

# International Trade, Economic Growth and Intellectual Property Rights: A Panel Data Study of Developed and Developing Countries

Patricia M. Higinio da Silva\*  
University of California, Santa Cruz

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## Abstract

This paper is an empirical investigation of the role of trade in determining the rate of innovation and economic growth in developed and developing countries. Endogenous growth models link trade to technological innovation. Trade increases technological innovation by providing access to foreign technology. Previous research has shown a positive link between trade in physical goods and technological diffusion. This paper complements the previous literature by including a more representative sample of developing countries and focusing on high-technology trade. The empirical analysis is conducted using a unique panel data set of 48 developed and developing countries from 1970 to 1990. Patent data is used as a proxy for innovation. The relationship between trade, innovation and growth is estimated in a framework that includes other important explanatory variables like foreign direct investment (FDI) and intellectual property rights (IPRs). The results suggest that human capital stock and market size have a positive effect on innovation, while high technology imports from developed countries and FDI inflows do not contribute to domestic innovation. Growth of per capita real GDP is primarily explained by growth in the per capita capital stock. For developed countries (DCs), foreign technology plays a bigger role than domestic technology in explaining growth. For developing countries, IPRs have a negative effect on the rate of domestic innovation. The results in this paper provide evidence that technological diffusion across DCs is different from diffusion between developed and developing countries, which has important implications for how trade policy is designed and implemented in these distinct groups of countries.

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\*Address for correspondence: Department of Economics, University of California, Santa Cruz, CA, 95064, USA. Fax: (831) 459-5900. E-mail: pmsilva@cats.ucsc.edu.

# 1 Introduction

The benefits of international trade for economic growth and development are difficult to understate. Imports bring additional competition and variety to domestic markets, benefiting consumers, and exports enlarge markets for domestic production, benefiting businesses. Trade exposes domestic firms to the best practices of foreign firms and to the demands of discerning customers, encouraging greater efficiency. Trade gives firms access to improved capital inputs such as machine tools, boosting productivity as well. Trade encourages the redistribution of labor and capital to more productive sectors. In particular, it has contributed to the ongoing shift of some manufacturing and service activities from industrial to developing countries, providing new opportunities for growth for the developing countries. Until recently, the Neoclassical Growth Model (Solow (1956), Swan(1956)) was the main theoretical framework used to explain economic growth. However, that framework did not offer a formal link between trade policies and long run growth.

The development of endogenous growth models (Romer (1990), Grossman and Helpman (1991), Rivera-Batiz and Romer (1991), Aghion and Howitt (1992)) provided such link and suggested different channels through which trade could affect economic growth<sup>1</sup>. One idea is that imports may embody innovations that are not available in the local economy, and local researchers may gain insights from these innovations. Therefore, by providing access to foreign innovations, trade can promote technological diffusion and economic growth.

Previous research has shown a positive link between trade in physical goods and technological diffusion. Some of these studies have focused on general imports as a channel for technological diffusion (Coe and Helpman (1995), Coe, Helpman and Hoffmaister (1997), Eaton and Kortum (1996, 1997) and Keller (1997)). Other studies have looked at a more disaggregated measure of imports (Wang and Xu (1997), Connolly (1998) and Keller (1999)). However, most of these studies have focused on developed countries<sup>2</sup>.

The motivation for this paper comes from the fact that many theoretical models suggest that technological diffusion among developed countries might differ from technological diffusion between developed and developing countries<sup>3</sup>. Additionally, in its 1998/99 Development Report, the World Bank emphasizes the importance of openness, stronger intellectual property rights (IPRs) and foreign direct investment (FDI) as important channels for acquiring imported knowledge, especially in develop-

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<sup>1</sup>See Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) for a discussion of these channels.

<sup>2</sup>Only Coe, Helpman and Hoffmaister (1997) and Connolly (1998) include developing countries in their sample.

<sup>3</sup>For example, Grossman and Helpman (1991), Segerstrom et al. (1990), Helpman (1993), Barro and Sala-i-Martin (1997).

ing countries. The investigation of these issues requires empirical work that includes both developed and developing economies, since policy recommendations that arise from this kind of analysis may have very different effects on these two groups of countries.

This paper conducts an empirical investigation of the role of trade in determining the rate of innovation and economic growth in developed and developing countries, and investigates the importance of IPRs and FDI in these processes. FDI has been identified in the literature as another important channel for technological diffusion (Grossman and Helpman, 1991; Helpman, 1993). Additionally, the link between trade and IPRs is important. In principle, patent protection directly affects growth through inducements to innovation. Deliberate investments in knowledge require an environment where IPRs are protected, otherwise investors cannot appropriate the fruits of their labor. Returns to innovation could be influenced by variations in international patent laws, with a primary channel being decisions by firms to trade in different markets. Thus patent regimes could be an additional factor in the relationship between trade and growth<sup>4</sup>.

More specifically, this paper focus on three main questions: 1) Does trade promote innovation and growth by providing access to foreign technology? 2) How important are FDI inflows and IPRs in these processes? and 3) Are the effects different for developed and developing countries? This study complements the literature by including a more representative sample of developing countries and by focusing on high-technology trade. The empirical analysis is conducted using a unique panel data set of 48 developed and developing countries from 1970 to 1990, in which patent data is used as a proxy for innovation. This paper is organized as follows. Section 2 briefly reviews the empirical literature on the subject. Section 3 discusses the methodology implemented in the paper. Section 4 describes the data. Section 5 presents the empirical results and section 6 concludes this paper.

