THE ROLE OF TOTAL FACTOR PRODUCTIVITY GROWTH IN MIDDLE INCOME COUNTRIES

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ABSTRACT

We examine the importance of total factor productivity (TFP) growth in middle-income countries based on cross-country panel data for the period 1975–2014. We find that TFP growth contributed significantly to a country's upward transition from middle-income to high-income country group. The TFP growth model reveals that the catch-up effect, human capital, smaller population, weak currency, and research and development (R&D) growth are significant sources of TFP growth. We do not find a systematic difference in the TFP growth models for middle-income countries. In analyzing the role of factors influencing TFP growth at different income stages, strengthening innovative activities and building innovative capacities are important in overcoming the challenges that middle-income countries face when transitioning to the high-income group. Governments of upper-middle-income countries need to initiate reform to motivate innovation by optimizing national R&D systems, and redesigning the educational system to target promoting innovation.

Keywords: economic growth, human capital, middle-income countries, research and development, total factor productivity

JEL codes: O47, O57

I. INTRODUCTION

In the past half century, the global economy has achieved outstanding growth performance, and many developing countries were able to reach the middle-income country status.[1] Among them, only a few would eventually leap to the high-income level, while the rest of middle-income countries could not upgrade their levels of income due to stagnant economic growth. Moreover, in the aftermath of the 2008 global financial crisis, the global economy is being challenged by a significant slowdown in economic growth despite many economic stimulus packages pursued by governments in response to the challenge.

The current prospect of future growth is not promising. According to the October issue of the 2016 *World Economic Outlook* published by the International Monetary Fund, global economic growth will remain subdued in 2016 at below 3.1% growth and will increase slightly to 3.4% growth in 2017.[2] A continuing fall in the trade volume growth and persistent economic slowdown of most advanced economies cast a significant doubt about the feasibility of sustainable global economic growth. There has been rising attention in searching for causes of the current ongoing growth slowdown, and also for a wide range of policies to address the deferment of economic development. In particular, the issues of hindrance of economic growth in middle-income countries have become pivotal, since emerging countries have accounted for the majority of the growth of global demand in recent years due to the fact that emerging markets expanded much faster than the advanced economies.

To unveil the causes of economic growth, it requires addressing an extensive range of measures related to efficient resource allocation, technological development, spillovers, accumulation of human capital, and firms' access to finance, among other things. So far, a long list of studies confirms that only a limited part of economic growth can be explained by the accumulation of factors of production, such as physical capital and working hours of labor. The unexplained part of economic growth, which presumably reflects development of production and process technologies, and is conventionally attributed as a key factor of growth, is the so-called total factor productivity (TFP) growth. Since 1947, we have witnessed that a significant portion of economic growth was due to TFP growth, and the gap in the productivity levels between income groups can be largely explained by the differences in TFP of different income groups.

The objective of our research is to examine whether TFP growth is essential for economic growth and how much TFP growth accounted for economic growth in middle-income countries. The second aim is to look at the empirics of the transition from middle-income group to high-income group, and note how this transition distinguishes itself from other transitions in economic progress. Last, we target to propose the policy measures for enhancing TFP growth to counteract the economic slowdown of middle-income countries.

The rest of the paper is laid out as follows. Section II summarizes the recent literature on TFP growth of middle-income countries. Section III provides various statistics on income-level dynamics of countries by income groups. In section IV, we review the trends and patterns of TFP growth by income-level country groups to identify cross-country patterns of growth and to get a better understanding of how much middle-income country group differs from other income groups. In section V, we conduct

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[1] Following the World Bank classification, middle-income country is defined as ccountries with per capita gross national incomes between $996 and $12,195.

[2] The prospect reflects an ongoing economic slowdown in the United States (US) and the United Kingdom's vote outcome to leave the European Union on 23 June 2016.

regression analysis to identify the major factors contributing to TFP growth in general and also confine analysis to a middle-income country group sample. Section VI reviews identified and potential factors which may be important for middle-income countries for their upward move. Section VII concludes with some policy implications.

II. LITERATURE ON TOTAL FACTOR PRODUCTIVITY GROWTH IN MIDDLE-INCOME COUNTRIES

A. Studies on Growth Slowdown in Middle-Income Countries

Many economies are experiencing chronic economic downturn in the aftermath of the 2008 global financial crisis. Rising concerns over the causal agency of the growth slowdown have invited various policies to tackle the deferment of economic growth. Increasing volumes of research centering on the economic growth slowdown have been put forth. In the process, researches have been paying keen attention on the issues of severe slowdown in growth and productivity in middle-income countries.

Majority of studies confirms that there is a middle-income trap (MIT), and that phenomenon affects a significant part of the world. Spence (2011) used the term "middle-income transition" to specify the "part of the growth process that occurs when a country's per capita income gets into the range of $5,000–$10,000" (Spence 2011, p. 100). Agénor, Canuto, and Jelenic (2012) argued that economic growth is likely to slow down substantively when a country's income reaches around $15,000–$16,000. Cross-country income variances were often attributed to an MIT "characterized by a sharp deceleration in growth and in the pace of productivity increases" (Agénor Canuto, and Jelenic 2012). [3] Using international data since 1957, Eichengreen, Park, and Shin (2012) studied the cases for the eventual slowdown in growth for fast-growing economies.[4] Their findings suggest that fast-growing economies slowed down considerably when their per capita incomes reach around $17,000 in 2005 constant international prices.[5] Extending the earlier study, Eichengreen, Park, and Shin (2014) analyzed the prevalence of growth stagnation in middle-income countries. Their finding suggests that many countries experienced slowdowns in two ranges of per capita income levels: one in the range of $10,000–$11,000 and another in the range of $15,000–$16,000. Numerous other studies made an empirical analysis identifying the MIT (Eichengreen, Park, and Shin 2012; 2014; Jankowska, Nagengast, and Perea 2012; Cai 2012; Aiyar et al. 2013; Flaaen, Ghani, and Mishra 2013; Han and Wei 2015; Arias and Wen 2016). Some mathematical MIT models are recently introduced (Agénor and Canuto 2012; Dabús, Tohmé, and Caraballo 2016).

On the other hand, studies such as Barro (2016), Im and Rosenblatt (2015), and Bulman, Eden, and Nguyen (2014) support the view that moving to high-income status from a middle-income country, while in the MIT, is not especially different than escaping from low-income status. Barro (2016) argued that there are no special patterns or trends of dispersion regarding gross domestic product (GDP) growth since 1870 for 25 countries. His study could not find that the second transition, i.e., moving from middle-income group to high-income level, is more difficult than the first transition, i.e., leaping from low- to middle-income group. Im and Rosenblatt (2015) also could not see the difference for middle-income countries in terms of transitions across the intercountry distribution of income. The growth

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[3] According to Aiyar et al. (2013), the "middle-income trap" refers to "the phenomenon of rapidly growing economies stagnating at middle-income levels and failing to graduate into the ranks of high-income countries." (Aiyar et al. 2013, p. 3).

[4] Where GDP per capita had been growing for 7 or more years at an average annual rate of 3.5%.

[5] The significant slowdown is defined as the downshift in the growth rate by at least 2 percentage points.

patterns of middle-income countries also do not present a distinctive pattern that can be easily categorized as a "trap."

B. Role of Total Factor Productivity in Economic Growth

Numerous studies were devoted to identify the role of TFP in growth dynamics in order to provide an explanation to the extensive variation in economic growth across countries. In most of MIT literature, TFP is regarded as one of the most significant elements for economic growth. For example, Eichengreen, Park, and Shin (2012) found that, on average, the decrease in the TFP growth rate explains around 85% of the growth slowdown in their sample, whereas the decreases in labor and capital growth only play a relatively negligible role. One of their findings is that growth slowdown is more likely to occur in countries that maintain their real exchange rates undervalued. Bulman, Eden, and Nguyen (2014) and Jitsuchon (2012) argue that countries that managed to successfully overcome the middle-income range had relatively high TFP growth. Tran (2013) claims that middle-income countries have to complete the "transition from input-driven to TFP-driven growth." A number of MIT literature highlights the importance of TFP growth in Latin America. Daude and Fernández-Arias (2010) show that the poor growth performance of Latin American countries (relative to the developed economies such as the United States [US]) is mostly because of a negative TFP growth gap rather than impediments of factor accumulation.

According to these studies, filling the productivity gap is a key to catch up with developed countries. Along the same line, Aiyar et al. (2013) specified the MIT as a particular event of growth slowdown, and suggested several determinants behind economic slowdown. They showed that the past growth slowdown in Latin America were mainly due to sharp declines in TFP growth, while the high growth in Asian Tigers, such as the People's Republic of China (PRC), and India can be explained by steady TFP growth.

C. Determinants of Total Factor Productivity Growth

Extending the analysis with data from 1870 to 2010, Shackleton (2013) evaluated the extensive forms of TFP growth in the US. The study affirmed the important role of technological innovations to the growth of varied sectors of the economy. It also identified the correlation between TFP growth and improvements in life expectancy, which in part represent the general health and well-being of a people. Last, the report discussed the potential difficulties to achieve further educational attainment, the ability of innovators to develop new technologies, and the resources for continued increase in TFP.

