

# Remittances or technological diffusion: Which is more important for generating economic growth in developing countries?

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## Abstract

*This paper examines the impact that technological diffusion and international migrants' remittances have on the economic development of developing countries. The hypothesis that skilled workers, living and working overseas, can effectively channel technological knowledge back to their home country, contributing to that country's economic growth, is tested utilizing data on the stock of high skilled workers from 50 developing countries working in industrialized countries over the last two decades. Results obtained lend strong support to this hypothesis. In addition, the effect that remittances from workers in developed countries, which are used for investment purposes in developing countries, have on the rate of growth of those developing economies is also investigated. Empirical evidence indicates that the remittances channel exerts a significant, positive impact on growth. More interestingly, the contribution of such investment-oriented remittances to driving sustainable economic development appears to be of relatively greater importance than that of technological diffusion.*

**Keywords:** sustainable economic development, technological diffusion, remittance

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## **1- Introduction**

The importance of technological diffusion to the process of economic development has been emphasized by authors that include Nelson and Phelps (1966), Grossman and Helpman (1991), Barro and Sala-i-Martin (1995), Coe and Helpman (1995) and Coe *et al.* (1997). Unlike the traditional neoclassical growth framework in which technological change is characterized as an unexplained residual, recent growth literature has shown that the growth rate of domestic technology is not only dependent on domestic innovative activities but also on those of the rest of the world. As a result, the rate of economic growth of a less-developed country can benefit from new technologies deployed in leading countries, although the extent of this benefit depends crucially on that country's capacity to adopt and implement such new technologies.

There are several conduits through which technological diffusion, or the transmission of ideas and knowledge, can take place. They include the import of high-technology products (as in the modeling of Coe and Helpman 1995, Coe *et al.* 1997, and Engelbrecht 1997), the adoption of foreign technology (either through direct technology transfer, e.g. Soete and Patel 1985, or foreign direct investment, e.g. Borensztein *et al.* 1998, van Pottelsberghe and Lichtenberg 2001), or the acquisition of human capital through various means (e.g. Park 2004). Besides these channels, skilled workers residing and working overseas can also be considered as a means of providing access to advanced technologies for developing countries. People, in general, often maintain very close ties to their country of origin. By keeping in close contact with family, friends and associates at home, perhaps by visiting regularly, skilled workers who reside overseas can help to diffuse the knowledge that they have accumulated from working in more advanced economies back to their home country.

Another potential positive gain for those developing countries that have skilled workers working overseas is the flow of remittances (cash and capital) that those workers send back home. Of course, there is considerable debate regarding the contribution of remittances to economic development in developing countries. Remittances are often argued to improve recipients' standard of living, providing money for basic needs such as foods, clothing, housing, and education, and to some extent, households' investments and savings.<sup>1</sup> At the macroeconomic level, remittances often provide a significant source of foreign currency, which is necessary for financing imports and which contributes to the balance of payments. However, the opponents of this remittance channel contend that remittances could have a net harmful impact on national economic growth because they have the potential to fuel inflation, disadvantage the tradable sector by appreciating the domestic currency, and reduce incentives to work since receiving households can then opt to live off of foreign transfer rather than by working.<sup>2</sup>

The aim of this paper is to empirically examine the extent to which less developed countries, which hardly invest in innovative activities at all themselves, benefit from the research and development (R&D) investment conducted in industrialized countries. Emphasis is placed on potential R&D spillovers that occur through the specific channel of the emigration of high skilled workers from developing countries to more developed ones. In addition, the role of remittances in driving economic growth in developing countries is investigated. In principle, this effect could have either sign, as is suggested in the theoretical literature. However, this

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<sup>1</sup> In a study on El Salvador, Cox Edwards and Ureta (2003) find that in rural areas the probability that a child from a household receiving a \$100 remittance per month leaves primary school is 56 percent lower than that of a child from a household without any receipts of remittances. In urban areas, this figure is 24 percent.

<sup>2</sup> For example, when examining a panel of 113 countries from the early 1970s, Chami *et al.* (2003) find a robust negative correlation between remittances and GDP growth. Remittances are more likely compensatory transfers than a resource for economic development.

paper focuses on the constructive aspect of remittances, carefully accounting for the proportion of remittances that are used for investment purposes to finance small businesses.<sup>3</sup>

The empirical work utilizes a framework of cross-country regressions. Data on stocks of highly skilled workers from 50 developing countries working in 13 industrial economies over the last two decades is used. The results in the paper shed new light on a significant source of R&D spillovers and represent a novel contribution to the literature on international R&D spillovers and economic growth. The research undertaken also confirms the positive role of remittances that are used for investment purposes towards economic development.