## 2 Empirical Studies on trade and technological diffusion

Several empirical studies consider the possible link between trade in physical goods and technological diffusion. In general, the findings of these papers support the notion that trade contributes significantly to technological diffusion, although the exact mechanism through which trade aids in technological diffusion is not specified. Some of these studies have focused on general imports as a channel for technological

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<sup>4</sup>See Maskus and Penubarti, 1995; Segerstrom et al., 1990; Grossman and Helpman, 1991; Helpman, 1993; Taylor, 1994.

diffusion (Coe and Helpman 1995; Coe, Helpman and Hoffmaister 1997; Eaton and Kortum 1996, 1997; Keller 1997).

Coe and Helpman (1995), using a sample of 22 developed countries find that both the domestic and the foreign R&D capital stocks have significant effects on a country's total factor productivity, and that the effect of the foreign R&D stocks is greater the more open is the economy. However, using the Coe and Helpman (1995) data, Keller (1997) finds evidence of international R&D spillovers using randomly generated bilateral trade shares, and casts doubt on the importance of trade in goods as the channel for technological diffusion when considering similar, interrelated countries<sup>5</sup>.

Coe, Helpman and Hoffmaister (1997) extend the Coe and Helpman type of analysis to 77 developing countries although only foreign stocks of R&D expenditures are considered. They find that the TFP of developing nations increases with a greater import weighted foreign (developed-country) R&D capital stock, with increased openness to trade with developed nations and with greater secondary school enrollment.

Eaton and Kortum (1996) develop a model of growth and technology diffusion which they fit to aggregate data from OECD countries. They estimate the model to explain international patterns of productivity and patenting and find that more than 50% of growth in each country in their sample derives from innovation in the United States, Germany, and Japan. Their results also indicate that imports are significant in explaining technological diffusion, however, geographical distance and human capital tend to play a much larger role in technological diffusion. Since they are only considering technological diffusion between developed nations these results may underestimate the role that trade may play between developed and developing nations.

Eaton and Kortum (1997) develop a Ricardian model that explores the role of trade in spreading the benefits of innovation among OECD countries. They find that trade can serve as an important conduit for gains from improved technology. An improvement in a country's technology almost always benefits everyone. But the magnitude of the gains abroad approach those at home only in foreign countries enjoying proximity to the source. Otherwise, foreigners benefit by only a tenth as much as the innovating country.

Other studies have looked at a more disaggregated measure of imports. Wang and Xu (1997) investigate R&D spillovers through capital goods and FDI in industrialized countries. Connolly (1998) consider imports within certain specific Standard International Trade Classification (SITC) classes so as to separate out the effects of imports of goods that embody technology, from general openness effects. She finds that high technology imports from developed countries not only positively affect domestic in-

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<sup>5</sup>Connolly (1998) suggests that this may be, at least in part, the result of the fact that in these papers only developed and relatively highly interactive countries are being considered. These results may be interpreted as suggesting that we should not focus narrowly on bilateral trade shares if the group of countries has a great deal of interaction amongst themselves.

novation, but also lead to increased GDP growth as higher quality capital goods are used in domestic production. Even though her paper provides empirical analysis inclusive of some developing countries, there remains an under representation of less developed nations relative to developed nations. Keller (1999) examines the evidence on technology diffusion through trade in differentiated intermediate goods in eight OECD countries. He finds that, conditional on technology diffusion from domestic R&D, the import composition of a country matters, but only if it is strongly biased towards or away from technological leaders.

### 3 Methodology

The empirical specifications of the innovation and growth regressions relate to the theoretical models developed by Grossman and Helpman (1991), Barro and Sala-i-Martin (1997) and Connolly (1997).

#### 3.1 Innovation Regression

Innovation in a given country is positively related to real import levels of capital goods from developed countries and to the stock of human capital. In addition, factors affecting the profitability of innovation, such as the size of the market and the enforcement of intellectual property rights (IPRs), also contribute positively to innovative activities<sup>6</sup>. Also, as suggested in Grossman and Helpman (1995), foreign direct investment (FDI) can potentially help disseminate technology to the host country. Finally, the flow of technology through FDI to a developing country is often constrained not so much by restrictive government policies in the host country as by its lack of infrastructure (Bardhan, 1995). Hence, a country’s ability to absorb foreign technology embodied in imports also depends on infrastructure. Therefore, the innovation regression is:

$$\begin{aligned}
 (1) \quad I_{it} &= \beta_0 + \beta_1 HK_{it} + \beta_2 H_{it} + \beta_3 NH_{it} + \beta_4 GDP_{it} \\
 &\quad + \beta_5 IPR_{it} + \beta_6 FDI_{it} + \beta_7 INF_{it} + \mu_{it}, \\
 \mu_{it} &= \alpha_i + \varepsilon_{it},
 \end{aligned}$$

where  $I_i$  is the innovation rate in country  $i$ ,  $HK_i$  is the level of human capital stock,  $H_i$  is the real import level of high technology goods from developed countries, and  $NH_i$  is the real import level of all goods other than high technology goods from developed nations. Non-high technology goods are included to determine whether imports in

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<sup>6</sup>See Grossman and Helpman (1991), Helpman (1993) and Keely and Quah (1998).

general, versus technology embodied in imports, matter to innovation<sup>7</sup>.  $GDP_i$  is the real gross domestic product (not scaled by population),  $IPR_i$  is the Ginarte and Park (1997) patent protection index for country  $i$ , and  $FDI_i$  measures inflows of foreign direct investment into country  $i$ . And  $INF_i$  is a measure of the country's infrastructure. All variables are measured in natural logs, except for FDI inflows which sometimes assume negative values.  $\alpha_i$  represents a latent individual effect which is assumed to be time-invariant and identically distributed across individual countries with variance  $\sigma_\alpha^2$ . The  $\varepsilon_{it}$  are assumed to be identically, independently distributed with zero mean and constant variance  $\sigma_\varepsilon^2$ , conditional on explanatory variables.