Using a growth accounting framework, Lee and Hong (2010) find that the main dynamics of the fast growth of developing Asia over the past 3 decades rely on the persistent growth in capital accumulation. In the region's past economic growth, they notice relatively limited contributions of education and TFP. Jankowska, Nagengast, and Perea (2012) revealed that newly industrialized economies[6] in Asia could reach high-income country status (more than $12,076 gross national income per capita) from middle-income status ($1,005–$12,075 gross national income per capita using the Atlas method as defined by the World Bank) due to a structural transformation through diversification into a greater number of products, as well as moving into higher value-added products over time. With a high level of educational attainment, which made a structural transformation possible, new production was relatively easily developed in industries (e.g., iron, steel, machinery, and electronics) from existing industries. According to this paper, Latin American countries' specialized industries are far from high

[6] Taipei,China; Hong Kong, China; Republic of Korea; and Singapore.

value-added industries, with lower linkage overall in their export competences. In terms of development strategy or the microeconomic determinants of growth, a volume of researches has been made on the strange position of middle-income countries within global supply chains. In particular, the incomes in middle-income countries have increased enough to graduate from low-skilled labor-intensive productions, but middle-income countries have not acquired their own innovation systems, or probably could not accumulate sufficient physical and human capital to compete with high-income countries in more advanced products. (Gill and Kharas 2007; Jankowska, Nagengast, and Perea 2012).

Ozturk (2016) proposed the middle class, innovation, and productivity as key growth factors, with foreign direct investment (FDI) as the source for diminishing marginal effect on economic growth. By examining the experiences of 80 countries, Yiping, Qin, and Xun (2014) suggested that, for the middle-income group, repressive policies on credit, bank entry, securities market, and the capital account significantly hinder economic growth.

Glawe and Wagner (2016) argue that, except for the scenarios based on the World Bank (2013) study and some of Eichengreen, Park, and Shin (2012; 2014) scenarios which are based on borderline cases, most of the implied scenarios showed that the PRC is not yet at the MIT. The majority of their scenarios indicated that the PRC will soon enter into the middle-income country status, but not trapped in an MIT. They projected that the PRC enters the MIT only if the Chinese growth rate decreases to the level of 3%–4% per annum. Further improvements of human capital accumulation and education as well as a tackling income inequality between urban and rural areas were proposed as adequate measures for preventing an MIT in the PRC. Some studies dealt with policy discussions of what has to be done (Kharas and Kohli 2011; Shijin. Junkuo, and Peilin 2012) to escape from middle-income status and arrive to high-income status successfully.

According to Agénor, Canuto, and Jelenic (2012), there are several public policies that governments can pursue, such as improving access to advanced infrastructure, improving the protection of property rights, reforming rigid labor markets, enhancing innovation by implementing technology upgrade, and research and development (R&D) to avoid MIT. Such policies explain why some economies, such as those in East Asia, were able to avoid the middle-income trap and reach high-income status. La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1997; 1998) influentially argued that the quality of a country's legal institutions—such as legal protection of foreign investors—could influence the degree of rent seeking by corporate domestic agents, and thereby promote financial development.

III. ROLE OF TOTAL FACTOR PRODUCTIVITY GROWTH IN TRANSITION TO HIGH INCOME

In the growth accounting decomposition of the previous section, we saw that the most successful middle-income country experienced faster TFP growth, and TFP growth accounted for a larger share of GDP than other middle-income economies. In this section, we take a closer look at the role of TFP growth in the graduation of middle-income economies to high income. To do so, we first look at income-level dynamics or the movement of countries into different income groups. We then examine the relationship between the movement of countries and TFP growth.

Income-Level Dynamics of Countries by Income Groups

Here, we examine the income-level dynamics of countries over time. As per capita income levels of countries change over time, depending on their economic performance, they may rise to upper income or fall to a lower income-level category. Given five income-level categories—lower-low income, upper-low income, lower-middle income, upper-middle income, and high income—we first analyze the income-level dynamics by looking into the income-level transition matrix of countries over time. Given the data for 1975–2014, we divide the sample into four nonoverlapping 10-year intervals and consider the transition of income level for each country within a decade.[7] For each 10-year interval, we check a country's income level of initial year and that of the ending year to see the income-level transition. The statistics are summarized in Table 1.

Table 1: Transition Matrix of Income Levels Over 10-Year Intervals (1–5)

Income Group		Income Level at Year *t*+10					
		1	2	3	4	5	Total
Income level at year *t*	1	16	8	0	0	0	24
	2	2	46	18	0	0	66
	3	0	4	43	27	0	74
	4	0	1	4	129	32	166
	5	0	0	0	4	134	138
	Total	18	59	65	160	166	468

1 = extremely low income, 2 = low income, 3 = lower-middle income, 4 = upper-middle income, 5 = high income.
Source: Authors' estimates.

Moving one level up from extremely low-income group (1) to low-income group (2) has been observed eight out of 24 cases, which is equivalent to approximately 30% of the total. One level upgrade from low-income group (2) to lower-middle-income group (3) occurred 18 out of 66 occasions, which accounts for approximately 27.2%. In the case of middle-income group, lower-middle-income countries (3) transitioning to upper-income level (4) was 27 out of 74 or 36.5 % of the total. However, upper-middle-income countries (4) moving up to high-income level (5) was only 19.3%. As for the high-income group, 97.1 % stayed at the same level. These findings indicate that moving up from one low to middle and middle to high income was less frequent than within income-level transition such as lower middle to upper middle. Further, the least frequent occasions were from upper-middle- to high-income transitions.

Income-level transition dynamics may have changed over time. In Table 2, we categorize each country by upward or downward movements in income levels for each 10-year interval. Table 2 shows that the percentage of upward transition to higher-income group has been increasing over time. During 1975–1985, 16% of countries achieved a one-level upgrade, 13% during 1985–1995, 19% during 1995–2005, and 25% during 2005–2014. In total, 78.6% of the countries (368 out of 468) remained at the same level of income group for the initial and ending year of each interval, while 18% moved up and 3.2 % moved down.

[7] Since the most recent data ended in 2014, we have started our sample from 1975 and divided the total sample in nonoverlapping 10-year intervals: 1975–1985, 1985–1995, 1995–2005, and 2005–2014. The last interval is for 9 years only.

Table 2: Distribution of Change in Income Levels by 10-Year Intervals (1–5)

Year	Two Levels Down	One Level Down	Same Level	One Level Up		Total
1975–1985	0	4	85	17	(16%)	106
1985–1995	1	6	98	15	(13%)	120
1995–2005	0	3	95	23	(19%)	121
2005–2014	0	1	90	30	(25%)	121
Total	1	14	368	85	(18%)	468

Source: Authors' computations.

In the case of lower-middle-income countries, Table 3 shows that the percentage of upward transition to higher-income group has also been increasing over time. During 1975–1985, 26% of countries achieved a one-level upgrade, 35% during 1985–1995, 50% during 1995–2005, and 42% during 2005–2014. The percentage of downgrades to lower-income group is less than 5.4% throughout the sample period.

Table 3: Distribution of Change in Income Levels by 10-Year Intervals: Lower-Middle-Income Countries

Year	One Level Down	Same Level	One Level Up		Total
1975–1985	1	16	6	(26%)	23
1985–1995	2	13	8	(35%)	23
1995–2005	1	7	8	(50%)	16
2005–2014	0	7	5	(42%)	12
Total	4	43	27	(36%)	74

Source Authors' computation.

On the contrary, in the case of upper-middle-income countries, the trend of stepping up to higher-income group decreased at first, and rebounded in the 2005–2014 period.

Table 4: Distribution of Change in Income Levels by Year: Upper-Middle-Income Countries

Year	Two Levels Down	One Level Down	Same Level	One Level Up		Total
1975–1985	0	1	26	6	(18%)	33
1985–1995	1	2	35	5	(12%)	43
1995–2005	0	0	37	7	(16%)	44
2005–2014	0	1	31	14	(30%)	46
Total	1	4	129	32	(19%)	166

Source: Authors' computation.

The proportion of upward transition during 1975–1985 was 18%, but the proportion fell to 12% in 1985–1995 subperiod and 16% in 1995–2005 subperiod. However, it sharply increased to 30% during 2005–2014 subperiod. On average, 3% of the total observation accounts for the downgrade to lower-income group.

IV. IMPORTANCE OF TOTAL FACTOR PRODUCTIVITY GROWTH ON THE PROBABILITY OF INCOME-LEVEL TRANSITION

Given the transition of income levels over time, this section discusses and evaluates how much TFP growth is correlated with income-level dynamics. We first describe how we calculate TFP growth, given the available data. Then, we evaluate and provide comparison of how much TFP growth occurred in different income-level country groups, taking into account the upward and downward transitions.

