RIETI Discussion Paper Series 07-E-045

On the Role of Technical Cooperation in International Technology Transfers

SAWADA Yasuyuki
RIETI

MATSUDA Ayako
the University of Tokyo

KIMURA Hidemi
RIETI

RIETI
Research Institute of Economy, Trade & Industry, IAA

The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 07-E-045

・ On the Role of Technical Cooperation in International Technology Transfers*

by

Yasuyuki Sawada,†

Ayako Matsuda,

and

Hidemi Kimura

June, 2007

Abstract

We investigate whether and how technical cooperation aid (TC) facilitates technological diffusion from developed to developing countries, comparing it with foreign direct investment (FDI) and external openness. Extending the model of Benhabib and Spiegel (2005), we estimate the degree to which these three channels contribute to countries' total factor productivity (TFP) growth rates. Our econometric model also allows us to identify whether a country will catch up to or diverge from the technological leader nation over time. Two sets of robust findings emerge. First, TC, FDI and openness all contribute to facilitate international technology transfers. Yet, among these three channels, openness seems to contribute the most, followed by TC. Also, TC seems to compensate for the lack of sufficient human capital in developing countries. Second, around 6 to 17 countries out of 85 in our sample fail to catch up to the technological leader over the 36 years. These results suggest that TC can play an important role in facilitating the technological catch up of developing countries.

Keywords: Technical Cooperation, Technology Diffusion, TFP, FDI, Openness

JEL Classification: O33, O47, O11, F43

---

* This research is a part of the project "Economics of Foreign Aid," undertaken at the Research Institute of Economy, Trade and Industry (RIETI). The authors would like to thank RIETI for their generous support for the project. The authors are also grateful to Mark Spiegel for sharing his data and the seminar participants at RIETI for their helpful suggestions. The opinions expressed and arguments employed in this paper are the sole responsibility of the authors and do not necessarily reflect those of RIETI or the Ministry of Economy, Trade and Industry of Japan.

† Yasuyuki Sawada (Corresponding Author): Faculty of Economics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan. Phone: +81(3) 5841-5572 or 5530. Fax: +81 (3) 5841-5521 (e-mail: sawada@e.u-tokyo.ac.jp); Ayako Matsuda: Ph.D. candidate, Graduate School of Economics, University of Tokyo (e-mail: aymatsu@gmail.com); Hidemi Kimura: Research Institute of Economy, Trade, and Industry (e-mail: kimura-hidemi@rieti.go.jp).

1. Introduction

Recently, a dispute has emerged over the effectiveness of foreign aid in facilitating economic growth (Burnside and Dollar 2000; Easterly et al. 2004; Dalgaard, et al. 2005). Burnside and Dollar (2000), one of the most influential papers on this issue, found that the impact of aid on the growth of recipients is positive, conditional on good policies. However, other studies cast doubt on this conditional linkage between aid and growth (Easterly et al. 2004; Easterly 2003). These studies treat aid as homogeneous official capital flows from developed to developing countries. Yet, three types of foreign aid flow exist: loans, grants, and technical cooperation aid (TC). By the Development Assistance Committee (DAC) of the OECD, loans, grants, and TC are defined, respectively, as "transfers for which repayment is required," "transfers made in cash, goods, or services for which no repayment is required," and "activities whose primary purpose is to augment the level of knowledge, skills, and technical know-how or productive aptitudes of the population of developing countries." Figure 1 shows the trend of these three aid components.

While there have been recent policy and academic debates over the relative effectiveness of loans and grants (Meltzer 2000; Bulow and Rogoff 2005; Iimi and Ojima 2006; Cordella and Ulku 2004; and Gupta et al. 2003), there are only a few existing studies which explicitly analyze heterogeneities in types of aid. Particularly, the effectiveness of technical cooperation aid has been largely unexplored. For example, Burnside and Dollar (2000) employed the aid variable compiled by Chang et al. (1998), which is a sum of loans and grants, excluding TC because, in their view, the donor rather than the recipient benefits from payments received in return for the technical assistance supplied. Moreover, Cassen et al. (1994) pointed out the absence of ready methodology for measuring the effectiveness of aggregate long-run effects of TC. Difficulties in measuring the impacts have hindered academia from conducting quantitative evaluations of TC.

Apparently, however, TC shares a non-negligible portion of the total ODA and the amount is increasing (Figure 1). Conceptually, it may be obvious that, by nature, there are positive spillover effects of international technology transfers through TC, as some international aid agencies state explicitly (JICA 2007; GTZ 2007). TC's range of coverage is wide: training staff to deliver technological skills in the areas of agriculture, forestry, engineering, and IT; to convey management skills in the areas of education, business, and banking; to design effective policies in the areas of social security, housing, health, and family planning.[1] TC in a wide variety of sectors has also played an important role in increasing the stock of human intellectual capital, or the capacity for more effective use of existing factor endowment. However, to our knowledge, its effectiveness has not yet been quantitatively measured. This paper aims to bridge this gap in the literature by analyzing the role of TC in facilitating technology transfers from donors to aid recipients.

In growth theories, technological progress has been regarded as a core element in long-run growth (Barro and Sala-i-Martin 2004; Aghion and Howitt 1998). The source of such technological progress in developing countries is multi-faceted. In addition to TC, we also examine the other three possibly important determinants of international technological transfers from developed to developing countries. First, for

[1] For example, Cassen et al. (1994) claims that smallpox eradication is one of the major successful outcomes of worldwide technical cooperation aid (p.149).

developing countries as latecomers, the adoption, imitation, and assimilation of the flows of technical know-how from developed countries, rather than the development of domestic R&D sectors, augment their productivity to catch-up to the technological leader.[2] This also suggests the importance of absorptive capacity of advanced foreign technologies in developing countries (Glass and Saggi 1998; Lucas 1993; Eaton and Kortum 1996; Keller 2004). The absorptive capacity, with which the gap between the technology frontier and the current level of productivity is filled, should closely depend on the level of human capital (Nelson and Phelps 1966; Keller 2004; Benhabib and Spiegel 2005).

Second, foreign direct investment (FDI) has long been considered an important channel for technological diffusion (Keller 2004). Existing case studies and cross-country regression results found that FDI contributes relatively more to economic growth than do domestic investments (Balasubramanyam et al. 1996; Borensztein et al. 1998; de Mello 1999; Eaton and Kortum 1999; van Pottelsberghe de la Potterie and Lichtenberg 2001; Carkovic and Levine 2005; Li and Liu 2005).[3] Interestingly, this positive nexus between FDI and growth is observed particularly when a sufficient absorptive capability of advanced technologies is available in the host economy (Borensztein et al. 1998). This finding suggests that FDI may be an important route of international technological spillover (Keller 2004).

Finally, international trade has been identified as an important means of

---

2 Ohkawa and Kohama (1989) suggest that Japan is a typical example of borrowed technology-driven industrialization. They argue that Japan's success was attributable to its rapid human capital accumulation by which absorptive capacity of foreign technology has been built.

3 Yet de Mello (1999) shows that FDI positively and significantly affects TFP for OECD countries, while it does not result in significant consequence for non-OECD countries. Also, Carkovic and Levine (2005) imply the consequences of FDI's positive impact on economic growth are possibly due to endogeneity bias.

transferring foreign technology (Keller 2004).[4] Knowledge spillovers will increase with the number of commercial interactions between domestic and foreign agents (Grossman and Helpman 1991). We also need to distinguish between imports and exports. Imports have been regarded as a significant channel of technology diffusion because, obviously, technologies move from an exporting country of intermediate inputs to another (Keller 2004). Coe and Helpman (1995) find that foreign R&D capital stocks have stronger effects on domestic productivity, the larger the share of domestic imports in GDP.[5] Also, exports may be important because firms can learn foreign technologies through exporting experiences (Keller 2004). While in existing empirical studies we do not necessarily have firm evidence of technology diffusion through importing and learning-by-exporting effects (Keller 2004), it would be reasonable to hypothesize that the extent of international technology transfers will increase with the volume of international trade.

In this paper, we compare the relative importance of different channels in facilitating international technology transfers quantitatively. Our strategy is to extend the standard model of international technology transfer of Benhabib and Spiegel (2005) by incorporating TC, FDI, and external openness, and to explore the role of TC as a channel of technological diffusion through comparisons with FDI and openness.

To preview the results, two sets of robust empirical findings emerge. First, TC, FDI, and openness all contribute to facilitating international technology transfers.

---

[4] In the initial phases of development, much of the R&D undertaken in Japan was absorptive, aimed at integrating foreign technologies (Blumenthal 1976). More recently, countries such as Mexico, Brazil, India, and China view FDI by firms from technologically advanced countries as a vehicle of technology transfer (Glass and Saggi 1998).

[5] Their estimates also suggest that the foreign R&D capital stock may be at least as important as the domestic R&D capital stock in the smaller countries, while in the larger countries (the G7) the domestic R&D capital stock may be more important.

Yet, among these three channels, openness seems to contribute the most, followed by TC. Also, TC seems to compensate for the lack of sufficient human capital in developing countries. Second, around 6 to 17 countries out of 85 in our sample fail to catch up to the technological leader over the 36 years. These results suggest that TC can play an important role in facilitating the technological catch-up of developing countries.

The remainder of the paper is organized as follows. In Section 2, we show our theory of international technological transfers which is an augmented version of the exponential and logistic specifications of the Benhabib and Spiegel (2005) model of international technology transfers. Section 3 describes the data and econometric framework as well as the nested functional forms of specification incorporating the exponential and logistic technology diffusion. In Section 4, we present estimation results of model parameters and the computed required amount of TC for each country that is needed for catching up to the technological leader. Section 5 describes various robustness tests, which is followed by concluding remarks in Section 6.

2. A Theoretical Framework of International Technology Transfers

There must be a certain market structure under which rational agents engage in innovation in the face of international technological diffusion (Barro and Sala-i-Martin 1997; Benhabib and Spiegel 2005). Yet, we abstract from such a model because our aim is not to provide the micro-foundations of international technological transfers. Rather, we intend to employ a tractable empirical model to uncover a wide variety of important dimensions of technology transfers.

The pattern of international technological diffusion can be exponential, which would predict that developing nations exhibit positive catch-up with the leader nation (Nelson and Phelps 1966; Benhabib and Spiegel 2005). In this case, the model of technology diffusion can be formalized by the following equation:

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = \alpha\Phi_i + \beta\Phi_i\left(\frac{A_{m0}}{A_{i0}} - 1\right), \qquad (1)$$

where the variables $\alpha\Phi$ and $\beta\Phi$ represent, respectively, the follower country's capacity to innovate its own technology and to absorb foreign technologies.

On the other hand, if international technological diffusion follows a logistic pattern, the gap between the technology leader and a follower may widen over time. For this model, as is shown in equation (2.3) of Benhabib and Spiegel (2005), we can postulate:

$$\begin{aligned}\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) &= \alpha\Phi_i + \beta\Phi_i\left(1 - \frac{A_{i0}}{A_{m0}}\right) \\ &= \alpha\Phi_i + \beta\Phi_i\left(\frac{A_{i0}}{A_{m0}}\right)\left(\frac{A_{m0}}{A_{i0}} - 1\right),\end{aligned} \qquad (2)$$

where the new part, A_{i0}/A_{m0}, indicates the difficulty of adopting distant technologies.

In this paper, we employ the Benhabib and Spiegel (2005) model of international technological transfers, which is a nested model of these two possibilities. We augment the Benhabib and Spiegel (2005) nested technological diffusion equation by including TC, FDI, and openness in addition to human capital and postulate the following equation:

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right)$$
$$= \left(g + \frac{c}{s}\right)\Phi(h_i, TC_i, FDI_i, OPEN_i) - \frac{c}{s}\Phi(h_i, TC_i, FDI_i, OPEN_i)\left(\frac{A_{iT}}{A_{mT}}\right)^s, \qquad (3)$$

where A_{i0} is the level of total factor productivity (TFP) for country i at year t where country m is the technological leader, e.g. the US, and i is a follower country. The variable Φ represents the follower country's capacity to innovate its own technology and to absorb foreign technologies. We assume that Φ is a function of the initial or long-term average level of human capital, h, the amount of TC received, TC, the flow of FDI, FDI, and the degree of external trade openness, $OPEN$. According to Benhabib and Spiegel (2005), the values of parameters, c, g, and s will determine whether a country will converge to the growth rate of the leader or whether the growth rates will diverge. Note that the specification represented in Equation (1) nests the logistic model when $s = 1$ and exponential model when $s = -1$.

In the case where $s \in (0,1]$, as is shown by Benhabib and Spiegel (2005), the technological catch-up condition for the technological progress rate of a country to converge to the technological growth rate of the leader becomes:

$$1 + \frac{c}{sg} > \frac{\Phi_m}{\Phi_i}. \qquad (4)$$

Note that this is a necessary condition for the catch-up. Hence, if the inequality did not hold and reversed, the country would not technologically catch-up to the leader. This situation may be called a "technological poverty trap."

3. An Econometric Model and Data

3.1 An Econometric Model

In order to empirically implement the estimation of equation (3), we postulate a linearity assumption for the capacity function Φ. Accordingly, our estimation equation becomes the following:

$$\frac{1}{T}\left(\log A_{iT} - \log A_{i0}\right) = b_0 + b_1\left(h_i + b_4 TC_i + d_1 FDI_i + e_1 OPEN_i\right) - b_2\left(h_i + b_4 TC_i + d_1 FDI_i + e_1 OPEN_i\right)\left(\frac{A_{i0}}{A_{m0}}\right)^{b_3} + u_i, \quad (5)$$

where u_i is a well-behaved *i.i.d.* disturbance term. Using this nested specification, we can test the logistic model and exponential model by testing whether $b_3 = 1$ and $b_3 = -1$, respectively. We can also test empirically whether TC facilitates international technological diffusion by testing whether b_4 takes a positive coefficient or not. Moreover, it is possible to compare the roles of TC, FDI, and external openness as a channel of technological diffusion by comparing the relative magnitude of the estimated coefficients of b_4, d_1, and e_1.