### 3.2 GDP Growth Regression

Growth in output per worker is a positive function of growth in both the aggregate quality level and the stock of intermediate goods. If a country allows free trade in intermediate goods then the quality level of the intermediate goods is determined by the technology of lead innovators, whether domestic or foreign. If the country imposes restrictions to trade, then the quality level is determined by domestic research. Therefore, the GDP growth regressions consider domestic innovation, as well as foreign innovation. Growth of per capita high technology imports from developed countries is used as a proxy for the effect of foreign technology on domestic growth. I also include FDI and IPRs in the growth regression in order to examine if those variables have a direct effect on growth<sup>8</sup>.

I use average annual data for four separate subperiods, 1970-74, 1975-79, 1980-84, and 1984-1989. For each subperiod, I consider the growth of real per capita GDP ( $\gamma_{Y_i}$ , in ln differences) as a function of the growth in the per capita physical capital stock ( $\gamma_{K_i}$ ), the innovation rate ( $I_i$ ), the growth of real per capita import levels of high technology goods ( $\gamma_{H_i}$ ), the level of intellectual property protection ( $IPR_i$ ) and foreign direct investment inflows ( $FDI_i$ ). In addition, the average 1965-69 real per capita GDP level,  $Y_{i,t=0}$ , is included as an independent variable, to test for convergence:

$$(2) \quad \gamma_{Y_{it}} = \beta_0 + \beta_1 Y_{i,t=0} + \beta_2 \gamma_{K_{it}} + \beta_3 I_{it} + \beta_4 \gamma_{H_{it}} + \beta_5 IPR_{it} + \beta_6 FDI_{it} + \mu_{it},$$

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<sup>7</sup>If this variable is positive and statistically significant, while the high technology imports variable is not, this would imply that it is simply an openness effect, rather than the technology embodied in high-technology imports in particular, which matters to innovation.

<sup>8</sup>A number of interesting studies examine the relationship between property rights in general and economic growth (Torstensson 1994, Svensson 1994, Sachs-Warner 1995, Gould and Gruben 1996, Park and Ginarte 1997).

$$\mu_{it} = \alpha_i + \varepsilon_{it}.$$

## 4 Data

Among the empirical studies that investigate the link between trade in physical goods and technological diffusion, very few have used data sets that take account of developing countries. In this paper, I have created a sample that consists of 20 developed and 28 developing countries. I have included all countries for which data was available. The list of countries used in the regressions is provided in Appendix 1.

Also, this paper focus on high-technology imports as a channel for technological diffusion. High technology imports are defined as the sum of classes 7, 86 and 89 of the Standard International Trade Classification (SITC, Rev.1)<sup>9 10</sup>. Previous studies have suggested that the import composition of a country matters. Coe and Helpman (1995) and Coe, Helpman and Hoffmaister (1997) suggest that a country should exhibit higher productivity levels if it imports to a large degree from countries that have accumulated high levels of technological knowledge. Keller (1999) argues that, conditional on technology diffusion from domestic R&D, the import composition of a country matters, but only if it is strongly biased towards or away from technological leaders. In order to investigate this idea, I consider high-technology imports from developed countries as well as high-technology imports from the world.

The proxy for innovation is defined as the number of US patents granted to residents of a given country each year as reported by the US Patent and Trademark Office. As pointed in Connolly (1998), this definition assumes that if an innovation is truly novel, its inventor will apply for and be granted a US patent. There are many reasons for which an innovation might not be patented in the United States, implying that this proxy will generally underestimate innovative activity. For example, if the inventor has no plans to sell in the US and is not worried about having US firms copy their good, then they will not bother applying for a US patent. Furthermore, while the US has very high levels of patent enforcement, there are industries in which it is easy to invent around a patent. Thus, within these industries, firms will generally avoid applying for patents since this might divulge information which increases the chances that they will lose their market to another competitor.

For brevity, the remainder of the data series is described in Appendix 2.

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<sup>9</sup>Class 7 includes machinery and transport equipment. Class 86 includes instruments (optical, medical and photographic), watches and clocks. And Class 89 includes “miscellaneous manufactured goods”.

<sup>10</sup>This definition is similar to the one used in Connolly (1998), but she considers only high technology imports from developed countries.

## 5 Empirical Results

The empirical analysis uses a panel data set consisting of four separate five-year periods, 1970-74, 1975-79, 1980-84, 1985-89 for a cross-section of developed and developing countries. All variables are used in natural logs, except for FDI<sup>11</sup>, and expressed in real terms. As it is standard in the literature, I also implement a cross-sectional estimation using the time average over all four periods (i.e., the time average from 1970 to 1989). Because of endogeneity problems, instrumental variables estimation (IVE) is attempted. The choice of instruments was primarily based on suggestions from the previous literature. The set of instrumental variables used for each explanatory variable is described in appendix 2. However, it should be noted that when the innovation proxy is used as an explanatory variable in the growth regressions, the average innovation from 1965 to 1969 and the level of intellectual property rights in 1965 are used as instruments.