Several policy recommendations are drawn from results derived in this paper. The fact that skilled workers overseas appear to transmit technological knowledge back to their home country suggests that openness to international (e)migration (often labeled as ‘Brain Drain’) may actually improve the growth rate of the labour outflow donor countries. In addition, more emphasis should be placed on the need to enhance national absorptive capacity through investment in the education activities of the labor force. There should also be appropriate mechanisms put in place that further encourage the use of remittances towards financing small businesses.

The rest of the paper is organized as follows. Section 2 briefly describes the model specification, from which the empirical framework in Section 3 is drawn and econometric regressions are carried out. Section 4 discusses the data used for these regressions. Empirical results and their economic interpretation are presented in Section 5. Section 6 ends the paper with some concluding remarks.

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<sup>3</sup> In a survey on the role of remittances in financing small businesses in El Salvador, Lopez-Calix and Seligson (1990) find that on average 16 percent of remittances were used for investment purposes.

## 2- Theoretical considerations

In any country, there are a large number of final goods producers. For simplicity, assume that all final goods producers, on aggregate, produce a homogenous consumption good according to the following production function:

$$Y_t = AK_t^\alpha D_t^{1-\alpha}, \quad A > 0, \quad 0 < \alpha < 1 \quad (1)$$

where  $Y_t$  is the output level at time  $t$ ,  $K_t$  is the existing stock of physical capital, and  $D_t$  is a composite input of differentiated goods which is defined as follows:

$$D_t = \left[ \int_0^{N_t} (q_{mkt} X_{kt})^{1-\alpha} dk \right]^{\frac{1}{1-\alpha}} \quad (2)$$

Here,  $N_t$  denotes the range of intermediate inputs used for production of final goods in the country (it might be different from the range of intermediate inputs produced in that country).

$X_{kt}$  is the physical amount of capital product  $k$  employed, and  $q_{mkt}$  is its attached quality grade which reflects the productivity of capital good in the production process. Capital goods are produced by specialized intermediate firms. Each firm produces only one kind of capital good at production cost which is normalized to 1 for simplicity, rent it out to final goods producers at a rental rate  $P_{kt}$ . The optimality condition requires that the rental rate of a capital good is equal to its marginal product:

$$\frac{\partial Y_t}{\partial X_{kt}} = AK_t^\alpha (1-\alpha) q_{mkt}^{1-\alpha} X_{kt}^{-\alpha} = P_{kt} \quad (3)$$

This gives the demand function for capital good  $k$ :

$$X_{kt} = \left( \frac{AK_t^\alpha (1-\alpha) q_{mkt}^{1-\alpha}}{P_{kt}} \right)^{\frac{1}{\alpha}} \quad (4)$$

With the assumption that each capital good producer facing a fixed set up cost  $\mu$ , the lifetime profit from producing a capital good is:

$$\Pi_{kt} = -\mu + \int_t^{\infty} (P_{kt} - 1)X_{kt} e^{-r(s-t)} ds \quad (5)$$

In this formula,  $(P_{kt} - 1)X_{kt}$  is the instantaneous profit flow at a point of time. The goal of intermediate firms is to set the price  $P_{kt}$  at each date to maximize this profit flow:

$$\text{Max}_{P_{kt}} (P_{kt} - 1) \left( \frac{AK_t^\alpha (1 - \alpha) q_{mkt}^{1-\alpha}}{P_{kt}} \right)^{\frac{1}{\alpha}}$$

This delivers the monopoly price that intermediate firms will charge:

$$P_{kt} = \frac{1}{1 - \alpha}, \quad \forall k, t, m \quad (6)$$

which is a mark-up over the marginal cost. Plugging the result into the demand function determines the total demand for capital variety  $k$  in equilibrium:

$$X_{kt} = \left( AK_t^\alpha (1 - \alpha)^2 q_{mkt}^{1-\alpha} \right)^{\frac{1}{\alpha}} \quad (7)$$

With the assumption of free entry, the rate of return  $r$  will be such that lifetime profits are equal to zero (the zero profit condition  $\pi_{kt} = 0$ ) so that:

$$r_t = \frac{1}{\mu} \cdot \alpha (1 - \alpha)^{\frac{2-\alpha}{\alpha}} A^{\frac{1}{\alpha}} K_t^{\frac{1-\alpha}{\alpha}} q_{mkt}^{\frac{1-\alpha}{\alpha}} \quad (8)$$