A. Calculation of Total Factor Productivity Growth

To calculate TFP growth, this study assumes a two-input neoclassical production function with constant returns to scale. TFP growths are calculated as

$$\Delta\, ln(TFP) = \Delta\, ln(Y) - (1 - a_L)\Delta\, ln(K) - \; a_L \Delta\, ln(L) \qquad (1)$$

where *Y* is GDP, *K* is capital stock, and *L* is total labor hours.[8] Total labor hours are derived from multiplying average annual work hours per employee by total employment for each country. However, since average work hour data are available only for less than 70 countries, we have used predicted values based on parameters derived from a regression linking average work hours to the log of per capita real income. The parameter a_L is the output elasticity with respect to labor. In TFP literature, it is very common to set the a_L as the labor share based on the competitive labor market assumption. However, labor compensation data are available only for limited countries and for a limited time period.[9] For example, the labor share data is available only for 23 of 40 low-income countries, 65 of 95 middle-income countries, and 45 of 50 high-income countries in 2000. Therefore, we produce TFP growth share following Fischer (1993) and assume a common labor share of 0.6 to calculate TFP growth.[10]

As for labor, we adjust for labor quality, which, according to the literature, is augmented by enhancements in human capital. Because formal education is a major source of human capital enhancement, we incorporate average educational attainment years of the population (*h*) of each country to adjust for labor quality. The adjustments are made in two different approaches. First, linear adjustment is assumed and the number of years of schooling (*h*) is multiplied by the amount of total labor hours. Thus, human capital (*H*) in this case is *h* and the calculated TFP based on this approach is *TFP2*. Second, since micro labor literature on the returns to schooling suggests that labor quality is enhanced by approximately *8%* per 1 additional year of schooling, we exponentially adjust labor by human capital (*H*) as exp*(0.08*h)L*.[11] This adjustment method is borrowed from Barro and Lee (2013) and the resulting TFP growth estimates are *TFP3*.[12]

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8 We are calculating and using our own TFP growth series rather than the one provided by Penn World Tables (PWT) 9.0 for the following reason. The TFP index provided by PWT 9.0 is constructed based on the human capital index, which is also created by PWT 9.0. We found that this index does not correspond well with the generally accepted measure of human capital series such as educational attainment data by Barro and Lee (2013). Therefore, we are taking a conservative approach by calculating our own TFP growth series based on the Barro and Lee (2013) educational attainment measure, which is widely accepted as a proxy for human capital.

9 Data on labor compensation are available from the United Nations National Accounts Statistics (https://unstats.un.org/unsd/snaama/dnlList.asp) and PWT 9.0.

10 In the related literature, labor shares are assumed to be 0.55 in Young (1994), 0.60 in Fischer (1993), and 0.65 in Bosworth and Collins (2003).

11 Although it is plausible to argue that the returns to schooling may widely differ across developed and developing economies, generally accepted measures specific to developing economies do not exist. We acknowledge that we use the estimates from the micro labor studies despite these limitation and imperfection in measurement.

12 The growth rates of TFP3 are calculated based on the following formula:

$$\Delta\, ln(TFP) = \Delta\, ln(Y) - (1 - a_L)\Delta\, ln(K) - \; a_L[\Delta\, ln(L) + (0.08)\Delta h]$$

B. Pattern of Total Factor Productivity Growth by Income-Transition Country Groups

We now analyze the contributing factors and their magnitudes on economic growth in each income transiting stage during the period from 1975 to 2004. The countries are grouped according to their income levels in the initial year of each interval and then further subgrouped according to the upward or downward income-level transitions. Therefore, there are 13 different income-transition-specific country groups: 5 different income levels and 3 different transition statuses for each income level. We then decompose the real GDP growth into four contributing components: physical capital growth, pure labor growth, human capital growth, and TFP growth (TFP2).[13] The contribution of each factor was calculated as follows. The percentage contributions are $(1-a_L)*dK/K$ for physical capital, a_L*dL/L for labor, and a_L*dH/H for human capital.

The results for the whole period are shown in Table 5 and graphically presented in Figure 1. The five income-level groups are lower-low income (1), upper-low income (2), lower-middle income (3), upper-middle income (4), and high income (5). Overall, when there is a fall in the income level, such as moving from income level 2 to 1, from 3 to 2, from 4 to 3, and from 5 to 4, the decrease of TFP growth is clearly observed, and the extent of decrease is much greater than GDP decline in every event. Especially, when countries transit from group 4 to 3, a very significant fall in the TFP growth (as much as 8.64%) was detected. On the other hand, as for the upward transition—leaping from 1 to 2, from 2 to 3, from 3 to 4, and from 4 to 5—an increase of TFP growth is apparent in every occasion. In sum, we find that the income-transition country groups experiencing downward transition is associated with negative TFP growth and also lower TFP growth than other subgroups within the same income levels. However, the subgroups that have succeeded in upward transition show higher TFP growth than all other subgroups within the same income levels. These findings are very much significant within the middle-income-level country group.

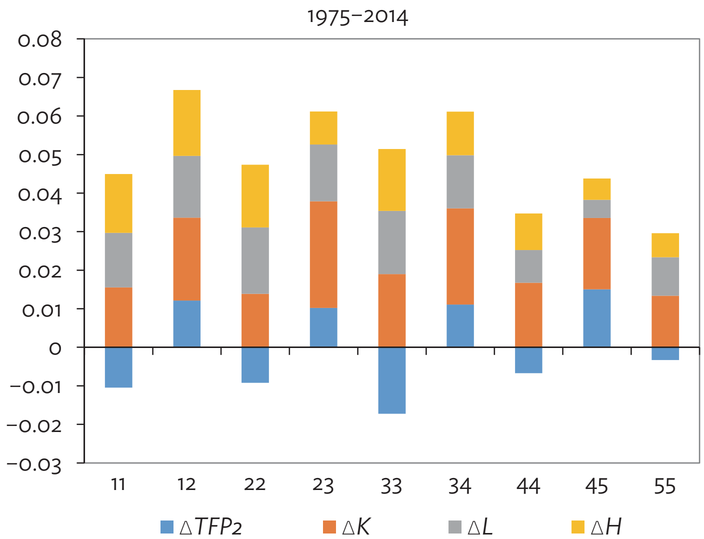
Table 5: Contribution of Factors to Economic Growth, by Income and Transition Country Groups

Income-Level Transition	*GDP* (%)	*TFP* (%)	*K* (%)	*L* (%)	*H* (%)
1→1	3.36	−1.10	1.51	1.41	1.54
1→2	6.67	1.21	2.15	1.60	1.71
2→1	−4.59	−7.98	0.37	1.63	1.39
2→2	3.82	−0.94	1.38	1.69	1.69
2→3	6.12	1.02	2.76	1.47	0.86
3→2	−3.56	−6.63	0.34	1.43	1.30
3→3	3.56	−1.73	1.98	1.63	1.63
3→4	6.19	1.05	2.60	1.30	1.16
4→3	−5.79	−8.64	0.48	1.22	1.15
4→4	2.89	−0.61	1.70	0.84	0.97
4→5	4.38	1.50	1.85	0.47	0.55
5→4	−2.45	−7.17	1.85	1.39	1.47
5→5	2.78	−0.47	1.39	1.19	0.67

GDP = gross domestic product, H = human capital, K = physical capital, L = labor, TFP = total factor productivity.
Sources: Authors' estimates, the United Nations National Accounts Statistic, Barro and Lee (2013).

[13] Decomposition estimates based on TFP3 is provided in Figures A1 and A2 of Appendix.

Figure 1: Contribution of Factors to Economic Growth, by Income and Transition Country Groups



Sources: Authors' estimates, the United Nations National Accounts Statistic, Barro and Lee (2013).

The results for each 10-year interval subperiods are shown in Figure 2. In all subperiods, the relative importance of TFP growth in different income-transition country groups is qualitatively the same as the full sample period. The contribution of TFP growth was highest during the 1995–2005 period, and the lowest during the 1985–1995 period. TFP growth performance in the upward transition middle-income countries (from 3 to 4, from 4 to 5) is clearly superior to the rest of the middle-income countries. Further, the relative contribution of TFP growth in upward transition from 4 to 5 was stronger than in the case of upward transition from 3 to 4.

Figure 2: Contribution of Factors to Economic Growth, by Income and Transition Country Groups and by 10-Year Interval Subperiods