The use of time averages for each country from 1970 to 1989 for the cross-sectional yields consistent and unbiased (although inefficient) estimates as long as there is no correlation between the latent individual effect and the explanatory variable. Random effects estimation is more efficient than between groups estimation and is in fact BLUE provided that there is no correlation between the latent individual effects and the explanatory variables. However, if there is correlation between the latent individual effect and the explanatory variables, then fixed effects estimation, which considers deviation from time averages, is the most appropriate estimation technique. This is because its estimates will be consistent and unbiased regardless of such correlation.

To implement the random effects 2SLS estimation I use the following transformation of equation (1)

$$\begin{aligned}
 (1RE) \ I_{it} - \theta \bar{I}_i &= (1 - \theta)\beta_0 + \beta_1(HK_{it} - \theta \bar{HK}_i) + \beta_2(H_{it} - \theta \bar{H}_i) \\
 &+ \beta_3(NH_{it} - \theta \bar{NH}_i) + \beta_4(GDP_{it} - \theta \bar{GDP}_i) \\
 &+ \beta_5(IPR_{it} - \theta \bar{IPR}_i) + \beta_6(FDI_{it} - \theta \bar{FDI}_i) \\
 &\beta_7(INF_{it} - \theta \bar{INF}_i) + [(1 - \theta)\alpha_i + (\varepsilon_{it} - \theta \bar{\varepsilon}_i)]
 \end{aligned}$$

where the variables with bars represent time averages from 1970 to 1989. The weight  $\theta$  used in the above transformation depends on  $\sigma_\alpha$  and  $\sigma_\varepsilon$ <sup>12</sup>. Note that if  $\theta$  equals 1, then random effects estimation is equivalent to fixed effects estimation. On the other hand, if  $\theta$  equals zero, then random effects estimation is equivalent to OLS estimation.

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<sup>11</sup>For the growth regressions that include developing countries only, I also use  $\ln(FDI_{it} + \min FDI + 1)$ . This transformation gets rid of the negative values for this variable and changes the functional form of the equation.

<sup>12</sup>Specifically,  $\theta = 1 - \frac{\sigma_\varepsilon}{(T\sigma_\alpha^2 + \sigma_\varepsilon^2)^{1/2}}$ , where  $T$  is the number of time periods.

For the growth equation, 2SLS random effects estimation uses a similar transformation of equation (2)

$$\begin{aligned}
 (2RE) \quad \gamma_{Y_{it}} - \theta \gamma_{Y_{it}}^- &= (1 - \theta)\beta_0 + (1 - \theta)\beta_1 Y_{i,t-1} + \beta_2(\gamma_{K_{it}} - \theta \gamma_{K_{it}}^-) + \beta_3(I_{it} - \theta \bar{I}_i) \\
 &+ \beta_4(\gamma_{H_{it}} - \theta \gamma_{H_{it}}^-) + \beta_5(IPR_{it} - \theta I\bar{P}R_{it}) \\
 &\beta_5(FDI_{it} - \theta F\bar{D}I_{it}) + [(1 - \theta)\alpha_i + (\varepsilon_{it} - \theta \varepsilon_i^-)]
 \end{aligned}$$

In these regressions  $\hat{\theta} = 0$ , implying that RE yields identical results to pooled 2SLS estimation. Therefore, I do not present separate results for the pooled 2SLS regressions. Also, the panel regressions were estimated using both fixed and random effects models. However, the FE regressions did not yield sensible results and were rejected over the RE model. Therefore, I do not report the results for FE estimation.

## 5.1 Innovation Regression

The innovation regression includes 45 countries (18 developed and 27 developing countries). Table 1 reports the results for the innovation regression using all countries in the sample. The results show that the size of the market (*GDP*) is positively linked to innovation and statistically significant in most regressions. Human Capital Stock (*HK*) has a positive and statistically significant effect on domestic innovation in regressions (1), (2) and (3). High technology imports from developed countries (*H<sub>DC</sub>*) only appear positive and statistically significant in the 2SLS cross-section regressions (columns 5 and 6). And non high technology imports (*NH*) do not appear significant in any regression. These results are somewhat consistent with the findings in Eaton and Kortum (1996), which show that imports are significant in explaining technological diffusion, however, human capital tends to play a much larger role in technological diffusion. However, the results are not consistent with Connolly's (1998) finding that high technology imports from developed countries positively affect domestic innovation. But it should be noted that, even though her sample includes some developing countries, there remains an under representation of developing countries to developed countries<sup>13</sup>. It might be possible that technological diffusion through high-technology imports plays a more relevant role in developed countries. And in fact, a dummy variable for developed countries is statistically significant (Table 2, columns 1 and 2).

I then split the sample between developed and developing countries. Table 3 reports the results for the sample that includes only developed countries. Tables 4 reports the results for the sample including developing countries only. When the regressions are run for developed countries only, *H<sub>DC</sub>* appears positive and statistically

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<sup>13</sup>Connolly (1998) estimates a similar innovation regression with a sample that includes 12 developed countries and 3 developing countries.

significant in regression (3). For the sample of developing countries, however, this variable remains statistically not significant in explaining domestic innovation.