To be consistent with the theoretical framework, we should exclude the constant term, b_0. Yet from the viewpoint of econometric analysis, the inclusion of a constant term is not necessarily an implausible idea. In fact, even from the theoretical viewpoint, Benhabib and Spiegel (2005) pointed out that the constant term could be interpreted as a speed of common exogenous technological progress that is independent of any country-specific characteristics. Accordingly, we decide to show the empirical results with and without the constant term.

We estimate equation (5) using the method of non-linear least squares (NLLS). In general, NLLS results are sensitive to a choice of initial vectors because the objective function we try to minimize is not necessarily a globally convex function. In order to mitigate the problem of local optima, we explored different sets of initial values to attain the stability of the estimated parameters. Our procedure is two-step and works as follows. First, we use the estimated parameters reported in Benhabib and Spiegel (2005) to estimate four different sets of parameters (Model 1, Model 2, Model 3, and Model 4). Then the attained baseline parameters are used as the initial parameters for each model.

3.2 Data

A major challenge in our empirical implementation is to measure technology because technology is an intangible. There are three widely used approaches to measure technology (Keller 2004): first, to measure R&D inputs; second, to measure outputs using patent data; and finally, to measure the effect of technology in terms of productivity. In our study, we follow Benhabib and Spiegel (2005) and take the third approach to quantify the level of technology as the level of productivity: we compute TFP as a measure of productivity level, A_{it}, by postulating a Cobb-Douglas aggregate production function. In this formulation, a technology level can be computed by the formula: $\log A_{it} = y_{it} - \alpha\, k_{it} - (1-\alpha)\, l_{it}$, where y, k, and l, are the log of real GDP, the log of physical capital inputs, and the log of population, respectively. We follow Benhabib and Spiegel (2005) and assume that $\alpha = 1/3$.

Since we do not have data on the physical capital stock, we also follow

Benhabib and Spiegel's (2005) procedure to compute the initial capital stock taking the method elaborated by Klenow and Rodriguez-Clare (1997). The procedure is to calculate the initial capital stock by using the formula $\frac{K_{1960}}{Y_{1960}} = \frac{I/Y}{\gamma + \delta + n}$, where I/Y is the average share of physical investment in GDP in the sampling periods, γ represents the average rate of growth of output per capita, n represents the average rate of population growth, and δ represents the depreciation rate of capital, which is set to 3%. After deriving the level of initial capital stock, we calculate the capital stock for each year using annual investment data. Data for GDP, investment, population, and openness were extracted from the Penn World Table version 6.1.[6] The estimated values of TFP growth by Benhabib and Spiegel (2005) seem plausible: the high performing East Asian countries exhibit the highest TFP growth while some of the Sub-Saharan African countries including the Democratic Republic of the Congo, Mozambique, Niger, the Central African Republic, and Zambia show the negative growth rates.

As for data for human capital, we follow Benhabib and Spiegel (2005) and employ the average years of schooling in the population above 25 years of age, which are obtained from Barro and Lee (2000), an updated version of the Barro and Lee (1993) dataset.

Data on TC is taken from the OECD/DAC's International Development Statistics.[7] The data set is available for both disbursement and commitment data for

[6] In particular, the variables, *pop*, *rgdpl*, *ki*, and *openk*, in PWT 6.1 are used in the present paper.
[7] The data is available at <http://stats.oecd.org/wbos/default.aspx?DatasetCode=TABLE%202A>. We exclude countries which became OECD members before 1975. Also, Eastern European countries and the former USSR countries are eliminated from the data set because the data quality is not satisfactory (Kimura and Todo, 2007).

TC. In this paper, we confine our analysis to the disbursement data because it is supposed to reflect the actual amount given to the recipient countries. We construct five different measures of TC. The first measure (*ta12*) is the average amount of TC over all available years. The value is converted into the constant 2004 price and in millions of US dollars (USD). The second measure (*tagdp12*) is computed by dividing the first measure (*ta12*) by the average GDP over the years 1960–1995. The third measure (*ta111*) is the initially available value of TC for each country. The fourth measure (*ta80*) is the average value of TC over all available observations in and before 1980. The final measure (*ta90*) is the average amount of TC for all available observations in and before 1990. Data on FDI are taken from UNCTAD's World Investment Report (2006).[8] In order to construct real FDI data, nominal FDI flows are divided by the GDP deflator of the recipient country using the World Bank's World Development Indicators (2006). Specifically, we construct four FDI variables. First, *FDIinflow* is a mean value of FDI inflows over 1970-1995. Second, *FDIinflowgdp* is defined by *FDIinflow* divided by average GDP over the years 1970–1995. Third, *FDIinflow80* is an average FDI inflows over the years 1970–1980. Finally, *FDIinflow90* is defined by average FDI inflows over the years 1970–1990. To check the robustness of our estimation, we also employ FDI data taken from the OECD (2005).

Finally, three openness variables are constructed by using the total amount of international trade, i.e. a sum of total imports and exports. The first variable, open, is defined as the ratio of total international trade, which is divided by GDP averaged over

[8] The data is available at
<http://www.unctad.org/sections/dite_dir/docs/wir2006_inflows_en.xls>.

the years 1960–1995. The second variable, open80, is the average ratio in and before 1980. The third variable, open90, is the average ratio in and before 1990. In order to conduct robustness tests, we also use alternative data sets such as an updated version of Sachs and Warner's (1995) Openness Index.

After compiling these variables, we constructed cross-country data which are composed of 85 countries for the period 1960–1995.

4. Benchmark Results

In this section, we show the benchmark estimation results of equation (5). The first specification includes only TC and excludes FDI and openness. The results reported in Table 1 show that the estimated coefficients on TC, i.e. b_4 in equation (2), are consistently positive and statistically significant. These results suggest that TC plays an important role in facilitating domestic technological progress and international technology transfers. Also, we cannot reject a null hypothesis that b_3=1, supporting the logistic model of international technological transfers.

In Table 2, we include FDI variables in addition to TC variables. The coefficients on FDI variables are largely positive. While the statistical significance depends on the choice of FDI variable, the coefficients are significant in 9 out of 14 specifications.

Finally, we include the three variables of our interest: TC, FDI, and openness. The results are presented in Table 3. Most of the openness variables are positive and statistically significant in 12 out of 14 specifications. On the other hand, the effects of the TC variable become less clear: there are 8 and 10 positive and significant cases out of 14 specifications in TC and FDI variables, respectively. Notably, the initial TC variable generates a positive and statistically significant effect.

4.1 Comparing the effects of TC, FDI, and openness

While our overall estimation results reveal that TC, FDI, and openness facilitate international technological transfers, the relative magnitude of these three factors is not necessarily clear. In order to compare the relative effectiveness of these three factors, we calculate the casual impact of one standard deviation change for each variable on the capacity variable, Φ, by multiplying each estimated coefficient by the standard deviation of each variable, as reported in the Appendix Table. We employ the estimated results of specifications (3.2), (3.5), (3.7), (3.9), (3.11), and (3.13) of Table 3. In most specifications, the effect of openness is the largest, followed by TC. FDI inflows have a positive—but the lowest—impact on building the capacity of recipient countries.

4.2 Testing the Catching-Up Condition

Since the estimated coefficient, b_3, is uniformly above one, our results favor the logistic diffusion model of technology transfers. Hence, there is a possibility for countries to encounter technological divergence from the leader country. In order to identify such countries quantitatively, we use the necessary condition represented by equation (4). Using estimated coefficients, the equation (4) can be rewritten as the following expression:

$$TC_i > \frac{1}{\hat{b}_4}\left(\frac{h_m \cdot \hat{b}_3\hat{g}}{\hat{b}_3\hat{g} + \hat{c}} - h_i - \hat{d}_1 FDI_i - \hat{e}_1 Open_i\right), \tag{6}$$

where we assume that the capacity of the leader nation depends only on its human capital. Alternatively, we can derive the catch-up condition incorporating the FDI effect of the leader nation:

$$TC_i > \frac{1}{\hat{b}_4}\left(\frac{\Psi_m \cdot \hat{b}_3\hat{g}}{\hat{b}_3\hat{g} + \hat{c}} - h_i - \hat{d}_1 FDI_i - \hat{e}_1 Open_i\right), \tag{7}$$

where $\Psi_m = h_m + \hat{b}_4 TA_m + \hat{d}_1 FDI_m + \hat{e}_1 Open_m$.

The test results of the catching-up condition are summarized in Tables 4 and 5. In both cases, if we use specification (3.2) in Table 3, our results identify six countries that do not comply with equation (4); Central African Republic, Mali, Mozambique, Niger, Nepal, and Togo. Alternatively, using specification (3.5) in Table 3 gives 10 technologically trapped countries: Bangladesh, the Central African Republic, Iran, Mali, Mozambique, Niger, Nepal, Pakistan, Togo, and Democratic Republic of Congo. In contrast, 68 out of 85 countries always satisfy the catch-up condition (Tables 4 and 5).

The countries, which do not satisfy the catch-up condition of equations (6) and (7), would not converge with the leader's technological progress. In such countries, we can employ equation (7) with the estimated parameters of equation (5) and compute the minimum required amount of TC to catch-up with the leader technologically. For example, the predicted necessary amounts of TC for the Central African Republic and for Pakistan are 68.49 million USD and 337.09 million USD in 2004 prices, respectively.[9] The actual average amounts of TC over the years 1960–1995 are 54.02

[9] These results are based on the results of specification (3.2) and (3.5), respectively, of Table 3.

million USD for the Central African Republic and 223.91 million USD for Pakistan. The actual amounts of TC in 2004 are 34.72 million USD and 124.4 million USD for the Central African Republic and Pakistan, respectively.

5. Robustness Tests

5.1 Regional Specificity

We perform four sets of robustness tests on the benchmark results. In order to check the regional specificity, we construct an East Asia and Pacific dummy variable (hereafter, Asian dummy) which takes one if a country is categorized within the World Bank's East Asia and Pacific region and zero otherwise. The Asian dummy variable is incorporated independently into the Φ function. We also include the interaction variable of TC, FDI, and openness with the Asian dummy variable. According to our estimation results reported in Tables 6 and 7, only the Asian dummy incorporated independently takes a statistically significant coefficient. The direction of the coefficient is positive, suggesting that Asian countries have a systematically higher capacity to catch-up with the technology leader nation.

5.2 Relaxing the Function Form of Capacity Function

The second robustness check is to relax further the function form of the capacity function, Φ, in equation (3) and (4). In this aim, we add the interaction terms of TC, FDI, and openness with the human capital variable. The resulting empirical model becomes:

$$\frac{1}{T}\left(\log A_{iT}-\log A_{i0}\right)=b_0+b_1(X\beta)-b_2(X\beta)\left(\frac{A_{it}}{A_{mt}}\right)^{b_3}+u_i, \qquad (8)$$

where X=[*h, TC*, *TC*h, FDI, FDI*h, Open, Open*h*] and β is its coefficient vector.

In Tables 8–11, we show estimation results of a wide variety of specifications with various interaction terms. As for the level coefficients on TC, FDI, and openness variables, they are consistently positive and largely significant. Yet, as for the interaction terms, the estimated coefficients of TC and human capital interaction terms are mostly negative and statistically significant, suggesting that when a country's human capital level is low, the technology transfer facilitation effect of TC becomes larger (Tables 8 and 11). According to descriptive statistics, low income countries with low levels of human capital tend to receive a larger amount of TC.[10] Hence, the negative coefficient on the TC and human capital interaction term indicates that TC effectively compensates the lack of sufficient human capital in developing countries, facilitating international technological transfers. Another interpretation, however, is that TC is not necessarily allocated to countries with a larger amount of human capital and thus high absorptive capacity of technologies.

The estimated coefficients of FDI and human capital interaction variables are shown in Tables 9 and 11. The magnitude of these coefficients is generally small and their direction seems to be inconclusive, while these coefficients are mostly negative in Table 9. As to the interaction term of openness and human capital variable, the coefficients are largely negative and significant (Tables 10 and 11). This finding suggests that even when a country's human capital level is low, external openness will

[10] A simple correlation between average per capita GDP for 1960–1995 and years of schooling in 1960 is 0.648. The figure between average per capita GDP for 1960-1995 and average per capita TC for 1960-1995 is -0.162.

significantly facilitate international technological diffusion.

5.3 Alternative Data

Third, we employ alternative datasets for FDI and openness to check further robustness. For FDI, we use the OECD's International Direct Investment Statistics (IDIS) data. As we can see from Tables 12 and 13, the qualitative results are the same as before.

We also employ two alternative indicators of openness: the ratio of imports to GDP, based on the World Bank's World Development Indicator, and the Sachs-Warner Index of Openness (Sachs and Warner 1995). The latter variable takes zero (closed) if a country satisfies one of the following five criteria: (1) its average tariff rate exceeded 40%; (2) its non-tariff barriers covered more than 40% of imports; (3) it had a socialist economic system; (4) it had a state monopoly of major exports; or (5) its black-market premium exceeded 20% during either the 1970s or 1980s. Results based on import data are summarized in Tables 14 and 15. Tables 16 and 17 show the results using the Sachs and Warner (1995) Openness Index. The qualitative results are comparable to those based on the benchmark results.

5.4 Missing observations

Since the human capital data for the year 1960 is available only for 85 countries, we confine our analysis to this sample size. This implies that we did not necessarily utilize other available information to the fullest extent. In order to increase the number of countries in our analysis, we employ modified zero-order regression

(Greene 2003, p. 60). In this method, we fill the missing variable with zeros and add a dummy variable that takes the value one for missing observations and zero for complete ones.

In fact, introduction of missing dummies for the initial human capital variable, denoted as *lhc60miss*, allows us to expand the sampling countries to 110. Though the qualitative results of all the estimations are the same, the coefficients of FDI variables are now more likely to be significant. The coefficients of cross term of *TC, FDI, openness* with human capital remain negative. The estimated coefficients of *lhc60miss* and *h* are mostly negative and significant. The results are summarized in Tables 18 and 19.