Assume that each individual maximizes the following standard intertemporal utility function:

$$U_t = \int_t^{\infty} \frac{C_s^{1-\sigma}}{1-\sigma} \cdot e^{-\rho(s-t)} ds \quad (9)$$

where  $C_t$  denotes per capita units of consumption of the final good  $Y_t$  at time  $t$ . The optimal consumption path is characterized by the following Euler equation:

$$\frac{\dot{C}_t}{C_t} = \frac{r_t - \rho}{\sigma} \quad (10)$$

In steady state, the growth rate of consumption is equal to the growth rate of output. Let  $g$  be the rate of growth of output then substituting results (8) into (10) we get:

$$g = \frac{1}{\sigma} \cdot \left[ \frac{1}{\mu} \cdot \alpha (1 - \alpha)^{\frac{2-\alpha}{\alpha}} A^{\frac{1}{\alpha}} K_t^{\frac{1-\alpha}{\alpha}} q_{mkt}^{\frac{1-\alpha}{\alpha}} - \rho \right] \quad (11)$$

This result shows that R&D investment, which is measured by the term  $q_{mkt}^{\frac{1-\alpha}{\alpha}}$ , increases the rate of growth of the economy. With international trade, investment, and migration, both domestic and foreign intermediate goods/ideas can be employed for a country's production. This means that output in a particular country may grow as a result of its domestic innovation or international technological spillovers from other countries. By an appropriate choice of unit normalization, the above index of R&D is equal to R&D capital stock which in turn can be decomposed into cumulative stock of R&D expenditure and foreign knowledge stock.

Result in equation (11) indicates that capital accumulation positively affects growth. In case of international migration, both domestic investment and migrants' remittances contribute to the stock of physical capital  $K_t$ . As a result, remittances can as well enhance the rate of growth of a country.

### 3- The Empirical Model

To assess empirically the effect of R&D spillovers and investment-oriented remittances on economic growth, we utilize the following straightforward linear specification, analogous to equation (11), that links growth of GDP per capita to the measures of domestic/foreign R&D capital stock and stock of international remittances used for investment purposes:

$$g = \Delta \log(y_{it}) = \alpha_{i0} + \alpha_1 \cdot \log SD_{it-1} + \alpha_2 \cdot \log SF_{it-1} + \alpha_3 \cdot \log RR_{it-1} + \alpha_4 \cdot t + \theta \cdot X_{it-1} + \varepsilon_{it} \quad (12)$$

where  $y_{it}$  is the real GDP per capita for country  $i$  in year  $t$ ,  $\alpha_{i0}$  is the country specific effect which captures institutional factors,  $SD_{it}$  is the real stock of domestic R&D investment,  $SF_{it}$  is the real stock of foreign R&D accumulated through the emigration of high skilled workers,  $RR_{it}$  is the real stock of international remittances used for investment purposes as share of GDP,  $X_{it}$  is a vector of control variables,  $t$  is a time trend used to characterize macroeconomic shocks and the up and down of the economy due to business cycles, and  $\varepsilon_{it}$  is the regression residuals.

To determine the robustness of the link between the growth of GDP per capita and R&D spillovers through migration of high skilled workers and remittances, vector  $X_{it}$  includes the following explanatory control variables:

- *Physical capital accumulation* ( $\log(KR)$ ): the propensity to accumulate physical capital is proxied by the ratio of gross fixed capital formation (fixed capital investment) to real GDP.
- *Indicator of the exposure to international trade* ( $\log(TR)$ ): it is calculated as the ratio of total trade to GDP.
- *Indicator of government size and financing* ( $\log(GR)$ ): it is represented by the ratio of government nominal consumption expenditure to nominal GDP.
- *Measure of inflation* ( $d\log(IFL)$ ): it is the rate of growth of the private final consumption deflator.

Implicit in the above specification is the assumption that output is affected by the latest change in technology, production, and policy factors. However, the diffusion of technology as



well as the effect of changes may take time. To capture this fact, all of the variables are introduced into the regression equation with a lag to better identify their impact on output.