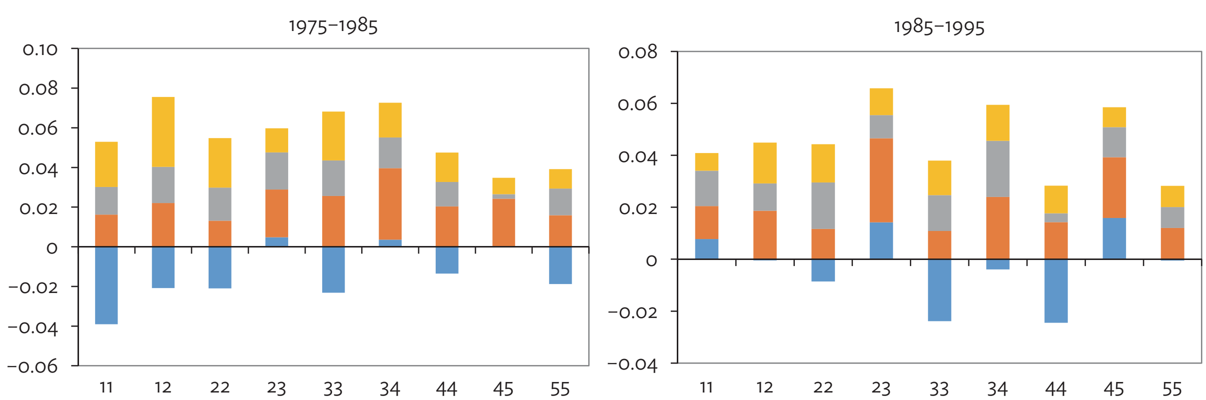


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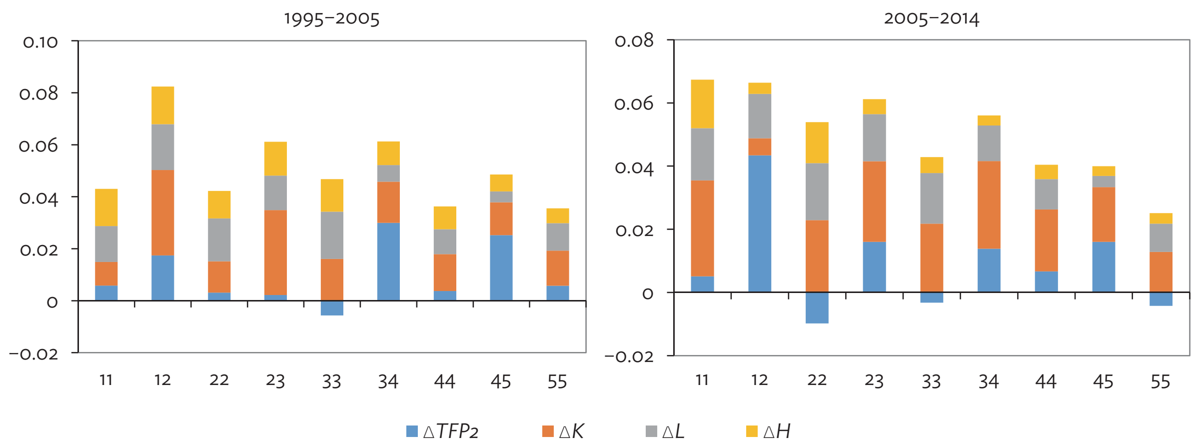
Figure 2 continued



Sources: Authors' estimates, the United Nations National Accounts Statistic, Barro and Lee (2013).

C. Group Mean Tests between Income-Transition Country Groups

Since we are investigating the importance of TFP growth for middle-income countries in moving up the ladder, this section tests whether the contribution of TFP growth was statistically different for the upward transitioning group countries (from 3 to 4, from 4 to 5) compared with that of the remaining within group countries (from 3 to 2, from 3 to 3, from 4 to 3, from 4 to 4).

We conducted t-test for the mean difference of growth in the factors of economic growth between two different income-transition groups. The results are shown in Table 6. In case of mean difference in TFP growth between income groups 34 and 33, t-statistic is statistically significant at the 1 % level. In other words, there exists a distinctive difference in mean TFP growth between the countries which have jumped from income group 3 up to income group 4, and which have stayed at the same level. The t-test for mean difference in physical capital growth is statistically significant at the 5 % level, while statistically insignificant in the case of the difference of labor growth and human capital growth. As for the mean difference t-test between income groups 44 and 45, TFP growth is statistically significantly different between two groups at the 1 % level. Human capital growths are statistically different between the two groups, but differences in physical capital growth and in labor growth are statistically insignificant.[14]

Table 6: Group Mean Tests between Country Groups (TFP2)

A. Mean Tests between Groups 34 and 33

	Group 34	Group 33	Difference in mean	t-statistics	p-value
Mean Growth in					
TFP	0.011	−0.017	0.028	4.358***	0.000
Physical Capital	0.062	0.047	0.015	2.016**	0.048
Labor	0.023	0.027	−0.004	1.096	0.277
Human Capital	0.019	0.027	−0.008	1.709*	0.092
Number of Observations	27	43			

continued on next page

[14] A similar result has been produced in both cases of t-test for TFP3 (Appendix Table A1: Author's estimates based on TFP3).

Table 6 continued

B. Mean Tests between Groups 45 and 44

	Group 45	Group 44	Difference in mean	t-statistics	p-value
Mean Growth in					
TFP	0.015	−0.007	0.021	3.940***	0.000
Physical Capital	0.046	0.042	0.004	0.917	0.360
Labor	0.008	0.014	−0.006	1.412	0.160
Human Capital	0.009	0.016	−0.007	3.061***	0.003
Number of Observations	32	129			

Note: t-statistics are in absolute value.
Sources: Authors' estimates based on PWT 9.0, the United Nations National Accounts Statistic, Barro and Lee (2013).

V. DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY GROWTH

This section conducts regression analysis to identify the determinants of TFP growth based on a comprehensive international data set. The main goal is to identify the main factors influencing TFP growth to understand the TFP growth dynamics in the global economies during the period 1975–2014. The TFP growth regression model follows Park (2012), which is a modified version of Bosworth and Collins (2003), to include human capital and R&D as additional determinants of TFP growth. The model, thus, incorporates the importance of intangible factors influencing TFP growth.

A. Baseline Model and Estimation Methods

The baseline model is a two-input production function with Cobb–Douglas technology and constant returns to scale. As previously discussed, the model assumes human capital (*H*) to improve the quality of labor in the form:

$$Y = AK^{1-a_L}(HL)^{a_L} \tag{2}$$

As for the technology dynamics ($\dot{A}/A$), we adopt Bosworth and Collins (2003) empirical TFP growth model to incorporate the catch-up effect in TFP growth and other country-specific characteristics. In addition, we augment the model to reflect the effect of human capital level and R&D on TFP growth. Human capital, therefore, affects the output through two channels: (i) It enters as a factor of input, and (ii) it enters as a factor that contributes to the growth in the technological level. The specification is

$$\dot{\text{A}}/\text{A} = F(catch - up\ effect, H\ , R\&D, other\ determinants) \tag{3}$$

where $\dot{\text{A}}/\text{A}$ is the rate of growth in technological progress which is determined by catch-up effect, level of human capital (*H*), R&D, and other factors.

First, we use an empirical equation with a human capital consideration as a baseline model:

$$\Delta\, ln(TFP)_{it} = \beta_0 + \beta_1\, ln\left(\frac{Y_{i0}}{Y_{us,0}}\right) + \beta_2\, H + \gamma' Z + dxy + dum\_yr_t + \varepsilon_{it} \tag{4}$$

This baseline model equation includes the initial conditions such as initial income per capita (−) relative to the US level ($\frac{Y_{i0}}{Y_{us,0}}$), educational attainment level (*H*) as the level of human capital, and other potential determinants (*Z*) that include the following variables: initial life expectancy relative to the US (*LIFES*, initial health condition), log of initial population (*POP*), an openness variable (*OPENC*) , and the index of real exchange rate (*OXR*). *OXR* is defined so that increase in the variable leads to appreciation of domestic currency relative to the US dollar. The variable *dxy* are income-transition dummies that equal 1 for countries at the level *x* in the initial year and at the level *y* in the ending year, and zero otherwise. This variable captures the remaining TFP growth differences due to different income-transition group after controlling for all other explanatory variables. Year dummies, *dum_yr*, are included to control for the omitted year-specific effects.

As innovation and competition have intensified, we consider an alternative model additionally augmented with R&D variable. Therefore, in the following model, the growth of R&D capital stock per worker enters as an additional determinant in the TFP growth regression because the only positive relationship could be found in a model where the R&D variable enters as the growth of R&D capital stock per worker.[15]

$$\Delta\, ln(TFP)_{it} = \beta_0 + \beta_1\, ln\left(\frac{Y_{i0}}{Y_{us,0}}\right) + \beta_2 H + \beta_3 \Delta ln(R\&D\ stock/worker) \\ + \gamma' Z + dxy + dum\_yr_t + \varepsilon_{it} \quad (5)$$

For regressions including R&D, the sample countries and periods are limited to those with available R&D data.

The sample is an unbalanced international country-level panel data set covering the period from 1975 to 2014.[16] Because the annual variation of TFP growth is usually filled with noise, we construct a 10-year interval data set, which consists of average values or initial values of variables from each nonoverlapping 10-year interval within the full sample. Initial values of each respective interval are considered for the variables representing initial conditions such as initial income per capita relative to the US level, initial life expectancy relative to the US, and initial population. To control the omitted time effect of each 10-year interval, we perform a panel regression with time fixed effect on the 10-year interval panel data set.

B. Data and Variables

We calculate TFP growth estimates based on equation (4), where labor quality is adjusted by the level of human capital. Following prior literature (Bosworth and Collins 2003, Fischer 1993, Young 1994), labor shares (a_L) are assumed to be 0.6 because actual labor shares are unavailable for most countries for most periods.[17] As for the explanatory variables, initial income per capita (–) relative to the US level, initial population, openness, and index of real exchange rate are either obtained from or constructed based on PWT 9.0. Initial life expectancy is from the World Bank's World Development Indicators (WDI).[18]

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[15] We have attempted tentative estimations of various versions of TFP growth models where R&D enters in different forms: the R&D intensity, the level of R&D capital, the level of R&D capital stock per worker, or the growth of R&D capital stock per worker. However, the TFP growth could neither be empirically shown to be positively related to the R&D intensity, the level of R&D capital, nor the level of R&D capital stock per worker.

[16] The ending year is set at 2014, which is the terminal year in the PWT 9.0 data set.

