005 | 0.01| −3.35| Sri Lanka         | 1990 | 0.08| −5.62|
| Republic of Moldova| 2010 | 0.01| 1.14 | Sri Lanka         | 1995 | 0.07| −2.02|
| Romania           | 1990 | 0.35| −38.58| Sri Lanka        | 2000 | 0.07| 1.59 |
| Romania           | 1995 | 0.07| −27.67| Sri Lanka        | 2010 | 0.13| 8.80 |
| Romania           | 2000 | 0.02| −16.77| Swaziland        | 1990 | 0.13| 15.96|
| Romania           | 2005 | 0.01| −5.87 | Swaziland        | 1995 | 0.06| −49.44|
| Singapore         | 1990 | 0.08| −5.12 | Sweden           | 1995 | 0.08| 0.53 |
| Singapore         | 1995 | 0.07| −2.39 | Sweden           | 2000 | 0.09| 2.27 |
| Singapore         | 2000 | 0.07| 0.34 | Sweden           | 2005 | 0.11| 4.01 |
| Singapore         | 2005 | 0.08| 3.07 | Thailand         | 1990 | 0.04| 15.80|
| Singapore         | 2010 | 0.10| 5.80 | The f. Yugosl. Rep. of Macedonia | 1990 | 0.50| −32.73|
| Slovakia          | 1995 | 0.03| −4.05 | The f. Yugosl. Rep. of Macedonia | 1995 | 0.13| −21.18|
| Slovakia          | 2000 | 0.03| 0.76 | The f. Yugosl. Rep. of Macedonia | 2000 | 0.07| −9.63 |
| Slovakia          | 2005 | 0.03| 5.58 | The f. Yugosl. Rep. of Macedonia | 2005 | 0.06| 1.91 |
| Slovenia          | 1995 | 0.15| −20.48| The f. Yugosl. Rep. of Macedonia | 2010 | 0.09| 13.46|
| Slovenia          | 2000 | 0.07| −10.22| Trinidad and Tobago | 1990 | 0.09| −19.65|
| Slovenia          | 2005 | 0.06| 0.04 | Trinidad and Tobago | 1995 | 0.05| −6.22|
| Slovenia          | 2010 | 0.08| 10.30| Trinidad and Tobago | 2000 | 0.05| 7.21 |
| Country                        | Year | TE  | TFPG |
|-------------------------------|------|-----|------|
| Tunisia                       | 1995 | 0.06| 3.30 |
| Tunisia                       | 2000 | 0.06| −2.56|
| Turkey                        | 1990 | 0.56| −15.91|
| Turkey                        | 1995 | 0.26| −16.57|
| Turkey                        | 2000 | 0.12| −17.23|
| Turkey                        | 2005 | 0.05| −17.89|
| United Kingdom                | 1990 | 0.13| −6.39 |
| United Kingdom                | 1995 | 0.11| −2.54 |
| United Kingdom                | 2000 | 0.11| 1.30 |
| United Kingdom                | 2005 | 0.13| 5.15 |
| United Republic of Tanzania   | 1990 | 0.00| 11.03|
| United Republic of Tanzania   | 1995 | 0.01| 10.91|
| United Republic of Tanzania   | 2005 | 0.03| 10.67|
| United Republic of Tanzania   | 2010 | 0.05| 10.55|
| United States of America      | 1990 | 0.16| −0.40|
| United States of America      | 1995 | 0.17| 0.60 |
| United States of America      | 2000 | 0.19| 1.61 |
| United States of America      | 2005 | 0.22| 2.61 |
| Uruguay                       | 1990 | 0.27| −8.96|
| Uruguay                       | 1995 | 0.18| −8.84|
| Uruguay                       | 2000 | 0.12| −8.73|
| Uruguay                       | 2005 | 0.08| −8.61|
| Venezuela (Bolivarian Republic of) | 1990 | 0.18| −27.81|
| Venezuela (Bolivarian Republic of) | 1995 | 0.06| −20.28|
| Viet Nam                      | 2000 | 0.01| −22.24|
| Viet Nam                      | 2010 | 0.01| 15.47|

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Declarations

Conflict of interest  There is no conflict of interest.

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