The results regarding intellectual property rights are not robust to the sample of countries being used in the regressions. *IPRs* enter negatively and are statistically significant in most regressions for the full sample of countries. The exceptions are some cross-section regressions (columns 5 and 6 in table 1). This negative relationship between domestic innovation and *IPRs* does not appear in the regressions that include DCs only. In fact, table 3 shows positive and statistically significant coefficients for *IPRs*. However, for developing countries, the coefficient for *IPRs* is always negative and it is statistically significant in most regressions (table 4).

Despite the positive effects that intellectual property rights might have on domestic innovation, tighter IPRs may lead to a higher cost of acquiring knowledge. They shift bargaining power toward producers of knowledge and away from its users. Since knowledge is a key input in the production of more knowledge, stronger IPRs may adversely affect follow-on innovations that draw on inventions whose patents have not yet expired. Therefore, tighter IPRs may actually slow the overall pace of innovation<sup>14</sup>. Even though this adverse effect of IPRs on innovation may occur in both developing and developed countries, it might be stronger in the former<sup>15</sup>.

There are a couple of explanations for the results obtained here. First, the IPR index values tend to be low in developing countries, and thus, innovative activity, when it does occur, responds to different incentives. Second, much of the innovative activity that occurs in developing countries may be of adaptive or imitative nature<sup>16</sup>. IPRs are likely to matter more for research activities targeted towards producing new innovations. So the results obtained here could suggest that all or most research activity taking place in developing countries is imitative and stronger IPR protection would discourage this type of “innovation”. Also, the results in this paper are in accordance with the results in Park and Ginarte (1997), who look at the effects of IPRs on physical and research capital investment for a cross-section sample of developed and developing countries. They find that IPRs explain only the physical and research capital investment behavior of the top 30 economies. IPRs are significant at only 24% significance level for the lesser developed countries’ R&D.

FDI inflows do not appear to affect domestic innovation. This result is consistent with work by Connolly (1998), who also finds that foreign direct investment inflows do not contribute to domestic innovation, and work by Lichtenberg and van

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<sup>14</sup>Bardhan (1995) also mentions the cases of restrictive business practices of many multinational firms like pre-emptive patenting and “sleeping” patents (where new patents are taken out in developing countries simply to ward off competitors but rarely are actually used in local production).

<sup>15</sup>See Helpman (1993) and World Bank (1998), for example.

<sup>16</sup>Imitation plays an especially important role in some trade between developed and developing countries as suggested by North-South endogenous growth models [Grossman and Helpman (1991), Segerstrom et al. (1990), Helpman (1993), Barro and Sala-i-Martin (1997)].

Pottelsberghe de la Potterie (1996), who find no relationship between FDI inflows and international R&D spillovers. Also Haddad and Harrison (1993) find no relationship between productivity growth of domestic firms and the presence of foreign firms. Columns 3 and 4 in table 2 show that dummy variables for low and lower-middle income countries (Ldummy and LMdummy) are negative and statistically significant. Also, dummy variables for upper-middle and high income countries (UMdummy and Hdummy) are positive and statistically significant<sup>17</sup>.

The inclusion of the variable ENERGY, in order to account for differences in infrastructure across countries, does not affect the results. Energy appears positive but it is not statistically significant in any regression.

In order to further investigate the role of trade in the diffusion of technology, I proceed to run the same set of regressions using high technology imports from the world ( $H_W$ ) instead of high technology imports from developed countries ( $H_{DC}$ ). The results are reported in tables 5 through 7 and are very similar to the results using high technology imports from developing countries ( $H_{DC}$ ).

## 5.2 Growth Regression

The growth regression includes 47 countries (19 developed and 28 developing countries). The results in tables 8 through 10 show that the growth in per capita physical capital stock (GKstock) has by far the greatest effect on real per capita GDP growth. This variable has coefficients above 0.5 and is statistically significant in all regressions.

FDI inflows do not have a significant effect on real per capita GDP growth. And growth of per capita high technology imports from developed countries ( $GH_{DC}$ ), which can be interpreted as a proxy for foreign innovation, also do not significantly affect per capita growth of real GDP. Even though the proxy for domestic innovation (INNOV) has a positive coefficient in all regressions, it is not statistically significant. And initial per capita GDP growth (RGDP69) enters negatively in the regressions that include a dummy variable for developed countries (table 8). In these cases, the results are consistent with the hypothesis of conditional convergence<sup>18</sup>.

The inclusion of growth of per capita human capital stock (GHK) does not seem to affect the results. GHK is not statistically significant. However, the results regarding the innovation regression suggest that the stock of human capital might have an indirect effect on growth through its effect on domestic innovation.

Intellectual Property Rights (IPRs) do not have a significant effect on per capita GDP growth. This result is consistent with the Park and Ginarte (1997) finding that IPRs have no statistically significant influence on growth, but can affect growth

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<sup>17</sup>The countries in the sample are classified according to the income groups defined by the World Bank. For more details, see Appendix 1.

<sup>18</sup>See Barro (1996).

indirectly through their effect on some reproducible factors that do contribute to growth, like R&D<sup>19</sup>.