[17] Labor shares are assumed at 0.55 in Young (1994), 0.60 in Fischer (1993), and 0.65 in Bosworth and Collins (2003).

[18] World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators, (accessed 08 July 2016).

Data on ratios of R&D to GDP are available in WDI and in the Organisation for Economic Co-operation and Development's (OECD) main science and technology indicators (MSTIs). The two data are complementary in the sense that WDI provides R&D data for a wide range of countries for only a short time period, and MSTIs provide R&D data for only OECD countries and selected developing countries for a lengthy period starting from 1981. We use the ratio of gross expenditure on R&D (GERD) to GDP from MSTIs as the main data and complement these data with the R&D ratio data from WDI.[19] We fill in a considerable number of missing values for R&D ratios by interpolation. To obtain the real R&D investment series, R&D ratios are multiplied by the real GDP series (in 2010 constant US dollars drawn from PWT 9.0).

To construct R&D capital stock, we first estimate the initial R&D capital stock (R_0) as

$$R_0 = \frac{I_0}{(depr+gr)} \tag{6}$$

We calculate the growth rate (*gr*) from the average 5-year growth rate of the R&D investment series from the first 6 years of each country's data.[20] We assume a depreciation rate (*depr*) of 0.15.[21] I_0 is the R&D investment of the year in which a positive growth occurred for the first time. Given the initial R&D capital stock estimate, we then construct the subsequent capital stock series by perpetual inventory method.

C. Estimation Results

Table 7 shows the regression results of the baseline empirical model described in equation (7). TFP2 is used as the dependent variable. Models 1 and 2 are the results of ordinary least squares (OLS) estimations based on full sample and on middle-income group subsample, respectively. Models 3 and 4 used fixed effects regressions based on full sample and on middle-income group subsample, respectively. The catch-up effects are statistically significant at the 1% level as the coefficients of *LNY_US* are strongly negative. Human capitals are significant sources of TFP growth in most models except for model 4. Among other potential determinants, smaller population (*POP*) and real currency depreciation (*OXR*) both consistently positively influence the TFP growth. Neither life expectancy nor openness is statistically significant.

The regression results show that, even accounting for the main explanatory variables of interest, we find that there are still significant differences in the remaining TFP growth for the different income-transition country groups. The estimates for income-transition dummies reveal a similar pattern as that shown in section IV. Especially among income-transition dummies, the upward-transitioning lower-middle-income country dummy (*d34*) and upward-transitioning upper-middle-income country dummy (*d45*) are strongly positive and statistically significant. As for the year dummies, all year dummies are statistically significant at the 1% level.

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[19] Some data from WDI are provided as a ratio of R&D to GNI. We convert these data ratio of R&D to GDP.

[20] More details are provided in Park (2012).

[21] The assumptions on depreciation rates vary from 10% to 20% in various empirical studies on R&D. Here, we use 15% as a benchmark. See Coe and Helpman (1995), Griliches and Lichtenberg (1984), and Park (2004) for further discussions regarding depreciation rates for R&D capital.

Table 7: Estimation Results of Baseline Total Factor Productivity Growth Model: 10-Year Average Growth (dependent variable = dln [TFP2])

Variables	(1) Full Sample OLS	(2) Middle-Income Country Sample OLS	(3) Full Sample Fixed Effects	(4) Middle-Income Country Sample Fixed Effects
LNY_US	−0.023***	−0.010*	−0.049***	−0.040***
	(−7.262)	(−1.876)	(−9.281)	(−4.949)
H	0.013***	0.012	−0.030*	−0.038
	(2.808)	(1.480)	(−1.909)	(−1.346)
LIFES	0.028*	−0.001	−0.011	−0.038
	(1.780)	(−0.034)	(−0.416)	(−0.868)
POP	0.001	−0.000	−0.027***	−0.083***
	(1.112)	(−0.291)	(−2.904)	(−4.367)
OPENC	0.000*	0.000	−0.000	−0.000
	(1.799)	(1.191)	(−0.283)	(−1.232)
OXR	0.001	0.001	−0.021**	−0.018
	(0.268)	(0.057)	(−2.283)	(−1.067)
d12	0.022*		0.012	
	(1.823)		(0.899)	
d21	−0.042		−0.038	
	(−1.575)		(−1.285)	
d22	0.006		0.008	
	(0.648)		(0.564)	
d23	0.025**		0.028*	
	(2.450)		(1.720)	
d32	−0.046***	0.033	−0.014	0.005
	(−3.088)	(1.605)	(−0.646)	(0.173)
d33	0.011	0.091***	0.027	0.050***
	(1.142)	(5.987)	(1.505)	(2.743)
d34	0.038***	0.119***	0.045**	0.066***
	(3.694)	(7.772)	(2.450)	(3.800)
d43	−0.078***		−0.048**	
	(−4.964)		(−2.160)	
d44	0.030***	0.101***	0.054***	0.066***
	(2.797)	(6.813)	(2.744)	(3.735)
d45	0.057***	0.119***	0.066***	0.061***
	(4.438)	(7.074)	(3.136)	(3.053)
d54	−0.012		0.025	
	(−0.711)		(1.007)	
d55	0.048***		0.059***	
	(3.396)		(2.611)	
Observations	454	235	454	235
Adjusted R-squared	0.410	0.411	0.327	0.287
Number of countries			119	79

OLS = ordinary least squares, TFP = total factor productivity.

Notes: The dependent variable (*dlnTFP*) is the 10–year average growth rate of total factor productivity. *LNY_US, LIFES,* and *POP* are the log of the per capita gross domestic product relative to that of the United States in the initial year of each respective 10–year interval, initial life expectancy relative to the United States, and log of initial population. *H* is exp(0.08**h*) where *h* is the 10–year averages of educational attainment level from Barro and Lee (2013) data set, and *OPENC* is an openness variable from the Penn World Tables 9.0. *OXR* is the index of real exchange rate. *dxy is* an income-transition dummy that equals 1 for country at the level *x* in the initial year and at the level *y* in the ending year, and zero otherwise. All models include unreported year-specific dummies. *t*–statistics are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Sources: Authors' estimates, the United Nations National Accounts Statistic, Barro and Lee (2013).

Table 8 presents the effects of the R&D-augmented empirical model described in equation (8) where the growth of R&D capital per worker (*dln(RDK_L)* is an additional determinant. Due to the data limitations, the sample size becomes much smaller and all values are post-1980 and biased toward higher-income country group.[22] Models 1~4 are the results of OLS estimations based on full sample and on middle-income group subsample. Models 3~6 additionally include the R&D variable. Models 5 and 6 used fixed effects regressions based on full sample and on middle-income group subsample, respectively.

As in Table 7, the catch-up effect, human capital, and real exchange rates are statistically significant and robust at the 1% or 5% level, and account for a substantial part of TFP growth in all models. In addition, the coefficient of R&D is all positive and statistically significant in three models, while model 6 is statistically insignificant. Log of life expectancy (*LIFES*), log of population (*POP*), and trade openness (*OPENC*) turn out to be statistically insignificant in all models. According to base model 5, which is the fixed effect regression results with R&D variable, income-transition dummies are all statistically insignificant, as opposed to the results in Table 7 without R&D variable. This indicates that R&D accounts for a truly important part of TFP growth, and may account for the remaining unexplained portion of TFP growth in Table 6. To mitigate the shortcomings from the different sample size between R&D inclusion model and the one without R&D, we have also conducted the OLS for the same sample size as the R&D-augmented model. The results are displayed as models 1 and 2. The results are qualitatively the same as models 3 and 4, except for the significance of income-transition dummies.

Table 8: Estimation Results of Total Factor Productivity Growth, with R&D-Augmented Empirical Model: 10-Year Average Growth (dependent variable = dln [TFP2])

	Full Sample	Middle-Income Country Sample	Full Sample	Middle-Income Country Sample	Full Sample	Middle-Income Country Sample
	OLS	OLS	OLS	OLS	Fixed Effects	Fixed Effects
Variables	(1)	(2)	(3)	(4)	(5)	(6)
LNY_US	−0.018***	−0.009	−0.017***	−0.009	−0.027***	−0.027**
	(−5.820)	(−1.595)	(−5.507)	(−1.556)	(−4.227)	(−2.059)
H	0.017***	0.029***	0.017***	0.030***	−0.005	0.006
	(4.036)	(3.826)	(4.037)	(3.909)	(−0.300)	(0.154)
LIFES	0.016	−0.010	0.027	−0.009	−0.124**	−0.058
	(0.907)	(−0.341)	(1.424)	(−0.336)	(−2.557)	(−0.790)
POP	0.001	−0.000	0.001	−0.000	0.026**	−0.005
	(0.933)	(−0.198)	(1.211)	(−0.086)	(2.452)	(−0.143)
OPENC	0.000*	0.000	0.000*	0.000	−0.000	0.000
	(1.931)	(0.348)	(1.678)	(0.123)	(−0.166)	(0.693)
OXR	−0.003	−0.025*	−0.004	−0.025*	−0.024*	−0.020
	(−0.585)	(−1.965)	(−0.763)	(−1.965)	(−1.946)	(−0.841)
dln(RDK_L)			0.028**	0.022	0.029	−0.022
			(2.086)	(1.105)	(1.119)	(−0.517)
d12	−0.003		−0.004		−0.010	
	(−0.136)		(−0.167)		(−0.418)	
d21	–	–	–	–	–	–
d22	−0.032***		−0.037***		−0.035	
	(−2.598)		(−2.974)		(−1.502)	

continued on next page

[22] Upper-middle- and high-income countries account for 86% of 90 countries in the R&D sample, whereas 75% of 118 countries in the full sample in 2005.