The R&D-based growth literature, such as Romer (1990), Grossman and Helpman (1991), Coe and Helpman (1995), among others, suggests that productivity depends on the domestic R&D capital stock. However, according to Coe *et al.* (1997), R&D expenditures in most developing countries are negligible. As a result, this paper opts to ignore domestic R&D capital stocks in the developing countries in the sample because they are assumed to be sufficiently small. That is the reason why the term characterizing domestic R&D expenditure,  $SD_{it}$ , will be omitted from the baseline regression equation (12).<sup>4</sup>

Before looking at empirical results, it is necessary to describe the measure of foreign R&D capital stock variable,  $SF$ , that we use in this paper. For a country to benefit from technological diffusion through migration, the country needs to have its skilled emigrant workers working in countries that are capable of providing it with the high-tech information that the country itself is in short supply. By having skilled workers working in an industrial country that has a larger stock of knowledge, a developing country can benefit from the direct knowledge spilling through the movement of knowledgeable people. For this reason, we construct for each developing country in our sample a measure of the relevant foreign R&D capital stock that we treat as a proxy for the stock of knowledge embodied in the country's migration profile. More precisely, this measure is intended to capture the foreign R&D capital stock embodied in *outward migration* and is constructed as follows:

$$SF_{it} = \sum_{j \neq i} \frac{l_{ijt}}{n_{jt}} \cdot SD_{jt}$$

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<sup>4</sup> In fact, this paper has attempted to test the impact of domestic R&D capital stock on the growth rate of developing countries. Unfortunately, it turns out to be a difficult task since data on R&D expenditure in those countries are either unavailable or extremely poor.

where  $SD_{jt}$  is the domestic R&D capital stock of industrial country  $j$  at time  $t$ ,  $l_{ijt}$  is the stock of highly skilled workers from developing country  $i$  working in industrial country  $j$ , and  $n_{jt}$  is the number of workers with high level of education in country  $j$  at time  $t$ .

Unlike many other papers which try to estimate the impact of remittances, in general, on economic growth, this paper concentrates on the role of remittances in creating incentives for household savings and private sector investment. In particular, we focus on the fraction of remittances that the receiving countries use to start up businesses, invest in human capital or financial assets, etc.. We expect that these uses for remittances would result in high economic payoffs for receiving countries. Here we calculate the amount of remittances that are employed towards investment each year for each country from data on annual flows of remittances. However, to do so we need information about the rate at which remittances are mobilized to finance small businesses. We hypothesise that this rate is likely to vary across countries and across regions given that countries are different in terms of economic development, financial market development, political structure, monetary and fiscal policies, and other institutional and behavioural factors. Unfortunately, limitations on data availability prevent us from obtaining a precise number for each individual country. To overcome this difficulty, this paper uses as a simple proxy the investment rate out of total income to estimate for the investment rate out of remittances.<sup>5</sup> After deflating this nominal amount by a GDP deflator to get real remittance investment, we compute the accumulated real remittance capital stock by using a perpetual inventory method with a depreciation rate assumed to be 5 percent per year (more details on how to construct this series can be found in Appendix 1).<sup>6</sup>

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<sup>5</sup> This figure is different from country to country and from year to year.

<sup>6</sup> First we thought of using the result from Lopez-Calix and Seligson (1990) that on average 16 percent of remittances (in El Salvador) were used to finance small businesses to compute the stock of investment-oriented remittances. However, it seems to be inappropriate to use a same constant rate for every country and every year. In the end, we decided to utilize the investment rate out of total income which, we believe, is a better choice.

#### **4- Data description**

Our empirical results are based on annual data series created for 50 developing countries over the 1980-2000 period which are summarized in Table 1. Raw data on GDP, GDP per capita, gross fixed capital formation, government expenditure, and inflation rate employed for the computation of the data series are from the United Nations Statistic Division's Database.<sup>7</sup> The foreign R&D capital stock for each developing country is a weighted average of the domestic R&D capital stocks of 13 OECD countries (Australia, Canada, Denmark, Finland, France, Ireland, Italy, Japan, Norway, Spain, Sweden, UK, US). The domestic R&D capital stocks of the OECD countries are constructed based on the method described in Coe and Helpman (1995) from data on R&D expenditures in these countries extracted from the OECD STAN Databases (2002, 2006). The data on remittances are collected from the IMF's Balance of Payment Statistics Yearbook.<sup>8</sup> The data used in this paper comprises both workers' remittances and compensation of employees to best reflect current transfers by migrant workers and the wages earned by nonresident workers.<sup>9</sup> Data on the investment rate (investment as share of GDP) are extracted from Penn World Table version 6.2 by Heston, Summer, and Bettina.<sup>10</sup>