6. Concluding Remarks

In this paper, we investigate whether and how TC facilitates international technological transfers from developed to developing countries and we compare its effect with those of FDI and external openness. Augmenting the model of Benhabib and Spiegel (2005), which nests exponential and logistic models of technology diffusion, two sets of robust findings emerge. First, our results suggest that TC, FDI, and openness all contribute to the facilitation of international technology transfers. Among these three channels, openness seems to contribute the most, followed by TC. Also, we found that TC complements the lack of human capital in facilitating international technological transfers. Second, 6 to 17 countries out of 85 in our sample do not satisfy the necessary condition of technological catch-up. These results suggest that TC can play an important role in enhancing absorptive capacities to facilitate technological catch-up of developing countries.

Technology involves non-codified tacit knowledge which can be transferred only through face-to-face interaction (Keller 2004). TC, which is composed of technological training by experts sent by developed countries to developing countries and trainees sent by the latter to the former, can facilitate person-to-person interactions in international transfers of non-codified tacit knowledge and technologies.

Cassen et al. (1994) stated that "[m]any factors make it impossible to produce a single measure of the overall effectiveness of TC, among them, the difficulties of setting verifiable objectives and the great variety of TC activities. However, it is probably the case that the attempts to evaluate TC have understated its effectiveness. This is because the evaluation literature concentrates disproportionately on 'soft' TC activities (where success is harder to achieve) and the tendency of evaluators to look for failure so as to improve their institution's performance." (p. 167.) We believe the use of the TFP concept, which is the broad measure of a country's aggregate productivity, including institutional and intangible elements, is suitable in order to evaluate overall effectiveness of TC, involving both soft and hard TC activities. By quantifying the role of TC in bridging the gap between the TFPs of the leader and developing countries, we believe that we make an important contribution to the literature on foreign aid.

References

Aghion, P., and P. W. Howitt (1998), *Endogenous Growth Theory,* MIT Press.

Balasubramanyam, V. N., M. Salisu, and D. Sapsford (1996), "Foreign Direct Investment and Growth in EP and IS Countries," *Economic Journal* 106(434):92–105.

Baldwin, R., H. Braconier, and R. Forslid (2005). "Multinationals, Endogenous Growth, and Technological Spillovers: Theory and Evidence," *Review of International Economics* 13(5):945-963.

Barro, R. J., and X. Sala-i-Martin (2004), *Economic Growth*, 2nd edition, Cambridge, MA: MIT Press.

Barro, R. J., and J. W. Lee (1993), "International Comparisons of Educational Attainment," *Journal of Monetary Economics* 32:363–394.

Barro, R. J., and J. W. Lee (2000), "International Data on Educational Attainment: Updates and Implications" *CID Working Paper* 42, April 2000.

Barro, R. J., and J. W. Lee (2005), "IMF Programs: Who is chosen and what are the effects?" *Journal of Monetary Economics* 52:1245-1269.

Barro, R. J., and X. Sala-i-Martin (1997), "Technological Diffusion, Convergence and Growth," *Journal of Economic Growth* 1:1–26.

Benhabib, J., and M. Spiegel (2005), "Human Capital and Technology Diffusion" In Aghion and Durlauf eds., *Handbook of Economic Growth*, 1A, Chap. 13, 935–966, Amsterdam: North Holland.

Blumenthal, T. (1976), "Japan's technological strategy," *Journal of Development Economics* 3:245-255.

Borensztein, E., J. De Gregorio, and J. W. Lee (1998), "How Does Foreign Direct Investment Affect Economic Growth?" *Journal of International Economics* 45:115–135.

Bulow, J., and K. Rogoff (2005), "Grants versus loans for development banks" *AEA Meetings Paper.*

Burnside, C. and D. Dollar (2000), "Aid, Policies, and Growth," *American Economic Review* 90(4):847–868.

Carkovic, M., and R. Levine (2005), "Does Foreign Direct Investment Accelerate Economic Growth?" In Theodore Moran ed., *The Impact of Foreign Direct Investment on Development: New Measurements, New Outcomes, New Policy Approaches,* Washington D.C., The Institute of International Economics.

Cassen, R., and associates (1994), *Does Aid Work?* Second edition, Clarendon Press: Oxford.

Chang, C. C., E. Fernandez-Arias, and L. Serven (1998), "Measuring Aid Flows: A New Approach," *Policy Research Working Paper* 2050, DECRG and the World Bank.

Ciccone, A., and K. Matsuyama (1996), "Start-up Costs and Pecuniary Externalities as Barriers to Economic Development," *Journal of Development Economics* 49(1):33–59.

Coe, D. T., and E. Helpman (1995), "International R&D spillovers," *European Economic Review* 39:859–887.

Cordella, T., and H. Ulku (2004), "Grants versus Loans" *IMF Working Paper* 04/161.

Dalgaard, C. J., H. Hansen, F. Tarp (2004), "On the Empirics of Foreign Aid and Growth," *Economic Journal* 114(496):191-216.

de Mello, L. R. Jr. (1999), "Foreign Direct Investment-Led Growth: Evidence from time series and panel data," *Oxford Economic Papers* 51(1):133-151.

Doppelhofer, D., R. Miller, and X. Sala-i-Martin (2004), "Determinants of Long-term Growth: A Bayesian Averaging of Classical Estimates (BACE) approach," *American Economic Review* 94(4):813-835.

Eaton, J. and S. Kortum (1999), "International Technology Diffusion: Theory and measurement," *International Economic Review* 40:537–570.

Eaton, J. and S. Kortum (2002), "Technology, Geography, and Trade," *Econometrica* 70(5):1741–1779.

Easterly, W. (2003), "Can Foreign Aid Buy Growth?" *Journal of Economic Perspectives* 17(3):23–48.

Easterly, W., R. Levine, and D. Roodman (2004), "New Data, New Doubts: A comment on Burnside and Dollar's 'Aid, Policies, and Growth (2000),'" *American Economic Review* 94(3):774–780.

Feyzioglu, T., V. Swaroop, and M. Zhu (1998), "A Panel Data Analysis of the Fungibility of Foreign Aid," *World Bank Economic Review* 12(1):29–58.

Glass, A. J., and K. Saggi (1998), "International Technology Transfer and the Technology Gap," *Journal of Development Economics* 55:369–398.

Grossman, G. M., and E. Helpman (1991), "Trade, Knowledge Spillovers, and Growth," *European Economic Review* 35:517–526.

GTZ (2007), *Corporate Profile*, German Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), <http://www.gtz.de/en/unternehmen/1698.htm>.

Gupta, S., B. Clements, A. Pivovarsky, and E. Tiongson (2003), "Foreign Aid and Revenue Response: Does the composition of aid matter?" *IMF Working Paper* 03/176.

Iimi, A., and Y. Ojima (2006), "Complementarities between Grants and Loans," *JBICI Working Paper* 20.

JICA (2007), *Guide to JICA*, Japan International Cooperation Agency <http://www.jica.go.jp/english/resources/brochures/2006/pdf/guide02.pdf>.

Keller, W. (1996), "Absorptive Capacity: On the creation and acquisition of technology development," *Journal of Development Economics* 96(49):199–227.

Keller, W. (2002a), "Geographic Localization of International Technology Diffusion," *American Economic Review* 92(1):120–142.

Keller, W. (2002b), "Trade and the Transmission of Technology," *Journal of Economic Growth* 7:5–24.

Keller, W. (2004). "International Technology Diffusion," *Journal of Economic Literature* 42(3):752–782.

Kimura, H., and Y. Todo (2007), "Is Foreign Aid a Vanguard of FDI?: A gravity-equation approach," *RIETI Discussion Paper* 07-E-007, Research Institute of Economy, Trade and Industry, Japan.

Klenow, P. J., and A. Rodriguez-Clare (1997), "The Neoclassical Revival in Growth Economics: Has it gone too far?" *NBER Macroeconomics Annual* 73–103.

Li, X., and X. Liu (2005), "Foreign Direct Investment and Economic Growth: An increasingly endogenous relationship," *World Development* 33(3):393–407.

Lucas, R. E. Jr. (1993), "Making a Miracle," *Econometrica* 61(2):251–272.

Melzer, A. H. (2000), Report of the International Financial Institution Advisory Commission Congress of the United States.

Nelson, R., and E. Phelps (1966), "Investment in Humans, Technological Diffusions, and Economic Growth," *American Economic Review* 56:69–75.

van Pottelsberghe de la Potterie, B., and F. Lichtenberg (2001), "Does Foreign Direct Investment Transfer Technology across Borders?" *Review of Economic and Statistics* 83(3):490–497.

OECD (2007a), DAC International Development Statistics Online.

OECD (2007b), DAC Statistical Reporting Directives.

OECD (2005), International Direct Investment Statistics Yearbook (1980-2003) CD-ROM.

Ohkawa, K., and H. Kohama (1989), *Lectures on Developing Economies: Japan's experience and its relevance*, University of Tokyo Press.

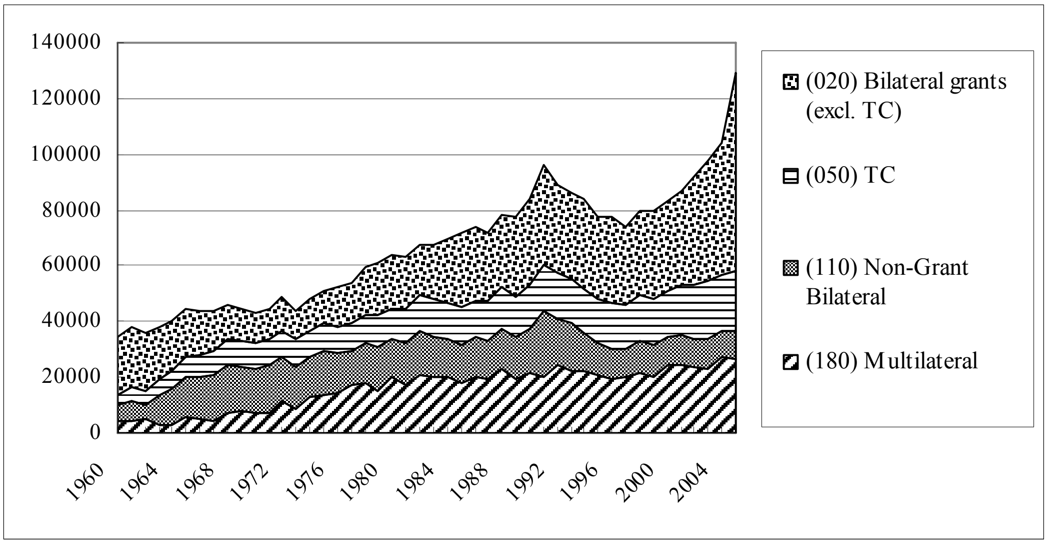
Sachs, J., and A. Warner (1995), "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity* 1–118.

Sawada, Y., H. Kohama, and H. Kono (2004), "Aid, Policies, and Growth: A further comment," Mimeo.

UNCTAD (2006), World Investment Report UNCTAD/UN.

Figure 1

ODA Decomposition
(All donors total, Gross Disbursements, 2005 USD million)



Note: Numbers in parentheses are DAC codes. Bilateral grant total (020) is the sum of investment project aid (046) including technical co-operation (050), programme aid (047) and other (080). The bilateral grants in Figure 1 represent the amount without TC. Technical co-operation (050) is made up of grants for the provision of training, research, and associated costs. Non-grant bilateral ODA (110) is the sum of all ODA lending activities, i.e. loans by government or official agencies (131), acquisition of equity (170), other lending (175) and offsetting entries for debt forgiveness (101). Basically, this represents the amount of loans. Finally, Multilateral Official Development Assistance (180) is the sum of grants and capital subscriptions (code 186) and concessional lending (210) to multilateral agencies.

Source: DAC1 “Official and Private Flows, Main Aggregates” International Development Statistics Online

Table 1 (Dependent variable: Average growth rate of TFP)

Table 1 (Dependent variable: average growth rate of TFP)

	(1-1)	(1-2)	(1-3)	(1-4)	(1-5)	(1-6)	(1-7)	(1-8)	(1-9)	(1-10)	(1-11)	(1-12)	(1-13)	(1-14)	(1-15)	(1-16)	(1-17)	(1-18)
	Model 1	Model 2	Model 3	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4
b_0 (=*C*)	0.02		0.02															
	(0.004)***		(0.004)***															
b_1	0.016	0.018	0.017	0.022	0.021	0.023	0.017	0.02	0.018	0.022	0.018	0.021	0.02	0.024	0.018	0.022	0.021	0.025
	(0.011)	(0.006)***	(0.004)***	(0.004)***	(0.007)***	(0.004)***	(0.005)***	(0.004)***	(0.005)***	(0.005)***	(0.005)***	(0.004)***	(0.006)***	(0.004)***	(0.005)***	(0.004)***	(0.007)***	(0.004)***
b_2	0.019	0.015	0.02	0.017	0.018	0.017	0.012	0.014	0.014	0.015	0.013	0.015	0.016	0.018	0.014	0.016	0.018	0.02
	(0.009)*	(0.006)**	(0.006)***	(0.006)***	(0.007)***	(0.009)*	(0.006)**	(0.007)*	(0.007)**	(0.008)*	(0.006)**	(0.007)**	(0.006)**	(0.007)**	(0.006)**	(0.007)**	(0.007)**	(0.008)**
b_3 (=*s*)	1.149	1.649	1	1	1.426	1	2.219	1	2.387	1	2.11	1	1.872	1	2.03	1	1.703	1
	(1.44)	(1.589)			(1.386)		(2.789)		(2.898)		(2.19)		(1.872)		(2.244)		(1.905)	
b_4 *TC*	0.001	0.008	0.001	0.007														
	(0.002)	(0.002)***	(0.002)	(0.002)***														
TC/GDP					25.978	25.769												
					(7.733)***	(7.614)***												
iniTC							0.018	0.017										
							(0.006)***	(0.005)***										
iniTC/iniGDP									94.282	86.343								
									(37.917)**	(34.946)**								
TC80											0.01	0.009						
											(0.003)***	(0.002)***						
TC80/GDP80													60.315	58.915				
													(19.078)***	(18.646)***				
TC90															0.008	0.007		
															(0.002)***	(0.002)***		
TC90/GDP90																	52.672	51.807
																	(17.197)***	(16.858)**
Observation	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared	0.25		0.25															

Note:

Coefficients of missing dummies for TCs are not shown. Standard errors are presented in parentheses.