Table 8 continued

Variables	Full Sample OLS (1)	Middle-Income Country Sample OLS (2)	Full Sample OLS (3)	Middle-Income Country Sample OLS (4)	Full Sample Fixed Effects (5)	Middle-Income Country Sample Fixed Effects (6)
d23	−0.009		−0.017		−0.017	
	(−0.681)		(−1.182)		(−0.651)	
d32	–	–	–	–	–	–
d33	−0.027**	−0.037***	−0.033**	−0.036***	−0.024	−0.025
	(−1.993)	(−4.724)	(−2.409)	(−4.633)	(−0.851)	(−1.186)
d34	0.008		0.001		0.006	0.001
	(0.591)		(0.068)		(0.228)	(0.068)
d43	–	–	–	–	–	–
d44	−0.009	−0.022***	−0.016	−0.021***	0.015	0.001
	(−0.628)	(−2.860)	(−1.140)	(−2.834)	(0.522)	(0.144)
d45	0.011	−0.009	0.003	−0.009	0.031	
	(0.746)***	(−0.842)	(0.213)	(−0.824)	(1.069)	
d54	−0.060***		−0.066***		−0.026	
	(−3.377)		(−3.681)		(−0.835)	
d55	0.004		−0.004		0.031	
	(0.250)		(−0.231)		(1.026)	
Observations	279	136	279	136	279	136
Adjusted R-squared	0.383	0.293	0.391	0.294	−0.002	−0.626
Number of countries					95	63

OLS = ordinary least squares, TFP = total factor productivity.

Notes: The dependent variable (*dlnTFP*) is the 10–year average growth rate of total factor productivity. *LNY_US, LIFES,* and *POP* are the log of the per capita gross domestic product relative to that of the United States in the initial year of each respective 10–year interval, initial life expectancy relative to the United States, and log of initial population. *H* is exp(0.08**h*) where *h* is the 10–year averages of educational attainment level from Barro and Lee (2013) data set, and *OPENC* is an openness variable from the Penn World Tables 9.0. *OXR* is the index of real exchange rate. The variable dln(RDK_L) is the growth rate of R&D capital stock per labor. *dxy is* an income-transition dummy that equals 1 for country at the level *x* in the initial year and at the level *y* in the ending year, and zero otherwise. All models include unreported year-specific dummies. *t*–statistics are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Sources: Authors' estimates, the United Nations National Accounts Statistic, Barro and Lee (2013).

This study has further attempted to identify if the effects of main explanatory variables on TFP growth are statistically different for middle-income countries compared with other income-level country groups using various approaches. In addition to the subsample regression analyses in Tables 7 and 8, we have also considered full sample analyses with income-level dummies interacted with the main variables of interest. However, in most of these attempts, we could obtain neither statistically meaningful nor consistent results showing a systematic difference in the TFP growth models for middle-income countries.[23]

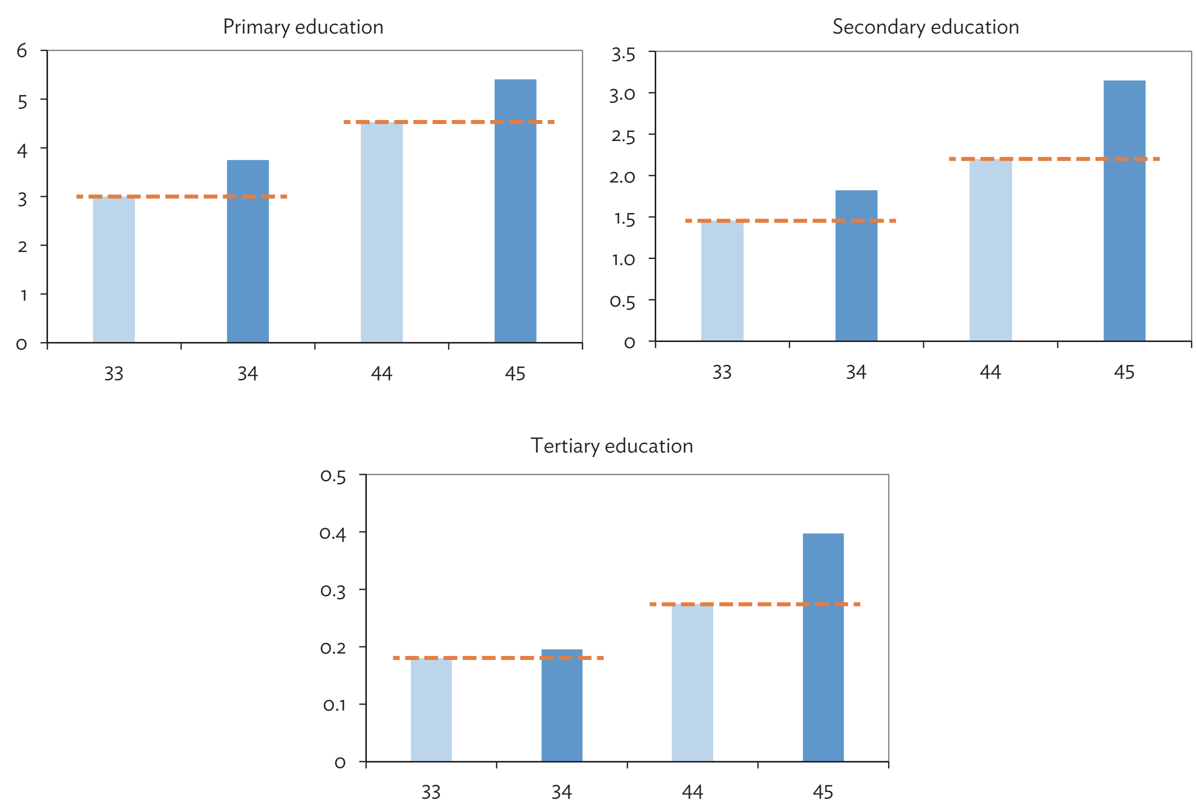
[23] The results for these regressions are available upon request.

VI. DRIVERS OF TOTAL FACTOR PRODUCTIVITY GROWTH

A. Importance of Intangible Capital and Innovation

The regression results in the previous section show that the human capital and R&D capital are the main determinants of TFP growth across all economies. These intangibles may play a critical role in creating new ideas and innovation, which may support much-needed TFP growth for middle-income countries to move up to the next level. In the following, we examine how these intangible capitals and other factors related to innovation differ for different subgroups within middle-income countries. Figure 3 shows the average schooling years for each educational level by income-transition country groups. It is notable that primary education is higher for upward-moving subgroup (d34) among lower-middle-income countries as well as that (d45) among upper-middle-income countries. However, as for secondary and tertiary education, the differences in values are significant only for the upward-moving subgroup (d45) within upper-middle-income countries. Therefore, secondary and tertiary education is especially important for upper-middle-income countries shifting to high income.[24]

Figure 3: Average Schooling Years by Income-Transition Country Group: Middle-Income Country Subgroups

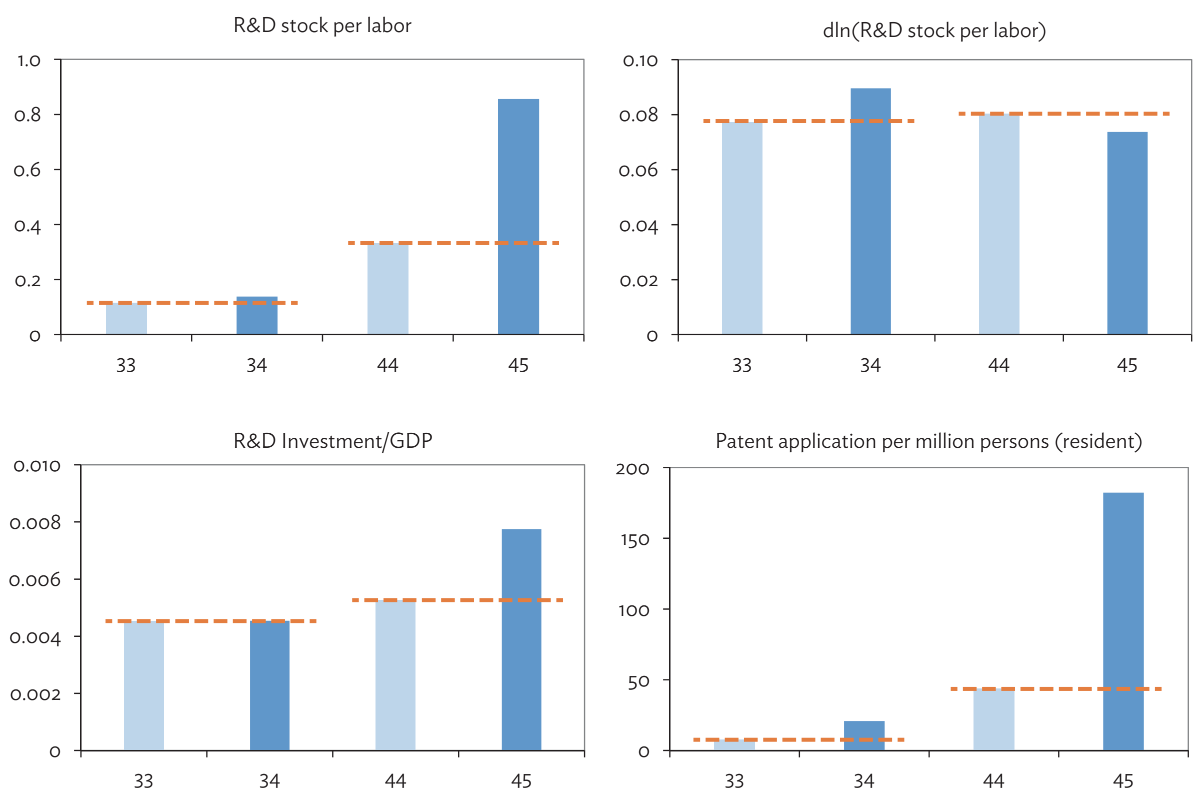


Notes: 33 = lower-middle income staying there, 34 = lower-middle income rising to upper-middle income, 44 = upper-middle income staying there, 45 = upper-middle income rising to high income.
Source: Barro and Lee (2013).