#### **5- Results**

All empirical results are presented in Table 2. All regressions are based on annual panel data for the two decades 1980-2000 and are estimated using pooled least squares. An obvious advantage of the panel data framework is that it allows for differences in countries' aggregate production functions in the form of unobservable individual 'country effects'. Another

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<sup>7</sup> These are available on website at [http://unstats.un.org/unsd/cdb/cdb\\_advanced\\_data\\_extract.asp](http://unstats.un.org/unsd/cdb/cdb_advanced_data_extract.asp)

<sup>8</sup> These can be downloaded from <http://migration.ucdavis.edu/mn/data/remittances/remittances.html>

<sup>9</sup> It is generally agreed that the quality of data on remittances is very poor due to the fact that large quantities of international remittances are transmitted through various unofficial channels such as friends, family members and are, therefore, not recorded in the balance of payments of many countries. As a result, official figures may underestimate the actual flows of remittances.

<sup>10</sup> Data are available on the following website: <http://pwt.econ.upenn.edu/php-site/pwt62/pwt62-form.php>

attractive feature lies in the fact that analysis can still be conducted even in a sample where each individual country has only a limited number of observations. However, in this paper, the final sample consists of 50 developing countries for which data on all variables are available.

The main regression results indicate that skilled workers working overseas are an effective channel of technological diffusion from industrial countries to less developed ones. In addition, the wage earnings they send home make a positive contribution to growth because these are actually an important financial source for investment purposes.

The results also indicate the important role of macroeconomic policy settings in determining the rate of growth of output per capita across countries and over time. Inflation has an important influence on output per capita as its coefficient is always significant and negative. This supports the hypothesis that high inflation adds noise to capital and other markets and discourages investors from undertaking investment projects by lowering average, expected returns from these projects.

The conjecture that the size of the government, proxied by government consumption, has an impact on growth receives strong support. The coefficient on government consumption always enters negative and is consistently, statistically significant. This implies that fiscal policy plays an important role in affecting growth. Higher government consumption leads to lower level of public savings and, hence, lower levels of domestic savings. This, in turn, raises interest rates which discourages investment (the crowding out effect), and generates less output growth.

The link between the degree of openness, proxied by total trade as share of GDP, and growth is also found. Results lend general support to the notion that more international trade helps a country to fully exploit its comparative advantage, expand its export market overseas, and

improve its production capacity to outperform other country competitors. Trade is also an important vehicle that channels resources (machinery, materials, etc.) towards a domestic economy to meet its rising production demand.

Importantly, estimates of equation (1) shows that the foreign R&D capital stock generated through the stock of skilled workers working in industrial countries, has a significant and positive impact on economic growth, even after physical capital accumulation, trade openness, government consumption, and inflation have all been controlled for. This suggests that, as far as it can be detected in this sample of countries, highly skilled workers apparently transfer some of the knowledge that they obtain from working overseas to their home country. The transferal process could be done in many different ways, for example, by visiting home regularly or by contacting people at home via telephones or the internet.

Estimates from equation specification (2) that replaces the R&D spillovers variable with a variable on remittances used for investment purposes, shows that this specification yields a coefficient on the remittances variable that is positive and highly significant. This means that growth responds positively to remittances when they are directed towards investment.

Unlike the previous two equations that include each variable separately, equation (3) examines the joint impact of R&D spillovers and remittances on growth by including an interaction term of these two variables. The corresponding coefficient is estimated as positive and statistically significant although with a modest value. Results imply that both technological diffusion and remittances appear to jointly influence growth.

Regression specification (4) tests the effects of R&D spillovers and remittances simultaneously in a same equation. The coefficients of these variables are both positive and significant although to a smaller scale as compared to those obtained in equation (2) and (3). While the coefficient of R&D spillovers term is significant at 5 percent level, that of

remittances is highly significant at 1 percent level. This reflects that the impact of remittances on the rate of growth of developing countries may be more profound than knowledge spillovers. The reason is that the impact of remittances on growth is more direct and more immediate than that of R&D spillovers. In addition, the benefit of R&D spillovers is very much dependent on how quickly and effectively a country is able to learn the new knowledge.

Equation (5) and (6) include foreign R&D capital stock and remittances individually in conjunction with their product. In that way, we can test jointly whether these variables affect growth mainly by themselves, or additionally through the interaction term. Results show that the coefficients of the individual spillovers and remittances variables are both positive and statistically significant, while that of the interaction term is positive and significant at the 1 percent level in equation (5) but negative and only significant at 10 percent level in equation (6). This implies that technological diffusion and remittances appear to affect growth both by themselves and also to some extent through their interaction.