The inclusion of dummy variables for developed countries and also for different income groups suggest that the results might be affected by the composition of the sample in question. So again I split the sample between developed and developing countries. Table 11 reports the results for the sample that includes only developed countries. Table 12 reports the results for the sample including developing countries only.

In fact, if the growth regression is run on developed countries and developing countries separately, the per capita growth of high technology imports from developed countries is statistically significant in explaining real per capita GDP growth in developed countries but not in developing countries (compare tables 11 and 12). This finding is consistent with the Eaton and Kortum (1996) finding that with the exception of the United States, the OECD countries derive almost all of their productivity from abroad. This result is also consistent to the findings in Connolly (1998).

Lastly, FDI inflows are positive and statistically significant in some of the regressions regarding developed countries (columns 1,2 and 3 in table 11). For the growth regressions that include developing countries only, I also use  $\ln(FDI_{it} + \min FDI + 1)$ . However, this transformation does not significantly affect the results<sup>20</sup>. These results are somewhat consistent with the work of Borenzstein, De Gregorio and Lee (1995). They investigate the effects of FDI inflows on growth in a sample of 69 developing countries over the 1970-89 period and find that FDI stimulates economic growth but only for host economies that have reached a minimum threshold stock of human capital.

## 6 Conclusion

This paper examines the hypothesis that trade increases innovation and economic growth by facilitating access to foreign technology, and investigates the importance of IPRs and FDI inflows in these processes. It complements the previous literature by focusing on high-technology trade and by considering a more representative sample of both developed and developing countries.

The results do provide evidence that technology diffusion across developed countries is different than diffusion between developed and developing countries. This has important implications for how trade policy is designed and implemented in these distinct groups of countries.

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<sup>19</sup>Gould and Gruben (1996) report a positive and significant effect of IPR protection on GDP growth. However, their measure of IPRs is based on that of Rapp and Rozek (1990) and exhibits less variability.

<sup>20</sup>In most regressions, FDI inflows are positive and statistically significant only at the 20% level.

With respect to the effect of high technology trade on innovation and growth, the results suggest that high technology imports from developed countries may have a positive effect on domestic innovation in developed countries but not in developing countries.

The stock of human capital and the domestic market size have a positive effect on innovation. One implication is that investment in education should be encouraged since it appears to be an important condition for developing a domestic research base. And growth of per capita real GDP is mostly explained by growth in the per capita physical capital stock.

With respect to FDI inflows, the results in this paper do not offer support for the hypothesis that they are an important channel for technological diffusion. However, FDI inflows may have a direct effect on growth, which appears to be stronger in developed countries.

Lastly, this paper also examines the effects of IPRs on the rates of domestic innovation and economic growth. The results suggest that IPRs do not have a direct effect on per capita income growth. However, they do affect positively domestic innovation in developed countries. With respect to developing countries, IPRs have a negative effect on the rate of domestic innovation. One possible explanation for this negative relationship is that most innovation in developing countries may actually be imitation or adaptive in nature. Therefore, providing stronger IPRs protects foreign firms at the expense of local firms.

The policy implication here is not to discourage the development of an intellectual property protection infrastructure in developing countries but to generate incentives for its creation and maintenance. Developing a significant research base in those countries would certainly contribute to this goal. Therefore, developed countries should find it in their best interest to support the development of a research base in developing countries in exchange for their support of an IPR infrastructure. Once such a base is established, innovative activities and IPR protection could grow in a complementary way.

## 7 Tables

The following tables report t-statistics in parentheses. And the statistics for the 2SLS RE regressions are corrected for heteroscedasticity using White's method.

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	45.524 (3.006)*	44.427 (2.892)*	47.018 (3.422)*	44.519 (3.434)*	.766 (2.042)**	.846 (2.316)**
NHDC	.189 (1.339)	.180 (1.274)	.222 (.878)	.184 (.638)	.001 (.790)	.001 (.696)
HDC	-.0208 (-.136)	-.0093 (-.060)	-.0063 (-.023)	.036 (.116)	.716 (1.838)***	.663 (1.723)***
HK	.449 (2.528)**	.427 (2.274)**	.4240 (1.990)**	.367 (1.539)	-.002 (-1.175)	-.002 (-1.276)
IPR	-123.65 (-2.161)**	-122.07 (-2.133)**	-123.09 (-3.210)*	-119.15 (-3.166)*	1.130 (1.978)***	1.091 (1.917)***
FDI	-.646E-09 (-.119)	-.574E-09 (-.106)	-.152E-08 (-.879)	-.132E-08 (-.784)	.753E-10 (.866)	.711E-10 (.821)
ENERGY		.0517 (.374)		.1297 (.484)	.001 (.947)	
Constant	-1076.66 (-3.025)*	-1050.62 (-2.909)*	-1109.54 (-3.376)*	-1050.75 (-3.401)*	-32.819 (-8.466)*	-33.590 (-8.875)*
Observations	180	180	180	180	45	45
Adj.R <sup>2</sup>	.2540	.2571	.2304	.2307	.8008	.8013
F-statistic			9.93	8.67	26.28	30.59

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 2- Innovation Regression - All countries  
Dependent Variable: Innovation