[24] Group mean t-tests for the differences between d33 and d34, and also between d44 and d45 confirm these findings. They are available upon request.

Innovation and idea creation are strongly correlated with innovative activities such as R&D. While R&D may serve as inputs for innovation process, patents can be considered as the outcome of the innovative activities. Figure 4 illustrates the relevant variables related to innovative activities according to income-transition country groups. We can see that R&D stock per labor, which may represent accumulated innovative capacity of the country, is significantly different for the upward-moving countries (d45) for the upper-middle-income group, while the respective difference is not significant for the lower-middle-income group. The finding is true for the R&D investment-to-GDP ratio, which can proxy for the R&D intensity. The growth of R&D stock per labor is not systematically different for alternative income-transition groups. Regarding patent application per million persons (resident), upward-moving countries (d34 and d45) have significantly higher values compared with the remaining groups (d33 and d44). However, it is notable that upper-middle-income countries moving to high-income groups possess considerably greater number of patents than other subgroups (footnote 23).

Figure 4: Innovative Activities and Outcomes by Income-Transition Country Group: Middle-Income Country Subgroups



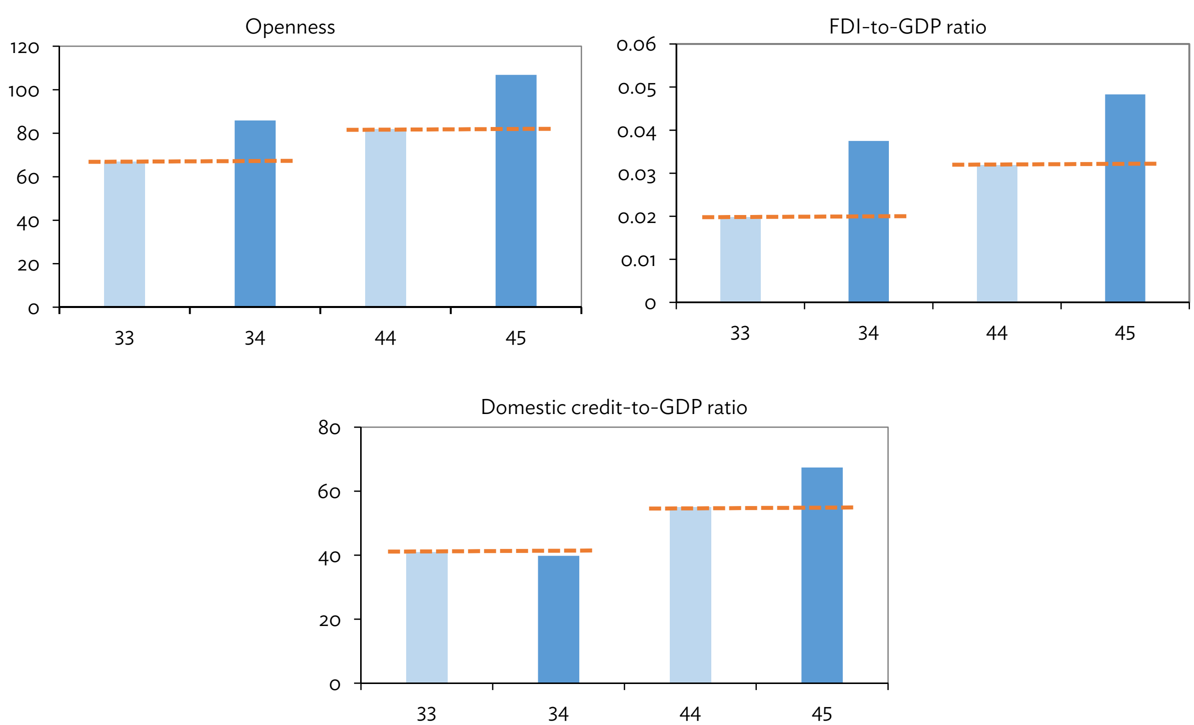
GDP = gross domestic product, R&D = research and development.
Notes: 33 = lower-middle income staying there, 34 = lower-middle income rising to upper-middle income, 44 = upper-middle income staying there, 45 = upper-middle income rising to high income.
Source: World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators (accessed 8 July 2016).

B. Other Potential Factors Influencing Total Factor Productivity Growth

In addition to human capital and R&D capital identified as determinants of TFP growth, we have also resorted to the existing literature and considered various other variables potentially important to middle-income country TFP growth. Some of these variables include FDI, financial development, government governance, and information and communications technology involvement. Data for some of these candidate variables, such as government governance and information and communications technology involvement, are limited in time and country dimensions to do any meaningful analysis. Other variables with sufficient data such as schooling years at different education levels, FDI, and financial development were not statistically significant in any models where they were included. However, we cannot exclude these variables from the potential pool of factors affecting TFP growth just based on inability to identify significance. This is because the insignificance may arise from many reasons, such as including nonlinearity of the true model, and strong correlation with other main variables in the model. Here, we present the statistics of some of these variable which may be potentially important to middle-income countries.

Figure 5 shows variables representing openness, FDI, and financial development by different income-transition country groups. It is notable that for, both openness and FDI-to-GDP ratios, groups d34 and d45 have clearly higher values than other within subcategory middle-income countries. As for financial development proxied by domestic credit-to-GDP ratio, the difference between d33 and d34 is statistically negligible, whereas it is weakly significant between d44 and d45 (footnote 23).

Figure 5: Openness and Financial Development by Income-Transition Country Group



FDI = foreign direct investment, GDP = gross domestic product.
Notes: 33 = lower-middle income staying there, 34 = lower-middle income rising to upper-middle income, 44 = upper-middle income staying there, 45 = upper-middle income rising to high income.
Source: World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators (accessed 8 July 2016).

The results of the group mean t-tests for all the variables discussed in this section are summarized in Table 9. It is evident that the factors inducing countries to move up from lower to upper-middle-income group are different from those inducing countries to move up from upper-middle- to high-income group. Innovations are strongly related to human capital accumulation and innovative activities. As can be seen in Table 9, middle-income countries transitioning to high income statistically differs from the remaining group in most of the key factors of innovative activities and innovative capacities such as secondary and tertiary education, R&D stock, R&D intensity, and patent applications. However, this difference is not observed in transition from lower to upper-middle-income group.

Openness and FDI are important for both cases of upward income transitions (d34 and d45), while financial development is weakly important for the upward movement from middle to high income.

Table 9: Group Mean T-Test for Potential Drivers of Total Factor Productivity Growth

Potential Drivers of TFP Growth	Country Group 33 vs 34	Country Group 44 vs 45
Intangible factors related to innovation		
Primary education	**	**
Secondary education		**
Tertiary education		**
R&D stock per labor		**
Growth of R&D stock per labor		
R&D investment/GDP		**
Patent application per million persons	**	**
Other factors		
Openness	**	**
FDI/GDP	**	*
Domestic credit/GDP		*

FDI = foreign direct investment, GDP = gross domestic product, R&D = research and development, TFP = total factor productivity.
Note: **, * group mean t-test is significant at the 5% and 10% levels, respectively.
Source: World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators (accessed 8 July 2016).