In short, the results from the regressions displayed in Table 2 show strong complementary effects between R&D spillovers and remittances on the growth rate of income. This result is consistent with the idea that the flow of advanced technology brought along by high skilled workers working overseas can increase the growth rate of the worker sending country. Moreover, remittances may encourage growth further if they are used more for investment purposes.

Looking at the results in Table 2, one can suggest that equation (4) is the most preferred specification based on the highest value of goodness-of-fit. To check whether our results are robust, we perform a series of sensitivity and robustness tests. In doing so, we omit groups of countries that may have characteristics different from the rest of the sample to see if the results are significantly influenced. The reason for doing that is it may be the case that our

results are driven by a group of countries with peculiar characteristics that have nothing to do with technological diffusion or remittances.

In Table 3, we report the coefficient estimates on the remittance share and foreign R&D capital stocks when our preferred specification is estimated using different sub-samples. Omitting countries from the Middle East and North Africa yields estimates on foreign R&D capital stock and remittances that are marginally different in terms of magnitude but which become more statistically significant. There are some small changes to the magnitudes of the coefficients when Sub-Saharan African countries are eliminated. Eliminating Latin America and the Caribbean makes the coefficient of foreign R&D capital stock insignificant. However, omitting East Asia and the Pacific and South Asia from the sample does not have significant impact on the coefficient estimates. In short, despite different sub-samples being used, the results qualitatively stay the same.

## **6- Concluding remarks**

In this paper, we show that skilled workers working overseas are potentially an effective channel through which developing countries can get access to advanced technologies already deployed in industrial countries. Through different channels, skilled workers working overseas can contribute to the stock of knowledge of their home country. This is clearly a ‘brain gain’ type effect that is associated with the oft decried ‘brain drain’ from developing countries. We also show that there is enough evidence to conclude that remittances specifically, when employed for investment purposes, provide a financial channel from skilled emigration that positively and significantly affects growth.

There are different policy implications which can be drawn from the above mentioned conclusions. As the benefit from R&D spillovers is very much dependent on a country’s

capacity of adoption and implementation of new technologies, more investment in education is likely to enhance the country's absorptive capacity given that a better educated labor force will likely be more able to overcome frictional and institutional barriers and emigrate to more technically advanced economies, and whilst there learn more quickly from the foreign technological base. In addition, there should be special institutional mechanisms and policy settings that encourage a larger flow of remittances, a larger fraction of those remittances to be invested and invested more efficiently, all of which will ultimately lead to higher income and output growth.

An important question that has been raised in the literature is: what role can the government play in affecting the manner in which remittances are used and the way foreign technological knowledge is utilized? Of course, if one believes that the evidence indicates that institutions matter in these regards then the best way for developing countries to enjoy the most benefits from remittances and technological diffusion is to enhance the quality of its institutions. In that case, a better quality of institution is likely to foster a better labor force and ensure a greater proportion of remittances is being used for productive investment. An empirical test for the robustness of this proposition is likely to enrich our future research agenda.



**Table 1- Summary statistics**

Country	Growth of real GDP per capita (% per annum)	Gross fixed capital formation as share of GDP (period average)	Trade as share of GDP (period average)	Government expenditure as share of GDP (period average)	Inflation rate (% period average)	Foreign capital (ratio 2000 to 1980)	R&D stock 2000 to	Remittances for investment purposes as share of GDP (% period average)
<b>Middle East and North Africa</b>								
Cyprus	3.41	0.27	0.60	0.16	4.80	1.72		2.43
Egypt	3.33	0.32	0.33	0.18	13.64	2.04		13.40
Israel	3.92	0.20	0.57	0.29	67.13	1.99		0.52
Malta	2.58	0.28	1.21	0.18	3.20	1.81		4.55
Tunisia	-0.75	0.28	0.64	0.16	6.56	2.08		6.50
<b>Sub-Saharan Africa</b>								
Benin	-3.20	0.16	0.48	0.13	2.79	2.06		7.63
Botswana	2.07	0.28	0.93	0.23	12.12	1.74		8.36
Burkina Faso	-2.99	0.22	0.28	0.13	3.81	2.08		12.20
Cameroon	-3.30	0.19	0.33	0.15	6.22	2.02		0.30
Cape Verde	1.40	0.30	0.54	0.20	9.36	1.99		81.69
Comoros	-3.36	0.23	0.35	0.26	4.72	2.06		4.42
Cote d'Ivoire	-5.14	0.14	0.55	0.18	5.75	2.04		0.88
Ethiopia	-4.08	0.20	0.20	0.13	6.19	2.04		0.35
Ghana	-7.70	0.12	0.37	0.10	37.34	1.82		0.15
Lesotho	-0.36	0.45	1.16	0.17	12.37	1.82		118.30
Madagascar	-5.40	0.11	0.28	0.42	14.02	2.07		0.19
Mali	-2.97	0.20	0.36	0.16	3.98	2.07		6.84
Mauritania	-3.70	0.22	14.42	0.19	7.10	2.07		1.03
Niger	-7.38	0.12	0.37	0.16	3.96	2.04		1.23
Nigeria	-2.18	0.33	0.60	0.13	24.80	1.84		0.66
Rwanda	-0.48	0.14	0.21	0.11	9.88	2.06		0.25
Senegal	-2.83	0.14	0.47	0.15	5.42	2.06		3.77
South Africa	-2.35	0.19	0.42	0.16	11.95	1.83		0.15
Sudan	3.67	0.11	0.17	1.07	57.80	1.91		4.17
Swaziland	-0.28	0.25	1.51	0.21	12.18	1.77		11.99
Togo	-4.74	0.18	0.70	0.26	5.55	2.06		2.63
<b>Latin America and the Caribbean</b>								