***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of *s* =1.

iniTC and iniGDP denotes for the amount of TC the earliest year available and GDP of the corresponding year.

Robustness tests of all 4 models are conducted for allvariations of TC.

Table 2 (Dependent variable: Average growth rate of TFP)

	(2-1) Model 1	(2-2) Model 2	(2-3) Model 3	(2-4) Model 4	(2-5) Model 2	(2-6) Model 4	(2-7) Model 2	(2-8) Model 4	(2-9) Model 2	(2-10) Model 4	(2-11) Model 2	(2-12) Model 4	(2-13) Model 2	(2-14) Model 4
b_0 (=*C*)	0.017 (0.003)***		0.017 (0.003)***											
b_1	0.407 (0.001)***	0.023 (0.012)*	0.014 (0.003)***	0.021 (0.003)***	0.019 (0.009)**	0.019 (0.004)***	0.014 (0.006)**	0.016 (0.004)***	0.02 (0.006)***	0.024 (0.004)***	0.015 (0.005)***	0.017 (0.004)***	0.021 (0.007)***	0.025 (0.004)***
b_2	0.407 ♦	0.021 (0.012)*	0.015 (0.004)***	0.019 (0.004)***	0.016 (0.008)**	0.016 (0.005)***	0.012 (0.005)**	0.013 (0.005)**	0.016 (0.007)**	0.018 (0.007)**	0.012 (0.005)**	0.014 (0.005)***	0.017 (0.007)**	0.02 (0.008)**
b_3 (=*s*)	0.02 (0.005)***	0.847 (0.725)	1	1	1.037 (1.144)	1	1.499 (1.658)	1	1.878 (2.102)	1	1.533 (1.515)	1	1.765 (2.072)	
b_4 *TC*	0.002 (0.002)	0.008 (0.002)***	0.002 (0.002)	0.008 (0.002)***										
TC/GDP					28.776 (8.864)***	28.753 (8.752)***								
iniTC														
iniTC/iniGDP														
TC80							0.01 (0.003)***	0.01 (0.003)***						
TC80/GDP80									61.548 (20.905)***	59.17 (20.042)***				
TC90											0.008 (0.002)***	0.008 (0.002)***		
TC90/GDP90													53.673 (18.582)***	52.177 (18.003)***
d_1 *FDIinflow*	0.001 (0.000)**	0.0003 (0.00017)*	0.0003 (0.00021)	0 .0003 (0.00015)*										
FDIinflow/GDP					7.072 (2.293)***	7.083 (2.270)***								
FDIinflow80							0.097 (0.041)**	0.099 (0.041)**						
FDIinflow80/GDP80									-3.895 (21.45)	-1.312 (21.743)				
FDIinflow90											0.122 (0.047)**	0.124 (0.047)***		
FDIinflow90/GDP90													-4.285 (24.358)	-1.925 (24.81)
Observation	85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared	0.34		0.32											

Note:

Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

♦ denotes that the standard error is not computed.

Table 3 (Dependent variable: Average growth rate of TFP)

	(3-1) Model 1	(3-2) Model 2	(3-3) Model 3	(3-4) Model 4	(3-5) Model 2	(3-6) Model 4	(3-7) Model 2	(3-8) Model 4	(3-9) Model 2	(3-10) Model 4	(3-11) Model 2	(3-12) Model 4	(3-13) Model 2	(3-14) Model 4
b_0 (=*C*)	0.016		0.013											
	(0.003)***		(0.004)***											
b_1	0.333	0.012	0.013	0.015	0.013	0.015	0.01	0.012	0.012	0.013	0.012	0.014	0.014	0.016
	(0.001)***	(0.004)***	(0.003)***	(0.003)***	(0.005)***	(0.004)***	(0.003)***	(0.004)***	(0.003)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
b_2	0.333	0.01	0.013		0.01	0.011	0.008	0.006	0.006	0.005	0.009	0.01	0.01	0.009
	♦	(0.004)***	(0.003)***		(0.004)**	(0.005)**	(0.003)***	(0.005)	(0.006)	(0.005)	(0.004)**	(0.005)**	(0.006)*	-0.007
b_3 (=*s*)	0.023	1.701		0.014	1.662	1	2.802	1	2.803	1	2.195	1	2.67	1
	(0.006)***	(1.008)*		(0.003)***	(1.591)		(1.819)		(4.105)		(2.272)		(3.039)	
b_4 *TC*	0.002	0.008	0.003	0.007										
	(0.002)	(0.003)***	(0.003)	(0.002)***										
TC/GDP					20.073	20.249								
					(9.990)**	(9.862)**								
iniTC							0.019	0.018						
							(0.008)**	(0.007)**						
iniTC/iniGDP									46.058	44.681				
									(42.457)	(42.595)				
TC80											0.009	0.009		
											(0.004)***	(0.003)***		
TC80/GDP80													27.548	26.395
													(26.775)	(26.424)
d_1 *FDIinflow*	0.001	0.0003	0.0004	0.0004			0.0003	0.0004						
	(0.000)**	(0.0002)	(0.0002)*	(0.0002)*			(0.0002)*	(0.0002)						
FDIinflow/GDP					5.423	5.708			4.031	4.309				
					(2.538)**	(2.523)**			(2.247)*	(2.305)*				
FDIinflow80											0.069	0.076		
											(0.041)*	(0.042)*		
FDIinflow80/GDP80													6.88	8.063
													(24.832)	(24.656)
e_1 *Open*	0.003	0.014	0.006	0.012	0.011	0.01	0.017	0.017	0.013	0.013				
	(0.004)	(0.005)***	(0.005)	(0.004)***	(0.005)**	(0.005)**	(0.006)***	(0.005)***	(0.005)**	(0.005)**				
Open80											0.007	0.006	0.011	0.01
											(0.004)*	(0.004)*	(0.005)**	(0.004)**
Observation	85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared	0.35		0.4											

Note:

Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not

♦ denotes that the standard error is not computed.

Table 4: Does the country satisfy the catch-up condition?

(The case where the capacity of the leader nation depends on its human capital only)

Name of specification		(3-2)	(3-5)	(3-7)	(3-9)	(3-11)	(3-13)
Variables		ta12 FDIinflow Open	tagdp12 FDIinflowgdp Open	ta111 FDIinflow Open	tagdp111 FDIinflowgdp Open	ta80 FDIinflow80 Open80	tagdp80 FDIinflowgdp80 Open80
Algeria	DZA	Yes	Yes	Yes	Yes	Yes	Yes
Argentina	ARG	Yes	Yes	Yes	Yes	Yes	Yes
Australia	AUS	Yes	Yes	Yes	Yes	Yes	Yes
Austria	AUT	Yes	Yes	Yes	Yes	Yes	Yes
Barbados	BRB	Yes	Yes	Yes	Yes	Yes	Yes
Belgium	BEL	Yes	Yes	Yes	Yes	Yes	Yes
Bolivia	BOL	Yes	Yes	Yes	Yes	Yes	Yes
Botswana	BWA	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	BRA	Yes	Yes	Yes	Yes	Yes	Yes
Canada	CAN	Yes	Yes	Yes	Yes	Yes	Yes
Chile	CHL	Yes	Yes	Yes	Yes	Yes	Yes
Colombia	COL	Yes	Yes	Yes	Yes	Yes	Yes
Costa Rica	CRI	Yes	Yes	Yes	Yes	Yes	Yes
Cyprus	CYP	Yes	Yes	Yes	Yes	Yes	Yes
Denmark	DNK	Yes	Yes	Yes	Yes	Yes	Yes
Dominican Republic	DOM	Yes	Yes	Yes	Yes	Yes	Yes
Ecuador	ECU	Yes	Yes	Yes	Yes	Yes	Yes
El Salvador	SLV	Yes	Yes	Yes	Yes	Yes	Yes
Fiji	FJI	Yes	Yes	Yes	Yes	Yes	Yes
Finland	FIN	Yes	Yes	Yes	Yes	Yes	Yes
France	FRA	Yes	Yes	Yes	Yes	Yes	Yes
Ghana	GHA	Yes	Yes	Yes	Yes	Yes	Yes
Greece	GRC	Yes	Yes	Yes	Yes	Yes	Yes
Guyana	GUY	Yes	Yes	Yes	Yes	Yes	Yes
Honduras	HND	Yes	Yes	Yes	Yes	Yes	Yes
Hong Kong	HKG	Yes	Yes	Yes	Yes	Yes	Yes
Iceland	ISL	Yes	Yes	Yes	Yes	Yes	Yes
Ireland	IRL	Yes	Yes	Yes	Yes	Yes	Yes
Israel	ISR	Yes	Yes	Yes	Yes	Yes	Yes
Italy	ITA	Yes	Yes	Yes	Yes	Yes	Yes
Jamaica	JAM	Yes	Yes	Yes	Yes	Yes	Yes
Japan	JPN	Yes	Yes	Yes	Yes	Yes	Yes
Jordan	JOR	Yes	Yes	Yes	Yes	Yes	Yes
Kenya	KEN	Yes	Yes	Yes	Yes	Yes	Yes
Korea, Republic of	KOR	Yes	Yes	Yes	Yes	Yes	Yes
Lesotho	LSO	Yes	Yes	Yes	Yes	Yes	Yes
Malawi	MWI	Yes	Yes	Yes	Yes	Yes	Yes
Malaysia	MYS	Yes	Yes	Yes	Yes	Yes	Yes
Mauritius	MUS	Yes	Yes	Yes	Yes	Yes	Yes
Mexico	MEX	Yes	Yes	Yes	Yes	Yes	Yes
Netherlands	NLD	Yes	Yes	Yes	Yes	Yes	Yes
New Zealand	NZL	Yes	Yes	Yes	Yes	Yes	Yes
Nicaragua	NIC	Yes	Yes	Yes	Yes	Yes	Yes
Norway	NOR	Yes	Yes	Yes	Yes	Yes	Yes
Panama	PAN	Yes	Yes	Yes	Yes	Yes	Yes
Papua New Guinea	PNG	Yes	Yes	Yes	Yes	Yes	Yes
Paraguay	PRY	Yes	Yes	Yes	Yes	Yes	Yes
Peru	PER	Yes	Yes	Yes	Yes	Yes	Yes
Philippines	PHL	Yes	Yes	Yes	Yes	Yes	Yes
Portugal	PRT	Yes	Yes	Yes	Yes	Yes	Yes
Romania	ROM	Yes	Yes	Yes	Yes	Yes	Yes

Name of specification		(3-2)	(3-5)	(3-7)	(3-9)	(3-11)	(3-13)
Variables		ta12 FDIinflow Open	tagdp12 FDIinflowgdp Open	ta111 FDIinflow Open	tagdp111 FDIinflowgdp Open	ta80 FDIinflow80 Open80	tagdp80 FDIinflowgdp80 Open80
Senegal	SEN	Yes	Yes	Yes	Yes	Yes	Yes
Seychelles	SYC	Yes	Yes	Yes	Yes	Yes	Yes
Singapore	SGP	Yes	Yes	Yes	Yes	Yes	Yes
South Africa	ZAF	Yes	Yes	Yes	Yes	Yes	Yes
Spain	ESP	Yes	Yes	Yes	Yes	Yes	Yes
Sweden	SWE	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	CHE	Yes	Yes	Yes	Yes	Yes	Yes
Syria	SYR	Yes	Yes	Yes	Yes	Yes	Yes
Taiwan	TWN	Yes	Yes	Yes	Yes	Yes	Yes
Thailand	THA	Yes	Yes	Yes	Yes	Yes	Yes
Trinidad & Tobago	TTO	Yes	Yes	Yes	Yes	Yes	Yes
United Kingdom	GBR	Yes	Yes	Yes	Yes	Yes	Yes
Uruguay	URY	Yes	Yes	Yes	Yes	Yes	Yes
Venezuela	VEN	Yes	Yes	Yes	Yes	Yes	Yes
Zambia	ZMB	Yes	Yes	Yes	Yes	Yes	Yes
Zimbabwe	ZWE	Yes	Yes	Yes	Yes	Yes	Yes
Bangladesh	BGD	Yes	No	Yes	No	Yes	No
Cameroon	CMR	Yes	Yes	Yes	No	Yes	Yes
Central African Republ	CAF	No	No	No	No	No	No
Congo, Dem. Rep.	ZAR	Yes	No	No	No	Yes	No
Guatemala	GTM	Yes	Yes	Yes	No	Yes	Yes
India	IND	Yes	Yes	Yes	No	Yes	No
Indonesia	IDN	Yes	Yes	Yes	No	Yes	Yes
Iran	IRN	Yes	No	Yes	No	Yes	No
Mali	MLI	No	No	No	No	No	No
Mozambique	MOZ	No	No	No	No	No	No
Nepal	NPL	No	No	No	No	No	No
Niger	NER	No	No	No	No	No	No
Pakistan	PAK	Yes	No	Yes	No	Yes	No
Sri Lanka	LKA	Yes	Yes	Yes	No	Yes	Yes
Togo	TGO	No	No	No	No	No	No
Turkey	TUR	Yes	Yes	Yes	No	Yes	Yes
Uganda	UGA	Yes	Yes	Yes	Yes	Yes	No
# of countries which is "No"		6	10	7	16	6	12

Table 5: Does the country satisfy the catch-up condition?