	(1) Pooled	(2) Pooled	(3) Pooled	(4) Pooled
RGDP	23.5993 (1.520)	21.5961 (1.379)	5.701 (.382)	5.701 (.382)
NH <sub>DC</sub>	.1909 (1.277)	.1569 (1.022)	.0726 (.522)	.0726 (.522)
H <sub>DC</sub>	-.0022 (-.014)	.0373 (.222)	.0515 (.342)	.0515 (.342)
HK	.5062 (3.454)*	.4528 (2.892)*	.3595 (2.588)*	.3595 (2.588)*
IPR	-196.50 (-3.454)*	-191.97 (-2.892)*	-137.96 (-2.569)**	-137.96 (-2.569)**
FDI	-.1048E-09 (-.020)	.6257E-10 (.012)	.6712E-09 (.138)	.6712E-09 (.138)
ENERGY		.1191 (.971)		
DCdummy	167.317 (2.605)*	165.22 (2.570)*		
Ldummy			-406.31 (-5.602)*	
LMdummy			-118.50 (-1.671)***	287.80 (4.873)*
UMdummy			-38.029 (-.551)	368.28 (5.075)*
Hdummy				406.31 (5.602)*
Constant	-550.9615 (-1.502)	-503.92 (-1.361)	12.034 (.031)	-394.28 (-1.125)
Observations	180	180	180	180
Adj.R <sup>2</sup>	.2552	.2550	.3695	.3695
F-statistic	9.77	8.66	12.66	12.66

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 3 - Innovation Regression - Developed Countries  
Dependent Variable: Innovation

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	1.4571 (5.840)*	1.4905 (5.689)*	.728 (3.452)*	.683 (3.225)*	.368 (.656)	.308 (.525)
NH <sub>DC</sub>	-.1057 (-.523)	-.1087 (-.529)	.189 (.598)	.216 (.698)	.315 (.387)	.390 (.460)
H <sub>DC</sub>	.0607 (.347)	.0654 (.366)	.376 (1.998)**	.296 (1.265)	.337 (.674)	.143 (.235)
HK	-.2832 (-1.187)	-.2951 (-1.205)	.449 (1.983)***	.412 (1.846)***	.941 (1.853)***	.837 (1.518)
IPR	.6559 (1.247)	.7169 (1.279)	2.911 (3.849)*	2.938 (3.940)*	4.162 (2.367)**	4.122 (2.273)**
FDI	-.1394E-10 (-1.419)	-.1422E-10 (-1.429)	-.609E-11 (-.531)	-.803E-11 (-.767)	.363E-10 (.579)	.200E-10 (.286)
ENERGY		-.0335 (-.500)		.074 (.691)		.176 (.601)
Constant	-31.42 (-6.956)*	-32.065 (-6.616)*	-29.845 (-8.966)*	-28.235 (-6.837)*	-24.429 (-2.859)**	-21.775 (-2.211)**
Observations	72	72	72	72	18	18
Adj.R <sup>2</sup>	.7898	.7866	.8497	.848	.863	.8546
F-statistic			67.9	57.82	18.86	15.27

(\*), (\*\*) and (\*\*\*) indicate statistical significance  
at the 1%, 5% and 10% levels, respectively

Table 4 - Innovation Regression - Developing Countries  
Dependent Variable: Innovation

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	5.9594 (.158)	4.9318 (.130)	14.125 (.454)	10.786 (.347)	.449 (.986)	.525 (1.122)
NH <sub>DC</sub>	.1518 (.820)	.1474 (.792)	.171 (.682)	.1373 (.478)	-.0001 (-.102)	-.0002 (-.187)
H <sub>DC</sub>	-.0014 (-.007)	.0043 (.021)	.015 (.057)	.055 (.179)	.185 (.361)	.041 (.088)
HK	.5701 (2.217)**	.5597 (2.077)**	.527 (2.243)**	.478 (1.876)***	.0004 (.307)	.0004 (.306)
IPR	-220.13 (-2.288)**	-219.46 (-2.270)**	-209.97 (-2.952)*	-206.39 (-2.932)*	-.831 (-1.333)	-.828 (-1.307)
FDI	.5985E-07 (.710)	.6033E-07 (.715)	.547E-07 (1.174)	.568E-07 (1.206)	.830E-09 (1.356)	.843E-09 (1.356)
ENERGY		.0276 (.150)		.118 (.451)		.986E-03 (.684)
Constant	-147.58 (-.168)	-123.35 (-.139)	-338.14 (-.462)	-259.98 (-.357)	-13.934 (-2.269)**	-12.674 (-2.103)**
Observations	108	108	108	108	27	27
Adj.R <sup>2</sup>	.2316	.2333	.1880	.1843	.4501	.4316
F-statistic			5.13	4.46	4.55	3.82

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 5 - Innovation Regression- All countries  
Dependent Variable: Innovation

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	47.323 (3.124)*	45.327 (2.952)*	48.564 (3.558)*	45.268 (3.448)*	.596 (1.619)	.656 (1.814)**
NHW	-.048 (-.384)	-.075 (-.580)	.0069 (.027)	-.058 (-.183)	.0015 (.951)	.0014 (.876)
HW	.205 (1.525)	.237 (1.683)***	.203 (.730)	.273 (.803)	.982 (2.382)**	.948 (2.312)**
HK	.455 (2.522)**	.416 (2.219)**	.414 (2.007)**	.351 (.221)	-.0013 (-.821)	-.0015 (-.928)
IPR	-123.52 (-2.159)**	-120.43 (-2.104)**	-122.75 (-3.226)*	-117.34 (-3.106)*	1.091 (1.962)***	1.052 (1.901)***
FDI	-.65E-09 (-.120)	-.528E-09 (-.098)	-.154E-08 (-.895)	-.127 (-.752)	.564E-10 (.663)	.529E-10 (.624)
ENERGY		.102 (.720)		.180 (.677)	.0014 (.924)	
Constant	-1125.11 (-3.160)*	-1077.99 (-2.987)*	-1151.34 (-3.523)*	-1074.25 (-3.437)*	-34.584 (-8.925)*	-35.273 (-9.294)*
Observations	180	180	180	180	45	45
Adj.R <sup>2</sup>	.2441	.2514	.2208	.2252	.8115	.8122
F-statistic			9.46	8.43	28.07	32.73