Argentina	0.40	0.12	0.13	0.14	303.29	2.10	0.09
Barbados	2.18	0.17	0.58	0.19	4.96	1.94	3.47
Bolivia	-1.32	0.14	0.33	0.11	663.82	2.05	0.14
Brazil	5.16	0.08	0.16	0.07	565.60	2.16	0.10
Colombia	0.85	0.19	0.27	0.12	22.12	2.02	0.94
Costa Rica	1.48	0.20	0.59	0.13	20.90	1.99	0.26
Dominica	4.45	0.31	0.81	0.22	4.86	1.93	10.07
Dominican Republic	2.57	0.21	0.50	0.06	17.80	1.99	5.52
El Salvador	1.59	0.03	0.45	0.13	14.00	2.03	5.87
Guatemala	-0.34	0.14	0.32	0.06	12.60	2.00	1.03
Haiti	0.33	0.17	0.27	0.09	14.04	2.03	8.69
Honduras	-0.59	0.23	0.61	0.11	13.35	1.99	1.03
Jamaica	2.49	0.22	0.65	0.14	21.64	1.97	22.27
Panama	0.49	0.22	1.87	0.17	2.10	1.98	2.77
Paraguay	-0.62	0.27	0.56	0.08	18.03	2.11	1.43
Trinidad and Tobago	-1.51	0.21	0.65	0.17	8.76	2.02	0.14
<b>East Asia and the Pacific</b>							
Fiji	-2.15	0.16	0.62	0.17	5.64	2.37	1.65
Malaysia	1.52	0.31	1.26	0.14	3.57	1.93	0.12
Philippines	-0.65	0.21	0.53	0.09	11.98	2.04	4.75
Thailand	2.90	0.32	0.59	0.11	5.23	2.02	1.33
<b>South Asia</b>							
Bangladesh	0.89	0.17	0.20	0.10	8.48	1.92	3.14
India	-0.09	0.22	0.15	0.11	9.09	1.95	1.69
Pakistan	-0.55	0.17	0.21	0.13	8.30	1.90	8.39
Sri Lanka	2.69	0.24	0.59	0.12	11.77	1.99	5.24

**Table 2-** *GDP per capita growth estimation results (pooled data 1980-2000, 50 countries)*

Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
$\log(KR)$	0.050*** (0.010)	0.051*** (0.009)	0.051*** (0.009)	0.051*** (0.009)	0.050*** (0.009)	0.052*** (0.009)
$\log(TR)$	0.097*** (0.018)	0.065*** (0.019)	0.069*** (0.019)	0.069*** (0.019)	0.073*** (0.019)	0.067*** (0.019)
$\log(GR)$	-0.056*** (0.011)	-0.057*** (0.011)	-0.055*** (0.011)	-0.059*** (0.011)	-0.058*** (0.011)	-0.058*** (0.011)
$d \log(IFL)$	-0.029*** (0.006)	-0.029*** (0.006)	-0.029*** (0.006)	-0.029*** (0.006)	-0.029*** (0.006)	-0.029*** (0.006)
$\log(SF)$	0.569** (0.242)			0.503** (0.240)	0.603** (0.240)	
$\log(RR)$		0.042*** (0.010)		0.041*** (0.010)		0.102*** (0.036)
$\log(RR) * \log(SF)$			0.006*** (0.002)		0.006*** (0.002)	-0.010* (0.006)
$R^2$	0.172	0.184	0.179	0.188	0.185	0.187
$Adj - R^2$	0.118	0.130	0.125	0.134	0.131	0.132