(The case where the capacity of the leader nation depends on its human capital, FDI and openness)

Name of specification		(3-2)	(3-5)	(3-7)	(3-9)	(3-11)	(3-13)
Variables		ta12 FDIinflow Open	tagdp12 FDIinflowgdp Open	ta111 FDIinflow Open	tagdp111 FDIinflowgdp Open	ta80 FDIinflow80 Open80	tagdp80 FDIinflowgdp80 Open80
Algeria	DZA	Yes	Yes	Yes	Yes	Yes	Yes
Argentina	ARG	Yes	Yes	Yes	Yes	Yes	Yes
Australia	AUS	Yes	Yes	Yes	Yes	Yes	Yes
Austria	AUT	Yes	Yes	Yes	Yes	Yes	Yes
Barbados	BRB	Yes	Yes	Yes	Yes	Yes	Yes
Belgium	BEL	Yes	Yes	Yes	Yes	Yes	Yes
Bolivia	BOL	Yes	Yes	Yes	Yes	Yes	Yes
Botswana	BWA	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	BRA	Yes	Yes	Yes	Yes	Yes	Yes
Canada	CAN	Yes	Yes	Yes	Yes	Yes	Yes
Chile	CHL	Yes	Yes	Yes	Yes	Yes	Yes
Colombia	COL	Yes	Yes	Yes	Yes	Yes	Yes
Costa Rica	CRI	Yes	Yes	Yes	Yes	Yes	Yes
Cyprus	CYP	Yes	Yes	Yes	Yes	Yes	Yes
Denmark	DNK	Yes	Yes	Yes	Yes	Yes	Yes
Dominican Republic	DOM	Yes	Yes	Yes	Yes	Yes	Yes
Ecuador	ECU	Yes	Yes	Yes	Yes	Yes	Yes
Fiji	FJI	Yes	Yes	Yes	Yes	Yes	Yes
Finland	FIN	Yes	Yes	Yes	Yes	Yes	Yes
France	FRA	Yes	Yes	Yes	Yes	Yes	Yes
Ghana	GHA	Yes	Yes	Yes	Yes	Yes	Yes
Greece	GRC	Yes	Yes	Yes	Yes	Yes	Yes
Guyana	GUY	Yes	Yes	Yes	Yes	Yes	Yes
Honduras	HND	Yes	Yes	Yes	Yes	Yes	Yes
Hong Kong	HKG	Yes	Yes	Yes	Yes	Yes	Yes
Iceland	ISL	Yes	Yes	Yes	Yes	Yes	Yes
Ireland	IRL	Yes	Yes	Yes	Yes	Yes	Yes
Israel	ISR	Yes	Yes	Yes	Yes	Yes	Yes
Italy	ITA	Yes	Yes	Yes	Yes	Yes	Yes
Jamaica	JAM	Yes	Yes	Yes	Yes	Yes	Yes
Japan	JPN	Yes	Yes	Yes	Yes	Yes	Yes
Jordan	JOR	Yes	Yes	Yes	Yes	Yes	Yes
Kenya	KEN	Yes	Yes	Yes	Yes	Yes	Yes
Korea, Republic of	KOR	Yes	Yes	Yes	Yes	Yes	Yes
Lesotho	LSO	Yes	Yes	Yes	Yes	Yes	Yes
Malawi	MWI	Yes	Yes	Yes	Yes	Yes	Yes
Malaysia	MYS	Yes	Yes	Yes	Yes	Yes	Yes
Mauritius	MUS	Yes	Yes	Yes	Yes	Yes	Yes
Mexico	MEX	Yes	Yes	Yes	Yes	Yes	Yes
Netherlands	NLD	Yes	Yes	Yes	Yes	Yes	Yes
New Zealand	NZL	Yes	Yes	Yes	Yes	Yes	Yes
Nicaragua	NIC	Yes	Yes	Yes	Yes	Yes	Yes
Norway	NOR	Yes	Yes	Yes	Yes	Yes	Yes
Panama	PAN	Yes	Yes	Yes	Yes	Yes	Yes
Papua New Guinea	PNG	Yes	Yes	Yes	Yes	Yes	Yes
Paraguay	PRY	Yes	Yes	Yes	Yes	Yes	Yes
Peru	PER	Yes	Yes	Yes	Yes	Yes	Yes
Philippines	PHL	Yes	Yes	Yes	Yes	Yes	Yes
Portugal	PRT	Yes	Yes	Yes	Yes	Yes	Yes
Romania	ROM	Yes	Yes	Yes	Yes	Yes	Yes

Name of specification		(3-2)	(3-5)	(3-7)	(3-9)	(3-11)	(3-13)
Variables		ta12 FDIinflow Open	tagdp12 FDIinflowgdp Open	ta111 FDIinflow Open	tagdp111 FDIinflowgdp Open	ta80 FDIinflow80 Open80	tagdp80 FDIinflowgdp80 Open80
Senegal	SEN	Yes	Yes	Yes	Yes	Yes	Yes
Seychelles	SYC	Yes	Yes	Yes	Yes	Yes	Yes
Singapore	SGP	Yes	Yes	Yes	Yes	Yes	Yes
South Africa	ZAF	Yes	Yes	Yes	Yes	Yes	Yes
Spain	ESP	Yes	Yes	Yes	Yes	Yes	Yes
Sri Lanka	LKA	Yes	Yes	Yes	Yes	Yes	Yes
Sweden	SWE	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	CHE	Yes	Yes	Yes	Yes	Yes	Yes
Syria	SYR	Yes	Yes	Yes	Yes	Yes	Yes
Taiwan	TWN	Yes	Yes	Yes	Yes	Yes	Yes
Thailand	THA	Yes	Yes	Yes	Yes	Yes	Yes
Trinidad & Tobago	TTO	Yes	Yes	Yes	Yes	Yes	Yes
United Kingdom	GBR	Yes	Yes	Yes	Yes	Yes	Yes
Uruguay	URY	Yes	Yes	Yes	Yes	Yes	Yes
Venezuela	VEN	Yes	Yes	Yes	Yes	Yes	Yes
Zambia	ZMB	Yes	Yes	Yes	Yes	Yes	Yes
Zimbabwe	ZWE	Yes	Yes	Yes	Yes	Yes	Yes
Bangladesh	BGD	Yes	No	Yes	No	Yes	No
Cameroon	CMR	Yes	Yes	Yes	No	Yes	Yes
Central African Republi	CAF	No	No	No	No	No	No
Congo, Dem. Rep.	ZAR	Yes	No	No	No	Yes	No
El Salvador	SLV	Yes	Yes	Yes	No	Yes	Yes
Guatemala	GTM	Yes	Yes	Yes	No	Yes	Yes
India	IND	Yes	Yes	Yes	No	Yes	No
Indonesia	IDN	Yes	Yes	Yes	No	Yes	Yes
Iran	IRN	Yes	No	Yes	No	Yes	No
Mali	MLI	No	No	No	No	No	No
Mozambique	MOZ	No	No	No	No	No	No
Nepal	NPL	No	No	No	No	No	No
Niger	NER	No	No	No	No	No	No
Pakistan	PAK	Yes	No	Yes	No	Yes	No
Togo	TGO	No	No	No	No	No	No
Turkey	TUR	Yes	Yes	Yes	No	Yes	Yes
Uganda	UGA	Yes	Yes	Yes	No	Yes	No
# of countries which is "No"		6	10	7	17	6	12

Table 6 (Dependent variable: Average growth rate of TFP)

	(6-1) Model 1	(6-2) Model 2	(6-3) Model 3	(6-4) Model 4	(6-5) Model 2	(6-6) Model 4	(6-7) Model 6	(6-8) Model 8	(6-9) Model 10	(6-10) Model 12
b_0 (=*C*)	0.016		0.015							
	(0.003)***		(0.004)***							
g_1 *EAP*	0.02	0.022	0.02	0.022	0.032	0.032	0.019	0.019	0.032	0.033
	(0.008)**	(0.009)**	(0.008)**	(0.009)**	(0.010)***	(0.010)***	(0.011)*	(0.011)*	(0.009)***	(0.009)***
b_1	0.301	0.011	0.011	0.014	0.011	0.013	0.011	0.013	0.011	0.013
	(0.001)***	(0.004)***	(0.003)***	(0.003)***	(0.004)***	(0.003)***	(0.003)***	(0.004)***	(0.003)***	(0.004)***
b_2	0.3	0.009	0.011	0.012	0.008	0.009	0.007	0.008	0.007	0.005
	♦	(0.004)**	(0.003)***	(0.003)***	(0.004)*	(0.004)*	(0.004)*	-0.005	(0.005)	(0.006)
b_3 (=*s*)	0.022	1.67	1	1	1.719	1	2.322	1	2.836	1
	(0.006)***	(1.068)			(1.859)		(2.779)		(3.893)	
b_c *TC*	0.0002	0.007	0.0003	0.007						
	(0.003	(0.003)**	(0.003)	(0.002)***						
TC/GDP					24.523	24.69				
					(11.026)**	(10.899)**				
TC80							0.008	0.008		
							(0.004)**	(0.003)**		
TC80/GDP80									38.102	37.373
									(29.25)	(29.309
g *TC*EAP*	-0.001	-0.004	-0.0002	-0.004						
	(0.006)	(0.006)	(0.006)	(0.005)						
*(TC/GDP)*EAP*					-163.079	-156.89				
					(162.244)	(161.157)				
*TC80*EAP*							-0.00004	-0.0005		
							(0.01)	(0.01)		
*(TC80/GDP80)*EAP*									-207.662	-211.883
									(232.583)	(239.507)
d *FDIinflow*	0.0006	0.0003	0.0004	0.0003						
	(0.0003)*	(0.0002)	(0.0003)	(0.0002)						
FDIinflow/GDP					4.384	4.614				
					(2.712)	(2.688)*				
FDIinflow80							0.054	0.061		
							(0.041)	(0.041)		
FDIinflow80/GDP80									8.539	8.798
									(25.869)	(25.333)
e_1 *Open*	0.003	0.014	0.006	0.012	0.012	0.011				
	(0.004)	(0.005)**	(0.005)	(0.005)**	(0.006)**	(0.005)**				
Open80							0.009	0.008	0.011	0.011
							(0.005)*	(0.004)*	(0.005)**	(0.005)**
Observation	85	85	85	85	85	85	85	85	85	85
R'(squared	0.44		0.43							

Note: Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively. In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a
♦ denotes that the standard error is not computed.

Table 7 (Dependent variable: Average growth rate of TFP)

	(7-1) Model 1	(7-2) Model 2	(7-3) Model 3	(7-4) Model 4	(7-5) Model 2	(7-6) Model 4	(7-7) Model 6	(7-8) Model 8	(7-9) Model 10	(7-10) Model 12
b_0 (=*C*)	0.017		0.016							
	(0.003)***		(0.004)***							
gg *EAP*	0.01	0.02	0.01	0.02	0.036	0.036	0.021	0.021	0.023	0.024
	(0.01)	(0.012)	(0.011)	(0.012	(0.016)**	(0.016)**	(0.015)	(0.014)	(0.014)	(0.014)*
b_1	0.324	0.011	0.011	0.014	0.01	0.011	0.01	0.012	0.011	0.013
	(0.001)***	(0.004)***	(0.003)***	(0.003)***	(0.004)**	(0.003)***	(0.003)***	(0.004)***	(0.003)***	(0.004)***
b_2	0.324	0.009	0.012	0.012	0.007	0.008	0.007	0.007	0.007	0.006
	♦	(0.004)**	(0.004)***	(0.003)***	(0.004)*	(0.004)**	(0.004)*	(0.005)	(0.005)	(0.006)
b_3 (=*s*)	0.021	1.728	1	1	1.496	1	2.379	1	2.749	1
	(0.006)***	(1.127)			(1.654)		(2.922)		(3.66)	
b_4 *TC*	0.0002	0.007	-0.00006	0.007						
	(0.003)	(0.003)**	(0.003)	(0.003)**						
TC/GDP					23.863	24.071				
					(12.589)*	(12.446)*				
TC80							0.009	0.008		
							(0.004)**	(0.004)**		
TC80/GDP80									39.974	39.191
									(30.059)	(29.911)
g_1 *TC*EAP*	-0.0003	-0.004	0.001	-0.004						
	(0.006)	(0.006)	(0.006)	(0.005)						
*(TC/GDP)*EAP*					-79.139	-82.677				
					(305.879)	(303.942)				
*TC80*EAP*							0.001	0		
							(0.012)	(0.011)		
*(TC80/GDP80)*EAP*									260.739	221.357
									(688.361)	(667.353)
d_1 *FDIinflow*	0.0005	0.0003	0.0003	0.0003						
	(0.0003)	(0.0002)	(0.0002)	(0.0002)						
FDIinflow/GDP					18.451	18.912				
					(8.483)**	(8.465)**				
FDIinflow80							0.076	0.082		
							(0.052)	(0.053)		
FDIinflow80/GDP80									8.97	9.787
									(26.514)	(26.185)
g_2 *FDIinflow*EAP*	0.004	0.002	0.003	0.002						
	(0.003)	(0.002)	(0.002)	(0.002)						
*(FDIinflow/GDP)*EAP*					-13.136	-14.132				
					(17.447)	(17.394)				
*FDIinflow80*EAP*							-0.144	-0.145		
							(0.135)	(0.137)		
*(FDIinflow80/GDP80)*EAP*									-1,437.74	-1,338.68
									(1984.546)	(1922.146)
e_1 *Open*	0.001	0.015	0.004	0.013	0.013	0.012				
	(0.004)	(0.006)**	(0.005)	(0.005)**	(0.007)*	(0.006)*				
Open80							0.009	0.008	0.011	0.011
							(0.005)*	(0.005)*	(0.005)**	(0.005)**
g_3 *Open*EAP*	-0.028	-0.021	-0.024	-0.019	-0.013	-0.01				
	(0.029)	(0.021)	(0.026)	(0.021)	(0.065)	(0.064)				
*Open80*EAP*							0.014	0.015	0.009	0.01
							(0.015)	(0.015)	(0.013)	(0.013)
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.46		0.45							

Note: Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively. In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed. Our definition of EAP follows that of the World Bank.