VII. CONCLUSION

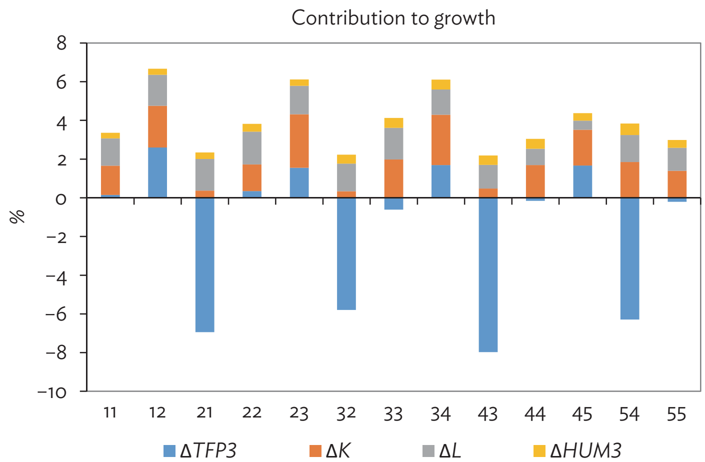
Our main findings can be summarized as follows. First, as we have reviewed in section II, numerous studies regarding middle-income country growth attributes TFP as one of the most essential triggering factors for economic growth. Our analysis showed the similar result that the decline in the TFP growth rate can explain a significant part of the growth slowdowns in middle-income countries, whereas labor and capital growth played a relatively smaller role in the slowdown. TFP growth contributed significantly in the upward transition of income level, especially in the transition to the middle-income countries. We find that the income-transition country groups experiencing downward transition are associated with negative TFP growth and also lower TFP growth than other subgroups within the same income levels. However, the subgroups that have succeeded in upward transition show higher TFP growth than all other subgroups within the same income levels.

Secondly, estimation results of TFP growth model reveal that catch-up effect, human capital, smaller population, weak currency, and R&D growth are significant sources of TFP growth. However, we could obtain neither statistically meaningful nor consistent results showing a systematic difference in the TFP growth models for middle-income countries.

Finally, we analyzed the role of various potential factors influencing TFP growth at different income stages. The findings indicate that strengthening innovative activities and building innovative capacities may not be crucial for the countries to move up from lower to upper-middle-income level. However, they seem to be critically important in overcoming the challenges that middle-income countries face when they need to transition to high-income group. This in turn implies that it is very much necessary for governments of upper-middle-income countries to initiate a reform to motivate innovation, perhaps by optimizing the national R&D system as well as redesigning the education system targeted toward promoting innovation.

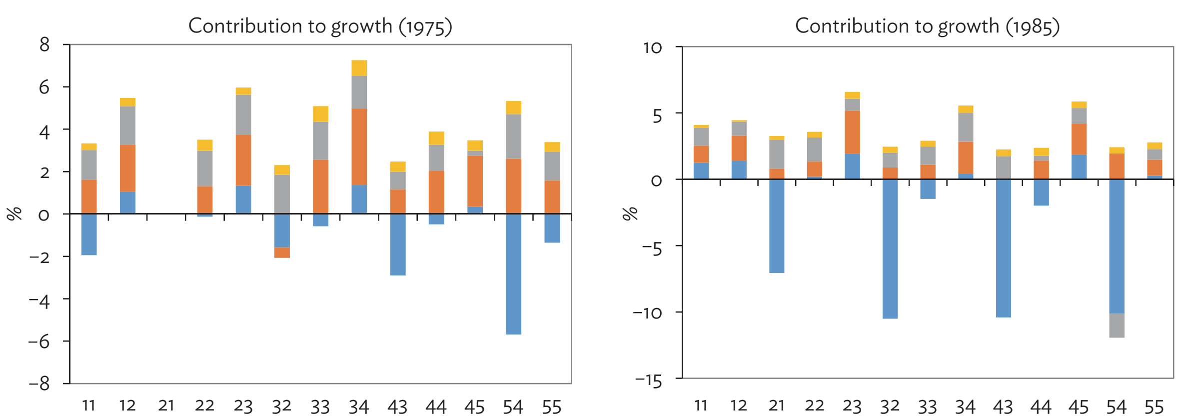
Appendix: Estimates based on TFP3[1]

Figure A1: Contribution of Factors to Economic Growth, by Income and Transition Country Groups



Sources: Authors' estimates based on PWT 9.0, the United Nations National Accounts Statistic, Barro and Lee (2013).

Figure A2: Contribution of Factors to Economic Growth, by Income and Transition Country Groups and by 10-Year Interval Subperiods

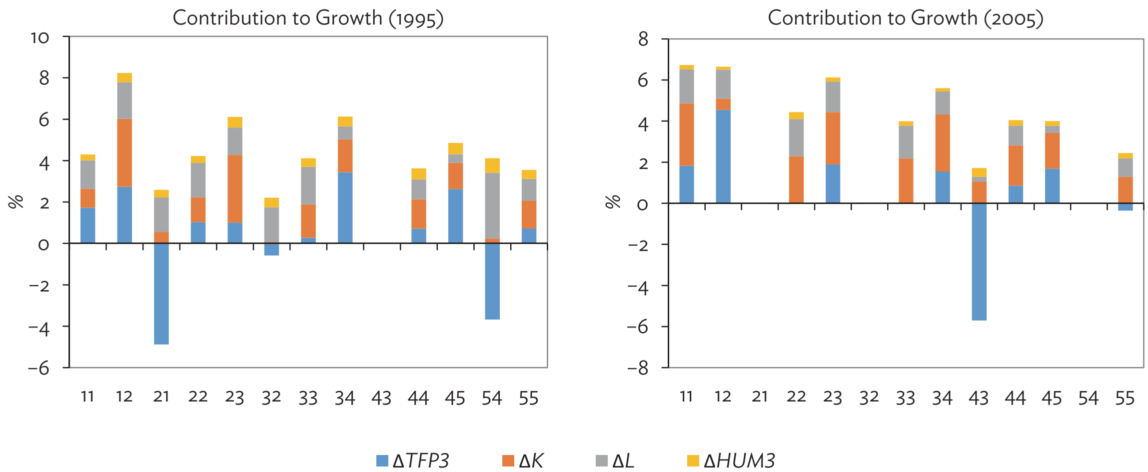


continued on next page

[1] The growth rates of TFP3 are calculated based on the following formula:

$$\Delta\, ln(TFP) = \Delta\, ln(Y) - (1 - a_L)\Delta\, ln(K) - a_L[\Delta\, ln(L) + (0.08)\Delta h]$$

Figure A2 continued



Sources: Authors' estimates based on PWT 9.0, the United Nations National Accounts Statistic, Barro and Lee (2013).

Table A1: Group Mean Tests between Country Groups (TFP3)

A. Mean Tests between Groups 34 and 33

	Group 34	Group 33	Difference in Mean	T-Statistics	P-Value
Mean growth in					
TFP	0.011	−0.017	0.028	4.358***	0.000
Physical capital	0.062	0.047	0.015	2.016**	0.048
Labor	0.023	0.027	−0.004	1.096	0.277
Human capital	0.019	0.027	−0.008	1.709*	0.092
Number of observations	27	43			

B. Mean Tests between Groups 45 and 44

	Group 45	Group 44	Difference in Mean	T-Statistics	P-Value
Mean growth in					
TFP	0.015	−0.007	0.021	3.940***	0.000
Physical capital	0.046	0.042	0.004	0.917	0.360
Labor	0.008	0.014	−0.006	1.412	0.160
Human capital	0.009	0.016	−0.007	3.061***	0.003
Number of observations	32	129			

Note: t-statistics are in absolute value.
Sources: Authors' estimates based on PWT 9.0, the United Nations National Accounts Statistic, Barro and Lee (2013).

Table A2: Other Factors of Total Factor Productivity Growth by Income and Transition Country Groups

Income Level Transition	Average Schooling Years (All Levels)	Primary Schooling Years	Secondary Schooling Years	Tertiary Schooling Years	Opennes s Index	FDI-to-GDP Ratio	Domestic Credit to GDP Ratio	R&D Capital Stock per Labor (in 2010 $)
1→1	2.082	1.713	0.355	0.014	0.389	0.007	0.231	37.9
1→2	3.582	2.760	0.781	0.041	0.607	0.018	0.221	35.4
2→1	4.724	3.201	1.474	0.049	0.668		0.668	
2→2	3.403	2.462	0.888	0.053	0.504	0.013	0.262	145.2
2→3	5.310	3.452	1.746	0.112	0.735	0.031	0.302	102.8
3→2	4.810	3.036	1.651	0.123	0.667	0.012	0.372	
3→3	4.635	3.000	1.454	0.180	0.670	0.020	0.409	256.7
3→4	5.767	3.749	1.823	0.195	0.859	0.038	0.398	303.9
4→3	5.548	3.236	2.159	0.154	1.031	0.012	0.397	948.0
4→4	7.005	4.530	2.201	0.274	0.818	0.032	0.550	667.3
4→5	8.954	5.407	3.149	0.397	1.068	0.048	0.674	1,671.4
5→4	5.673	3.204	2.121	0.349	0.658	−0.002	0.349	842.8
5→5	8.953	5.135	3.303	0.515	0.992	0.194	0.944	6,312.6

FDI = foreign direct investment, GDP = gross domestic product, R&D = research and development.
Sources: Authors' estimates based on PWT 9.0, the United Nations National Accounts Statistic, Barro and Lee (2013).

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The Role of Total Factor Productivity Growth in Middle Income Countries

Our study, based on cross-country panel data, during 1975–2014 shows that total factor productivity (TFP) growth is the main factor explaining the income group transition of countries, especially for middle-income countries. The TFP growth model reveals that the catch-up effect, human capital, smaller population, weak currency, and research and development (R&D) growth are significant sources explaining TFP growth. Strengthening innovative activities and building innovative capacities matter in overcoming middle-income country challenges. Governments in upper-middle-income countries need reform to motivate innovation by optimizing national R&D system and redesigning education system targeted toward promoting innovation.

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