**Notes:** The dependent variable is  $\Delta \log y$  (log differenced of real GDP per capita). All equations include unreported country-specific and time trend constants. Standard errors are given in parentheses.  $KR$  is gross fixed capita formation as share of GDP;  $TR$  is foreign trade as share of GDP;  $GR$  is government expenditure as share of GDP;  $IFL$  is inflation rate;  $SF$  is stock of foreign R&D embodied in outward migration;  $RR$  is stock of remittances used for investment purposes as share of GDP. \*\*\*, \*\*, and \* indicate that parameters are statistically significant at the 1%, 5%, and 10% probability level respectively.

**Table 3- Robustness to sub-samples and omitted observations**

Omitted region	$\log(SF)$	$\log(RR)$	Observations	$R^2$	$Adj - R^2$
None	0.503** (0.241)	0.041*** (0.010)	1000	0.188	0.134
Middle East and North Africa	0.616** (0.270)	0.043*** (0.011)	900	0.186	0.131
Sub-Saharan Africa	0.771** (0.268)	0.024** (0.011)	580	0.175	0.120
Latin America and the Caribbean	0.382 (0.274)	0.045*** (0.013)	680	0.206	0.148
East Asia and the Pacific	0.490* (0.271)	0.044*** (0.011)	920	0.196	0.141
South Asia	0.477* (0.255)	0.039*** (0.011)	920	0.191	0.136

**Notes:** Standard errors are given in parentheses.  $SF$  is stock of foreign R&D embodied in outward migration;  $RR$  is stock of remittances used for investment purposes as share of GDP. \*\*\*, \*\*, and \* indicate that parameters are statistically significant at the 1%, 5%, and 10% probability level respectively. In each of the sub-samples, countries from the Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific, and South Asia are eliminated.

### Appendix 1 - Data sources and definitions

For each country, data on GDP, GDP per capita, gross fixed capital formation, government expenditure, and inflation rate are from the United Nations Statistics Division's Database.

The domestic R&D capital stocks of the 13 OECD countries (Australia, Canada, Denmark, Finland, France, Ireland, Italy, Japan, Norway, Spain, Sweden, UK, US) are derived from data on R&D expenditures in these countries extracted from the OECD STAN Databases (2002, 2006) based on the method employed by Coe and Helpman (1995, p.878). Coe and Helpman first calculated real R&D expenditures as nominal expenditures deflated by an R&D price index  $PR = 0.5P + 0.5W$  where  $P$  is the implicit deflator for business sector output and  $W$  is an index of average business sector wages (both of them come from OECD Economic

Outlook Database 2006). Domestic R&D capital stocks were then calculated from domestic real R&D expenditures based on the perpetual inventory method assuming a depreciation rate of 5 percent. The study in this paper has computed outward migration shares matrices for every developing country over the period 1980-2000. These weighting matrices were then used to compute alternative foreign R&D capital stocks using the above obtained data on domestic R&D capital stocks of the OECD countries as described above in the text.

Finally, the data on remittances were calculated by adding up workers' remittances and compensation of employees (these were collected from the IMF's Balance of Payment Statistics Yearbook) to get remittance flows for each year. These figures were then deflated by the implicit deflator for business sector output to obtain the real remittance inflows. To obtain a measure of the amount of remittances that are used for investment purposes in each receiving country, we used that country's investment rate out of total GDP as an estimate for the rate at which remittances were cumulated to finance small business capital expenditure. Data on investment rates were obtained from Heston, Summer, and Bettina's Penn World Table version 6.2. We next calculated remittance stocks at the beginning of the period based on the perpetual inventory model:

$$R_t = (1 - \delta)R_{t-1} + I_{t-1}$$

where  $\delta$  is the depreciation rate, which was assumed to be 5 percent. The benchmark for  $R$  was calculated as follows:

$$R_0 = \frac{I_0}{g + \delta}$$

where  $I_0$  is the remittance inflow of the first year for which the data were available,  $R_0$  is the benchmark for the beginning of that year, and  $g$  is the average annual logarithmic growth of remittance inflow over the period for which remittance data were available.

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