♦ denotes that the standard error is not computed.

Table8 (Dependent variable: Average growth rate of TFP)

	(8-1) Model 1	(8-2) Model 2	(8-3) Model 3	(8-4) Model 4	(8-5) Model 2	(8-6) Model 4	(8-7) Model 2	(8-8) Model 4	(8-9) Model 2	(8-10) Model 4
b_0 (=*C*)	0.016		0.013		0.018	0.021				
	(0.003)***		(0.004)***		(0.006)***	(0.005)***				
b_1	0.369	0.013	0.014	0.017	0.015	0.017	0.01	0.013	0.023	0.029
	(0.001)***	(0.005)**	(0.005)***	(0.005)***	(0.006)**	(0.006)***	(0.006)*	(0.006)**	(0.008)***	(0.006)***
b_2	0.369	0.012	0.014	0.016	0.015	0.017	0.007	0.008	0.02	0.024
	(0.000)	(0.005)**	(0.005)***	(0.005)***	(0.006)**	(0.006)***	(0.005)	(0.006)	(0.008)**	(0.009)***
b_3 (=*s*)	0.023	1.621	1	1	1.543	1	2.304	1	1.837	1
	(0.008)***	(1.000)			(1.364)		(2.564)		(1.792)	
b_4 *TC*	0.002	0.007	0.003	0.007						
	(0.002)	(0.002)***	(0.003)	(0.002)***						
TC/GDP					27.743	27.639				
					(8.097)***	(7.910)***				
TC80							0.01	0.01		
							(0.005)**	(0.004)**		
TC80/GDP80									32.459	31.051
									(16.464)*	(15.463)**
f_1 *TC*log(HC $_{1960}$)*	-0.001	-0.001	-0.0004	-0.002						
	(0.003)	(0.003)	(0.003)	(0.003)						
*(TC/GDP)*log(HC $_{1960}$)*					-26.176	-26.301				
					(9.458)***	(9.316)***				
*TC80*log(HC $_{1960}$)*							0.003	0.002		
							(0.008)	(0.007)		
*(TC80/GDP80)*log(HC $_{1960}$)*									-63.951	-65.793
									(16.180)***	(15.335)***
d_1 *FDIinflow*	0.001	0.0003	0.0004	0.0003						
	(0.000)*	(0.0002)	(0.0002)	(0.0002)*						
FDIinflow/GDP					4.238	4.415				
					(1.807)**	(1.781)**				
FDIinflow80							0.083	0.087		
							(0.064)	(0.063)		
FDIinflow80/GDP80									25.563	28.267
									(18.298)	(18.146)
e_1 *Open*	0.002	0.012	0.006	0.01	0.006	0.006				
	(0.004)	(0.006)**	(0.005)	(0.005)**	(0.004)*	(0.003)*				
Open80							0.009	0.008	0.006	0.005
							(0.007)	(0.006)	(0.003)**	(0.002)**
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.35		0.34							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 9 (Dependent variable: Average growth rate of TFP)

		(9-1) Model 1	(9-2) Model 2	(9-3) Model 3	(9-4) Model 4	(9-5) Model 2	(9-6) Model 4	(9-7) Model 2	(9-8) Model 4	(9-9) Model 2	(9-10) Model 4
b_0 (=*C*)		0.019		0.018							
		(0.004)***		(0.004)***							
b_1		0.017	0.011	0.015	0.013	0.013	0.015	0.012	0.014	0.015	0.018
		(0.017)	(0.004)***	(0.004)***	(0.003)***	(0.005)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
b_2		0.021	0.009	0.02	0.01	0.01	0.011	0.009	0.01	0.011	0.01
		(0.014)	(0.004)**	(0.007)***	(0.005)**	(0.004)**	(0.005)**	(0.004)**	(0.005)*	(0.006)*	(0.007)
b_3 (=*s*)		0.869	1.623	1	1	1.67	1	2.191	1	2.67	1
		(1.306)	(1.462)			(1.638)		(2.277)		(2.862)	
b_4	*TC*	-0.0003	0.007	-0.0003	0.007						
		(0.003)	(0.003)***	(0.003)	(0.002)***						
	TC/GDP					18.613	18.747				
						(10.958)*	(10.801)*				
	TC80							0.01	0.009		
								(0.005)**	(0.004)**		
	TC80/GDP80									-11.365	-11.438
										(30.223)	(29.974)
d_1	*FDIinflow*	0.002	0.001	0.002	0.001						
		(0.001)**	(0.001)*	(0.001)**	(0.001)**						
	FDIinflow/GDP					9.041	9.475				
						(12.675)	(12.605)				
	FDIinflow80							0.065	0.072		
								(0.055)	(0.055)		
	FDIinflow80/GDP80									336.307	334.444
										(160.245)**	(161.755)**
f_2	*FDIinflow*log(HC $_{1960}$)*	-0.001	-0.001	-0.001	-0.001						
		(0.000)**	(0.000)	(0.000)**	(0.000)*						
	*(FDIinflow/GDP)*log(HC $_{1960}$)*					-3.103	-3.236				
						(10.578)	(10.530)				
	*FDIinflow80*log(HC $_{1960}$)*							0.005	0.006		
								(0.050)	(0.050)		
	*(FDIinflow80/GDP80)*log(HC $_{1960}$)*									-281.526	-279.118
										(134.294)**	(135.533)**
e_1	*Open*	0.001	0.014	0.002	0.013	0.011	0.01				
		(0.004)	(0.005)***	(0.004)	(0.005)***	(0.005)**	(0.005)**				
	Open80							0.007	0.007	0.012	0.011
								(0.004)*	(0.004)	(0.004)***	(0.004)***
Observation		85	85	85	85	85	85	85	85	85	85
R-squared		0.4		0.4							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 10 (Dependent variable: Average growth rate of TFP)

	(10-1) Model 1	(10-2) Model 2	(10-3) Model 3	(10-4) Model 4	(10-5) Model 2	(10-6) Model 4	(10-7) Model 2	(10-8) Model 4	(10-9) Model 2	(10-10) Model 4
b_0 (=*C*)	0.016		0.013							
	(0.004)***		(0.005)***							
b_1	0.334	0.017	0.014	0.021	0.023	0.027	0.017	0.021	0.02	0.025
	(0.001)***	(0.005)***	(0.005)**	(0.005)***	(0.007)***	(0.005)***	(0.004)***	(0.005)***	(0.005)***	(0.005)***
b_2	0.334	0.015	0.014	0.019	0.019	0.021	0.014	0.015	0.016	0.017
	♦	(0.005)***	(0.005)**	(0.005)***	(0.007)***	(0.007)***	(0.005)***	(0.007)**	(0.007)**	(0.008)**
b_3 (=*s*)	0.023	1.653	1	1	1.514	1	2.476	1	2.414	1
	(0.009)**	(0.964)*			(1.297)		(1.857)		(2.258)	
b_4 *TC*	0.002	0.004	0.003	0.004						
	(0.003)	(0.002)*	(0.003)	(0.002)*						
TC/GDP					4.736	4.696				
					(5.36)	(5.301)				
TC80							0.005	0.005		
							(0.003)*	(0.003)*		
TC80/GDP80									-1.778	-2.488
									(18.786)	(18.432)
d_1 *FDIinflow*	0.001	0.0002	0.0004	0.0003						
	(0.0004)*	(.0001)	(0.0003)	(0.0001)*						
FDIinflow/GDP					0.004	0.004				
					(0.001)***	(0.001)***				
FDIinflow80							0.0001	0.0001		
							(0.0001)	(0.0001)		
FDIinflow80/GDP80									14.4	16.42
									(17.163)	(17.482)
e_1 *Open*	0.003	0.014	0.007	0.013	0.013	0.012				
	(0.006)	(0.004)***	(0.006)	(0.003)***	(0.003)***	(0.003)***				
Open80							0.012	0.011	0.014	0.013
							(0.003)***	(0.003)***	(0.003)***	(0.003)***
f_3 *Open*log(HC $_{1960}$)*	-0.0002	-0.006	-0.001	-0.006	-0.01	-0.01				
	(0.006)	(0.003)*	(0.006)	(0.003)**	(0.002)***	(0.002)***				
*Open80*log(HC $_{1960}$)*							-0.006	-0.006	-0.008	-0.008
							(0.003)**	(0.002)**	(0.002)***	(0.002)***
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.35		0.34							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 11 (Dependent variable: Average growth rate of TFP)

	(11-1) Model 1	(11-2) Model 2	(11-3) Model 3	(11-4) Model 4	(11-5) Model 2	(11-6) Model 4	(11-7) Model 2	(11-8) Model 4	(11-9) Model 2	(11-10) Model 4
b_0 (=*C*)	0.019		0.018							
	(0.004)***		(0.004)***							
b_1	0.023	0.02	0.017	0.023	0.025	0.029	0.014	0.018	0.028	0.035
	(0.034)	(0.008)**	(0.008)**	(0.007)***	(0.008)***	(0.005)***	(0.007)*	(0.008)**	(0.009)***	(0.007)***
b_2	0.028	0.016	0.023	0.018	0.021	0.023	0.012	0.014	0.024	0.029
	(0.031)	(0.008)*	(0.011)**	(0.009)**	(0.007)***	(0.007)***	(0.007)*	(0.008)*	(0.009)***	(0.010)***
b_3 (=*s*)	0.683	1.409	1	1	1.465	1	2.123	1	1.783	1
	(1.265)	(1.251)			(1.205)		(2.092)		(1.572)	
b_4 *TC*	0.0002	0.003	0.0004	0.003						
	(0.002)	(0.002)*	(0.002)	(0.002)*						
TC/GDP					10.332	10.269				
					(7.131)	(7.013)				
TC80							0.006	0.006		
							(0.004)	(0.003)*		
TC80/GDP80									3.468	4.004
									(18.122)	(17.1)
d_1 *FDIinflow*	0.002	0.001	0.002	0.001						
	(0.001)*	(0.000)**	(0.001)*	(0.000)**						
FDIinflow/GDP					0.547	0.748				
					(6.678)	(6.621)				
FDIinflow80							0.025	0.027		
							(0.051)	(0.05)		
FDIinflow80/GDP80									97.904	94.512
									(95.819)	(92.4)
e_1 *Open*	0.0002	0.012	0.001	0.011	0.011	0.011				
	(0.006)	(0.004)***	(0.006)	(0.004)***	(0.003)***	(0.003)***				
Open80							0.012	0.011	0.009	0.008
							(0.007)*	(0.005)*	(0.003)***	(0.002)***
f_1 *TC*log(HC $_{1960}$)*	-0.002	-0.002	-0.002	-0.002	-8.87	-9.023				
	(0.003)	(0.002)	(0.003)	(0.002)	(8.305)	(8.229)				
*(TC/GDP)*log(HC $_{1960}$)*										
*TC80*log(HC $_{1960}$)*							0.001	0.0002		
							(0.005)	(0.005)		
*(TC80/GDP80)*log(HC $_{1960}$)*									-42.535	-45.308
									(15.798)***	(14.777)***
f_2 *FDIinflow*log(HC*	-0.001	-0.0003	-0.001	-0.0004						
	(0.001)*	(0.0002)	(0.001)*	(0.0002)*						
*(FDIinflow/GDP)*log(HC $_{1960}$)*					2.885	2.802				
					(5.59)	(5.549)				
*FDIinflow80*log(HC $_{1960}$)*							0.034	0.034		
							(0.047)	(0.046)		
*(FDIinflow80/GDP80)*log(HC $_{1960}$)*									-62.36	-57.044
									(82.074)	(78.975)
f_3 *Open*log(HC $_{1960}$)*	0.0002	-0.006	0.0005	-0.006	-0.009	-0.009				
	(0.006)	(0.003)**	(0.006)	(0.003)**	(0.002)***	(0.002)***				
*Open80*log(HC $_{1960}$)*							-0.007	-0.007	-0.005	-0.005
							(0.004)*	(0.004)*	(0.002)**	(0.002)***
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.4		0.4							

Note:

Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 12 (Dependent variable: Average growth rate of TFP)

		(12-1) Model 1	(12-2) Model 2	(12-3) Model 3	(12-4) Model 4	(12-5) Model 2	(12-6) Model 4	(12-7) Model 2	(12-8) Model 4	(12-9) Model 2	(12-10) Model 4	(12-11) Model 2	(12-12) Model 4	(12-13) Model 2	(12-14) Model 4
b_0 (=C)		0.025		0.023											
		(0.005)***		(0.005)***											
b_1		0.008	0.011	0.013	0.014	0.017	0.019	0.011	0.009	0.016	0.02	0.013	0.016	0.015	0.018
		(0.003)**	(0.003)***	(0.004)***	(0.004)***	(0.006)**	(0.004)***	(0.003)***	(0.004)**	(0.006)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
b_2		0.02	0.009	0.016	0.009	0.016	0.018	0.006	0	0.015	0.017	0.01	0.009	0.012	0.012
		(0.014)	(0.004)**	(0.006)***	(0.005)*	(0.006)***	(0.005)***	(0.004)	(0.005)	(0.006)***	(0.006)***	(0.005)*	(0.007)	(0.006)**	(0.007)*
b_3 (=s)		3.174	2.416	1	1	1.359	1	3.48	1	1.632	1	2.606	1	2.263	1
		(2.894)	(2.054)			(1.072)		(3.907)		(1.477)		(2.608)		(2.270)	
b_4	*TC*	0.004	0.008	0.004	0.008										
		(0.003)	(0.003)***	(0.003)	(0.003)***										
	TC/GDP					11.315	10.944								
						(9.018)	(8.820)								
	iniTC							0.019	0.022						
								(0.008)**	(0.010)**						
	iniTC/iniGDP									6.47	-0.063				
										(36.569)	(33.350)				
	TC80											0.008	0.008		
												(0.003)**	(0.003)**		
	TC80/GDP80													12.413	9.497
														(26.043)	(25.301)
d_1	*IDISFDIinflow*	-0.0001	0.00004	-0.00001	0.00003			0.0001	0.00003						
		(0.0001)	(0.00008)	(0.00015)	(0.00008)			(0.00008)	(0.00006)						
	IDISFDIinflow/GDP					34.535	36.608			31.196	33.832				
						(13.431)**	(13.214)***			(12.304)**	(12.135)***				
	IDISFDIinflow80											0.00004	0.00003		
												(0.0001)	(0.0001)		
	IDISinflow80/GDP80													16.412	17.659
														(35.265)	(35.148)
e_1	*Open*	0.013	0.015	0.011	0.014	0.003	0.003	0.017	0.02	0.004	0.003				
		(0.008)*	(0.006)**	(0.007)	(0.006)**	(0.005)	(0.004)	(0.007)**	(0.008)**	(0.005)	(0.004)				
	Open80											0.008	0.007	0.007	0.006
												(0.004)*	(0.004)*	(0.004)	(0.004)
Observation		85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared		0.34		0.33											

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 13 (Dependent variable: Average growth rate of TFP)

	(13-1) Model 1	(13-2) Model 2	(13-3) Model 3	(13-4) Model 4	(13-5) Model 2	(13-6) Model 4	(13-7) Model 2	(13-8) Model 4	(13-9) Model 2	(13-10) Model 4
b_0 (=*C*)	0.023		0.023							
	(0.004)***		(0.004)***							
b_1	0.013	0.019	0.021	0.024	0.024	0.028	0.018	0.023	0.026	0.032
	(0.010)	(0.007)***	(0.009)**	(0.007)***	(0.008)***	(0.006)***	(0.007)**	(0.009)**	(0.008)***	(0.007)***
b_2	0.025	0.015	0.03	0.017	0.019	0.021	0.014	0.014	0.021	0.024
	(0.011)**	(0.008)*	(0.012)**	(0.009)*	(0.008)**	(0.008)**	(0.009)	(0.011)	(0.009)**	(0.010)**
b_3 (=*s*)	1.85	2.211	1	1	1.522	1	2.527	1	1.832	1
	(1.791)	(1.951)			(1.395)		(2.505)		(1.756)	
b_4 *TC*	0.003	0.004	0.003	0.004						
	(0.003)	(0.002)**	(0.002)	(0.002)**						
TC/GDP					10.825	10.604				
					(7.356)	(7.251)				
TC80							0.005	0.005		
							(0.003)*	(0.002)*		
TC80/GDP80									19.595	18.211
									(16.236)	(15.758)
d_1 *IDISFDIinflow*	0.002	0.0002	0.003	0.0003						
	(0.002)	(0.001)	(0.002)	(0.001)						
IDISFDIinflow/GDP					69.31	71.508				
					(28.005)**	(27.846)**				
IDISFDIinflow80							-0.00007	0.0001		
							(0.001)	(0.001)		
IDISFDIinflow80/GDP80									321.405	340.109
									(183.824)*	(178.099)*
e_1 *Open*	0.01	0.015	0.008	0.014	0.008	0.007				
	(0.006)	(0.005)***	(0.005)	(0.004)***	(0.004)**	(0.004)*				
Open80							0.011	0.01	0.008	0.007
							(0.005)**	(0.004)**	(0.003)**	(0.003)**
f_1 *TC*log(HC $_{1960}$)*	-0.002	-0.002	-0.002	-0.002						
	(0.003)	(0.002)	(0.002)	(0.002)						
*(TC/GDP)*log(HC $_{1960}$)*					-10.865	-10.91				
					(8.624)	(8.558)				
*TC80*log(HC $_{1960}$)*							-0.001	-0.001		
							(0.004)	(0.004)		
*(TC80/GDP80)*log(HC $_{1960}$)*									-33.764	-34.893
									(15.431)**	(15.084)**
f_2 *IDISFDIinflow*log(*	-0.001	-0.0001	-0.001	-0.0001						
	(0.001)	(0.0003)	(0.001)	(0.0003)						
*(IDISFDIinflow/GDP)*log(HC $_{1960}$)*					-36.186	-37.068				
					(17.679)**	(17.675)**				
*IDISFDIinflow80*log(HC $_{1960}$)*							0.00005	-0.0001		
							(0.001)	(0.0004)		
*(IDISFDIinflow80/GDP80)*log(HC $_{1960}$)*									-182.635	-191.948
									(105.977)*	(102.422)*
f_3 *Open*log(HC $_{1960}$)*	-0.003	-0.006	-0.003	-0.006						
	(0.005)	(0.003)**	(0.004)	(0.003)**						
*Open80*log(HC $_{1960}$)*					-0.006	-0.006	-0.005	-0.005	-0.005	-0.005
					(0.003)**	(0.002)**	(0.003)**	(0.003)*	(0.002)**	(0.002)**
Observation	85	85	85	85						
R-squared	0.37		0.37							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 14 (Dependent variable: Average growth rate of TFP)

		(14-1) Model 1	(14-2) Model 2	(14-3) Model 3	(14-4) Model 4	(14-5) Model 2	(14-6) Model 4	(14-7) Model 2	(14-8) Model 4	(14-9) Model 2	(14-10) Model 4	(14-11) Model 2	(14-12) Model 4	(14-13) Model 2	(14-14) Model 4
b_0 (=*C*)		0.015 (0.003)***		0.015 (0.004)***											
b_1		0.413 (0.001)***	0.03 (0.024)	0.016 (0.003)***	0.022 (0.003)***	0.012 (0.005)**	0.013 (0.003)***	0.021 (0.010)**	0.022 (0.003)***	0.012 (0.005)**	0.013 (0.003)***	0.017 (0.005)***	0.021 (0.003)***	0.01 (0.005)*	0.011 (0.004)***
b_2		0.413 (0.000)	0.029 (0.023)	0.016 (0.004)***	0.018 (0.003)***	0.009 (0.005)**	0.01 (0.004)**	0.019 (0.010)*	0.02 (0.004)***	0.007 (0.004)	0.007 (0.005)	0.014 (0.005)**	0.017 (0.005)***	0.007 (0.004)*	0.008 (0.004)*
b_3 (=*s*)		0.021 (0.005)***	0.567 (0.640)	1	1	1.233 (1.367)	1	1.075 (0.978)	1	1.563 (2.548)	1	1.692 (1.398)	1	1.302 (1.714)	1
b_4	*TC*	0.002 (0.002)	0.006 (0.002)***	0.003 (0.002)	0.006 (0.002)***										
	TC/GDP					7.904 (11.602)	7.772 (11.499)								
	iniTC							0.014 (0.005)***	0.014 (0.004)***						
	iniTC/iniGDP									8.387 (45.164)	5.179 (43.087)				
	TC80											0.009 (0.003)***	0.008 (0.002)***		
	TC80/GDP80													-39.99 (50.695)	-43.172 (49.654)
d_1	*FDIinflow*	0.0004 [0.0003]	0.0002 (0.0002)	0.0002 (0.0002)	0.0002 (0.00014)			0.0001 (0.0001)	0.0001 (0.0001)						
	FDIinflow/GDP					0.003 (0.004)	0.003 (0.004)			0.002 (0.003)	0.002 (0.003)				
	FDIinflow80											0.000001 (0.0002)	0.00001 (0.0002)		
	FDIinflow80/GDP80													-1.167 (37.544)	0.073 (37.776)
e_1	*IM*	1.99E-11 (1.36E-11)	1.08E-11 (8.68E-12)	1.23E-11 (1.10E-11)	8.92E-12 (7.86E-12)			1.68E-11 (8.30E-12)**	1.71E-11 (7.93E-12)**						
	IM/GDP					4.149 (1.665)**	4.155 (1.659)**			4.119 (1.363)***	4.173 (1.367)***				
	IM80											1.79E-11 (1.15E-11)	1.95E-11 (1.18E-11)		
	IM80/GDP80													6.936 (3.110)**	7.08 (3.139)**
Observation		85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared		0.38		0.35											

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%, 5% and 10% levels, respectively.

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 15 (Dependent variable: Average growth rate of TFP)

	(15-1) Model 1	(15-2) Model 2	(15-3) Model 3	(15-4) Model 4	(15-5) Model 2	(15-6) Model 4	(15-7) Model 2	(15-8) Model 4	(15-9) Model 2	(15-10) Model 4
b_0 (=*C*)	0.018		0.017							
	(0.003)***		(0.004)***							
b_1	0.45	0.044	0.018	0.024	0.023	0.024	0.016	0.016	0.022	0.021
	(0.002)***	(0.084)	(0.005)***	(0.005)***	(0.011)**	(0.006)***	(0.011)	(0.006)**	(0.015)	(0.006)***
b_2	0.45	0.04	0.024	0.021	0.018	0.019	0.013	0.013	0.018	0.017
	(0.037)	(0.081)	(0.008)***	(0.007)**	(0.009)*	(0.007)**	(0.01)	(0.006)**	(0.013	(0.007)**
b_3 (=*s*)	0.025	0.358	1	1	1.098	1	1.068	1	0.909	1
	(0.0078)	(0.986)			(1.193)		(1.315)		(1.303)	
b_4 *TC*	-0.0014	0.0045	-0.0006	0.0048						
	(0.002)	(0.0014)***	(0.002)	(0.0013)***						
TC/GDP					4.909	4.757				
					(9.412)	(9.232)				
TC80							0.008	0.008		
							(0.004)**	(0.004)**		
TC80/GDP80									-49.922	-49.417
									(36.559)	(35.918)
d *FDIinflow*	0.002	0.0006	0.002	0.0005						
	(0.001)**	(0.0004)	(0.0008)**	(0.0003)						
FDIinflow/GDP					4.744	4.833				
					(10.303)	(10.109)				
FDIinflow80							0.057	0.057		
							(0.054)	(0.054)		
FDIinflow80/GDP80									162.378	161.206
									(143.524)	(140.782)
e_1 *IM*	5.50E-11	3.55E-11	4.47E-11	3.38E-11						
	(3.25E-11)*	1.59E-11)**	(2.65E-11)*	1.52E-11)***						
IM/GDP					1.283	1.251				
					(1.674)	(1.645)				
IM80							4.19E-11	4.20E-11		
							(2.40E-11)*	(2.39E-11)*		
IM80/GDP80									4.744	4.733
									(1.665)***	(1.649)***
f_1 *TC*log(HC 1*	-0.002	-0.002	-0.001	-0.002						
	(0.003)	(0.002)	(0.003)	(0.002)						
*(TC/GDP)*log(HC $_{1960}$)*					-11.124	-11.044				
					(10.942)	(10.844)				
*TC80*log(HC $_{1960}$)*							0.001	0.001		
							(0.005)	(0.005)		
*(TC80/GDP80)*log(HC $_{1960}$)*									-22.659	-22.468
									(27.421)	(27.093)
f_2 *FDIinflow*lo*	-0.001	-0.0002	-0.001	-0.0002						
	(0.0006)**	(0.00024)	(0.0004)**	(0.0002)						
*(FDIinflow/GDP)*log(HC $_{1960}$)*					-1.273	-1.31				
					(8.189)	(8.071)				
*FDIinflow80*log(HC $_{1960}$)*							0.012	0.012		
							(0.046)	(0.045)		
*(FDIinflow80/GDP80)*log(HC $_{1960}$)*									-124.011	-123.33
									(123.737)	(121.834)
f_3 *IM*log(HC 1*	-1.16E-11	-1.66E-11	-1.41E-11	-1.66E-11						
	(1.78E-11)	(8.65E-12)*	(1.43E-11)	(8.37E-12)						
*(IM/GDP)*log(HC $_{1960}$)*					-1.407	-1.414				
					(0.697)**	(0.691)**				
*IM80*log(HC $_{1960}$)*							-1.42E-11	-1.42E-11		
							(1.24E-11)	(1.23E-11)		
*(IM80/GDP80)*log(HC $_{1960}$)*									-1.387	-1.384
									(0.841)	(0.829)*
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.41		0.41							

Note:

Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical

In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 16 (Dependent variable: Average growth rate of TFP)

	(16-1) Model 1	(16-2) Model 2	(16-3) Model 3	(16-4) Model 4	(16-5) Model 2	(16-6) Model 4	(16-7) Model 2	(16-8) Model 4	(16-9) Model 2	(16-10) Model 4	(16-11) Model 2	(16-12) Model 4	(16-13) Model 2	(16-14) Model 4
b_0 (=*C*)	0.014 (0.003)***		0.014 (0.003)***											
b_1	0.245 (0.0005)***	0.025 (0.035)	0.009 (0.003)***	0.013 (0.003)***	0.034 (0.113)	0.012 (0.003)***	0.011 (0.006)*	0.012 (0.003)***	0.011 (0.007)	0.011 (0.003)***	0.009 (0.004)**	0.01 (0.003)***	0.013 (0.007)*	0.014 (0.004)***
b_2	0.245 ♦	0.024 (0.035)	0.009 (0.003)***	0.012 (0.003)***	0.032 (0.112)	0.011 (0.004)***	0.01 (0.006)*	0.01 (0.003)***	0.009 (0.006)	0.009 (0.004)**	0.006 (0.003)*	0.007 (0.004)*	0.01 (0.006)*	0.011 (0.005)**
b_3 (=*s*)	0.021 (0.007)***	0.346 (0.628)	1	1	0.193 (0.795)	1	1.028 (0.952)	1	1.027 (1.378)	1	1.692 (1.928)	1	1.246 (1.616)	1
b_4 *TC*	0.002 (0.003)	0.009 (0.003)***	0.003 (0.003	0.009 (0.003)***										
TC/GDP					38.634 (14.864)**	39.209 (14.417)***								
iniTC							0.023 (0.010)**	0.023 (0.009)**						
iniTC/iniGDP									136.632 (67.205)**	136.084 (62.745)**				
TC80											0.013 (0.006)**	0.013 (0.005)**		
TC80/GDP80													72.714 (31.571)**	72.18 (31.029)**
d_1 *FDIinflow*	0.001 (0.0004)	0.0003 (0.0002)	0.0002 (0.0003)	0.0002 (0.0002)			0.0002 (0.0003)	0.0002 (0.0002)						
FDIinflow/GDP					7.643 (3.534)**	7.061 (3.203)**			7.17 (3.340)**	7.173 (3.320)**				
FDIinflow80											0.089 (0.055)	0.093 (0.056)		
FDIinflow80/GDP80													1.402 (34.044)	2.606 (33.95)
e_1 *SW*	4.161 (1.961)**	3.286 (1.240)***	3.871 (1.811)**	3.074 (1.148)***	3.683 (1.442)**	3.354 (1.296)**	3.964 (1.521)**	3.967 (1.511)**	3.778 (1.468)**	3.783 (1.458)**				
SW80											3.235 (1.434)**	3.28 (1.459)**	3.087 (1.203)**	3.138 (1.219)**
Observation	85	85	85	85	85	85	85	85	85	85	85	85	85	85
R-squared	0.48		0.46											

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at 1%,
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 17 (Dependent variable: Average growth rate of TFP)

	(17-1) Model 1	(17-2) Model 2	(17-3) Model 3	(17-4) Model 4	(17-5) Model 2	(17-6) Model 4	(17-7) Model 2	(17-8) Model 4	(17-9) Model 2	(17-10) Model 4
b_0 (=*C*)	0.013		0.014							
	(0.003)***		(0.003)***							
b_1	0.382	0.054	0.015	0.021	0.026	0.018	0.015	0.017	0.022	0.023
	(0.002)***	(0.199)	(0.005)***	(0.005)***	(0.032)	(0.004)***	(0.007)**	(0.005)***	(0.011)*	(0.005)***
b_2	0.381	0.05	0.018	0.017	0.021	0.014	0.009	0.01	0.015	0.016
	♦	(0.196)	(0.007)***	(0.006)***	(0.030)	(0.005)***	(0.007)	(0.007)	(0.010)	(0.008)*
b_3 (=*s*)	0.02	0.212	1	1	0.474	1	1.658	1	1.208	1
	(0.007)***	(1.011)			(1.063)		(2.694)		(1.885)	
b_4 *TC*	0.001	0.005	0.001	0.005						
	(0.002)	(0.002)***	(0.002)	(0.002)***						
TC/GDP					31.577	31.879				
					(9.053)***	(8.856)***				
TC80							0.008	0.008		
							(0.003)***	(0.003)***		
TC80/GDP80									34.994	34.725
									(19.032)*	(18.547)*
d_1 *FDIinflow*	0.001	0.001	0.001	0.0005						
	(0.001)	(0.0004)	(0.001)*	(0.0003)						
FDIinflow/GDP					-0.006	-0.006				
					(0.010)	(0.010)				
FDIinflow80							0.001	0.001		
							(0.001)*	(0.001)*		
FDIinflow80/GDP80									167.381	168.692
									(118.199)	(117.319)
e_1 *SW*	3.999	3.367	3.755	3.359	4.065	3.967				
	(1.560)**	(0.952)***	(1.581)**	(0.922)***	(1.222)***	(1.161)***				
SW80							3.177	3.166	2.79	2.792
							(1.191)***	(1.175)***	(0.876)***	(0.874)***
f_1 *TC*log(HC* $_{1960}$*)*	-0.004	-0.005	-0.003	-0.005						
	(0.002)	(0.002)***	(0.003)	(0.002)***						
*(TC/GDP)*log(HC* $_{1960}$*)*					-24.333	-24.406				
					(9.625)**	(9.348)**				
*TC80*log(HC* $_{1960}$*)*							-0.006	-0.006		
							(0.003)**	(0.003)**		
*(TC80/GDP80)*log(HC* $_{1960}$*)*									-67.092	-67.282
									(17.565)***	(17.397)***
f_2 *FDIinflow*log(H*	-0.001	-0.0003	-0.001	-0.0002						
	(0.0004)	(0.0002)	(0.0004)**	(0.0002)						
*(FDIinflow/GDP)*log(HC* $_{1960}$*)*					0.008	0.009				
					(0.009)	(0.009)				
*FDIinflow80*log(HC* $_{1960}$*)*							-0.001	-0.001		
							(0.0004)	(0.0004)*		
*(FDIinflow80/GDP80)*log(HC* $_{1960}$*)*									-131.475	-132.316
									(103.269)	(102.629)
f_3 *SW*log(HC* $_{1960}$*)*	-1.297	-1.358	-1.127	-1.444	-1.933	-1.922				
	(0.893)	(0.556)**	(0.901)	(0.529)***	(0.681)***	(0.657)***				
*SW80*log(HC* $_{1960}$*)*							-0.975	-0.959	-0.932	-0.93
							(0.654)	(0.649)	(0.519)*	(0.518)*
Observation	85	85	85	85	85	85	85	85	85	85
R-squared	0.53		0.41							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 18 Robustness tests (Dependent variable: Average growth rate of TFP)

	(18-1) Model 1	(18-2) Model 2	(18-3) Model 3	(18-4) Model 4	(18-5) Model 2	(18-6) Model 4	(18-7) Model 2	(18-8) Model 4	(18-9) Model 2	(18-10) Model 4	(18-11) Model 2	(18-12) Model 4	(18-13) Model 2	(18-14) Model 4
b_0 (=*C*)	0.009		0.009											
	(0.004)**		(0.004)**											
h	-0.657	-0.401	-0.657	-0.374	-2.672	-2.737	-0.263	-0.203	-1.735	-1.792	0.055	0.071	0.625	0.782
	(0.474)	(0.392)	(0.47)	(0.371)	(1.476)*	(1.475)*	(0.396)	(0.352)	(1.243)	(1.241)	(0.406)	(0.39)	(1.16)	(1.114)
b_1	0.013	0.012	0.013	0.015	0.013	0.015	0.011	0.015	0.013	0.014	0.012	0.014	0.014	0.016
	(0.006)**	(0.004)***	(0.003)***	(0.003)***	(0.004)***	(0.003)***	(0.003)***	(0.003)***	(0.004)***	(0.004)***	(0.003)***	(0.004)***	(0.004)***	(0.004)***
b_2	0.012	0.011	0.012	0.013	0.01	0.011	0.009	0.012	0.007	0.007	0.008	0.009	0.01	0.01
	(0.006)**	(0.003)***	(0.003)***	(0.003)***	(0.004)***	(0.004)***	(0.003)***	(0.003)***	(0.005)	(0.005)	(0.004)**	(0.004)*	(0.005)**	(0.006)*
b_3 (=*s*)	1.017	1.488	1	1	1.503	1	2.261	1	1.973	1	2.183	1	2.419	1
	(0.775)	(0.718)**			(1.197)		(1.096)**		(2.896)		(2.032)		(2.518)	
b_4 *TC*	0.004	0.007	0.004	0.006										
	(0.002)*	(0.002)***	(0.002)**	(0.002)***										
TC/GDP					14.522	13.444								
					(7.079)**	(6.509)**								
iniTC							0.017	0.013						
							(0.006)***	(0.005)***						
iniTC/iniGDP									10.608	9.709				
									(28.491)	(27.946)				
TC80											0.009	0.009		
											(0.003)***	(0.003)***		
TC80/GDP80													17.087	13.661
													(19.225)	(18.437)
d_1 *FDIinflow*	0.0004	0.0003	0.0004	0.0003			0.0004	0.0003						
	(0.0002)**	(0.0001)**	(0.0002)**	(0.0001)**			(0.0001)**	(0.0001)***						
FDIinflow/GDP					5.842	6.055			3.762	3.974				
					(2.560)**	(2.555)**			(2.152)*	(2.141)*				
FDIinflow80											0.06	0.063		
											(0.036)*	(0.035)*		
FDIinflow80/GDP80													12.645	15.281
													(23.75)	(23.648)
e_1 *Open*	0.011	0.015	0.011	0.014	0.011	0.011	0.018	0.016	0.014	0.014				
	(0.005)**	(0.005)***	(0.005)**	(0.004)***	(0.005)**	(0.004)**	(0.006)***	(0.004)***	(0.004)***	(0.004)***				
Open80											0.009	0.008	0.011	0.011
											(0.004)**	(0.004)**	(0.004)***	(0.004)***
Observation	110	110	110	110	110	110	110	110	110	110	110	110	110	110
R-squared	0.39		0.39											

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical significance at
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Table 19 (Dependent variable: Average growth rate of TFP)

	(19-1)	(19-2)	(19-3)	(19-4)	(19-5)	(19-6)	(19-7)	(19-8)	(19-9)	(19-10)
	Model 1	Model 2	Model 3	Model 4	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4
b_0 (=*C*)	0.006		0.007							
	(0.005)		(0.004)*							
h	-0.582	-0.479	-0.567	-0.444	-1.887	-1.896	-0.102	-0.074	0.297	0.429
	(0.312)*	(0.245)*	(0.302)*	(0.228)*	(0.802)**	(0.799)**	(0.358)	(0.338)	(0.672)	(0.623)
b_1	0.019	0.02	0.021	0.025	0.024	0.026	0.014	0.017	0.028	0.034
	(0.008)**	(0.007)***	(0.006)***	(0.006)***	(0.008)***	(0.005)***	(0.007)**	(0.007)**	(0.009)***	(0.006)***
b_2	0.017	0.017	0.019	0.021	0.02	0.022	0.011	0.013	0.024	0.028
	(0.008)**	(0.006)***	(0.006)***	(0.007)***	(0.007)***	(0.006)***	(0.006)*	(0.007)*	(0.008)***	(0.009)***
b_3 (=*s*)	1.24	1.551	1	1	1.29	1	1.956	1	1.605	1
	(0.917)	(0.837)*			(0.952)		(1.66)		(1.309)	
b_4 *TC*	0.003	0.003	0.003	0.003						
	(0.002)*	(0.001)**	(0.001)*	(0.001)***						
TC/GDP					4.627	4.036				
					(4.271)	(3.886)				
TC80							0.007	0.006		
							(0.003)*	(0.003)**		
TC80/GDP80									-0.903	-2.754
									(11.524)	(10.76)
d_1 *FDIinflow*	0.0003	0.0003	0.0003	0.0003						
	(0.0001)**	(0.0001)**	(0.0001)**	0.00001)***						
FDIinflow/GDP					3.922	4.242				
					(7.091)	(7.008)				
FDIinflow80							0.016	0.015		
							(0.038)	(0.036)		
FDIinflow80/GDP80									132.156	138.494
									(84.837)	(82.007)*
e_1 *Open*	0.011	0.013	0.01	0.012	0.011	0.011				
	(0.004)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***				
Open80							0.012	0.011	0.009	0.008
							(0.006)**	(0.005)**	(0.002)***	(0.002)***
f_1 *TC*log(HC $_{1960}$)*	-0.001	-0.002	-0.001	-0.002						
	(0.002)	(0.002)	(0.002)	(0.002)						
*(TC/GDP)*log(HC $_{1960}$)*					-2.395	-2.053				
					(7.575)	(7.452)				
*TC80*log(HC $_{1960}$)*							0.001	0.001		
							(0.005)	(0.005)		
*(TC80/GDP80)*log(HC $_{1960}$)*									-42.156	-43.688
									(14.959)***	(14.437)***
f_2 *FDIinflow*log(HC*	-0.00008	-0.00008	-0.00006	-0.00006						
	(0.0001)	(0.00007)	(0.00009)	(0.00007)						
*(FDIinflow/GDP)*log(HC $_{1960}$)*					0.585	0.383				
					(5.932)	(5.873)				
*FDIinflow80*log(HC $_{1960}$)*							0.042	0.046		
							(0.042)	(0.041)		
*(FDIinflow80/GDP80)*log(HC $_{1960}$)*									-90.097	-93.194
									(73.372)	(71.197)
f_3 *Open*log(HC $_{1960}$)*	-0.005	-0.006	-0.005	-0.006	-0.009	-0.009				
	(0.003)**	(0.002)***	(0.002)**	(0.002)***	(0.002)***	(0.002)***				
*Open80*log(HC $_{1960}$)*							-0.007	-0.007	-0.004	-0.004
							(0.003)**	(0.003)**	(0.002)**	(0.002)**
Observation	110	110	110	110	110	110	110	110	110	110
R-squared	0.4		0.4							

Note:
Coefficients of missing dummies for TC and FDI are not shown. Standard errors are presented in parentheses. ***, **, * signify statistical
In Model 3 and 4, we impose the restriction of s=1. Robustness tests of all 4 models are conducted for all variations of TC and FDI. Since the specifications of Model 2 and 4 exclude a constant term, a conventional R2 is not computed

Appendix Table
Descriptive Statistics of Variables Used in this Paper

Variable	Mean	Std. Dev.	Min	Max
rgdp60	$7.95*10^{10}$	$2.57*10^{11}$	$1.28*10^{8}$	$2.24*10^{12}$
pop60	19887.75	52605.64	41.70	434849.00
lhc60	0.90	0.99	-2.66	2.26
avgtfpgrowth	0.03	0.02	-0.02	0.07
TA	63.56	75.52	0.00	344.21
TA/GDP	0.01	0.02	0.00	0.13
iniTA	20.59	32.34	0.00	148.62
iniTA/iniGDP	0.00	0.00	0.00	0.02
ta80	47.03	55.78	0.00	235.13
ta80/gdp80	0.00	0.01	0.00	0.03
FDIinflow	1264.12	3955.34	0.00	32243.77
FDIinflow/GDP	31.82	89.48	0.00	753.30
FDIinflow80	676.46	1888.56	-50.03	11967.61
FDIinflow80/GDP80	0.00	0.01	0.00	0.09
open	62.03	43.28	10.04	240.64
open80	60.22	50.30	5.60	287.18
import	$2.21*10^{10}$	$4.82*10^{10}$	0.0	$3.53*10^{10}$
import/gdp	0.320	0.192	0.0	0.960
import80	$1.38*10^{10}$	$3.03*10^{10}$	0.0	$2.10*10^{11}$
import80/gdp80	0.302	0.195	0.0	0.888