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 6 - Innovation Regression - Developed Countries  
Dependent Variable: Innovation

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	1.352 (5.896)*	1.377 (5.750)*	.666 (3.633)*	.636 (3.552)*	.368 (.616)	.232 (.357)
NHW	-.016 (-.143)	-.011 (-.097)	.212 (1.072)	.223 (1.176)	.313 (.379)	.504 (.561)
H <sub>W</sub>	.140 (.743)	.150 (.775)	.474 (2.867)*	.410 (1.921)***	.348 (.717)	.077 (.119)
HK	-.357 (-1.502)	-.376 (-1.539)	.409 (1.836)***	.386 (1.737)***	.925 (1.786)***	.838 (1.528)
IPR	.621 (1.176)	.687 (1.220)	2.854 (4.204)*	2.904 (4.296)*	4.106 (2.398)**	4.038 (2.291)**
FDI	-.168E-10 (-1.645)	-.172E-10 (-1.667)***	-.106E-10 (-1.026)	-.117E-10 (-1.171)	.354E-10 (.539)	.222E-10 (.315)
ENERGY		-.035 (-.520)		.058 (.559)		.212 (.650)
Constant	-32.629 (-7.312)*	-33.362 (-6.916)*	-31.051 (-9.299)*	-29.647 (-6.962)*	-24.591 (-2.848)**	-21.233 (-2.069)***
Observations	72	72	72	72	18	18
Adj.R <sup>2</sup>	.7935	.7904	.8522	.8727	.8631	.8555
F-statistic			69.28	58.79	18.87	15.38

(\*), (\*\*) and (\*\*\*) indicate statistical significance  
at the 1%, 5% and 10% levels, respectively

Table 7 - Innovation Regression - Developing Countries  
Dependent Variable: Innovation

	(1) RE	(2) RE	(3) 2SLS RE	(4) 2SLS RE	(5) 2SLS Cross	(6) 2SLS Cross
RGDP	4.032 (.107)	1.487 (.039)	12.732 (.414)	7.786 (.251)	.620 (1.404)	.360 (.761)
NHW	-.086 (-.528)	-.108 (-.635)	-.042 (-.166)	-.105 (-.336)	-.497E-03 (-.325)	.303E-04 (.019)
H <sub>W</sub>	.223 (1.271)	.249 (1.348)	.221 (.805)	.289 (.862)	-.041 (-.093)	.265 (.500)
HK	.595 (2.280)**	.567 (2.098)**	.538 (2.469)**	.483 (2.099)**	.373E-03 (.234)	676E-03 (.408)
IPR	-224.22 (-2.331)**	-221.81 (-2.295)**	-213.33 (-3.013)*	-208.53 (-2.974)*	-.875 (-1.407)	-.780 (-1.232)
FDI	.709E-07 (.842)	.725E-07 (.860)	.636E-07 (1.372)	.672E-07 (1.422)	.839E-09 (1.368)	.833E-09 (1.348)
ENERGY		.083 (.438)		.173 (.669)		.108E-02 (.772)
Constant	-111.56 (-1.127)	-51.898 (-.058)	-313.19 (-.433)	-197.94 (-.272)	-13.148 (-2.226)**	-13.532 (-2.173)**
Observations	108	108	108	108	27	27
Adj.R <sup>2</sup>	.2256	.2320	.1823	.1832	.4467	.4388
F-statistic			4.98	4.43	4.50	3.90

(\*), (\*\*) and (\*\*\*) indicate statistical significance at  
the 1%, 5% and 10% levels, respectively

Table 8 - Growth Regression - All Countries  
Dependent Variable: Growth of Real Per Capita GDP

	(1) Pooled	(2) Pooled	(3) Pooled	(4) Cross	(5) Cross	(6) Cross
INNOV	.575E-05 (1.157)	.562E-05 (1.111)	.610E-05 (1.152)	.430E-03 (.514)	.395E-03 (.450)	.330E-03 (.359)
FDI	.218E-12 (.662)	.211E-12 (.633)	.204E-12 (.611)	.857E-13 (.173)	.759E-13 (.150)	.987E-13 (.191)
GH <sub>DC</sub>	-.304E-05 (-.711)	-.305E-05 (-.710)	-.279E-05 (-.637)	-.038 (-1.230)	-.037 (-1.125)	-.037 (-1.105)
GKStock	.552 (10.879)*	.554 (10.634)*	.556 (10.548)*	.557 (7.384)*	.557 (7.289)*	.553 (7.029)*
GHK		-.007 (-.146)	-.006 (-.130)		-.009 (-.153)	-.010 (-.166)
RGDP69	-.0032 (-1.664)***	-.0032 (-1.646)***	-.0034 (-1.665)***	-.004 (-2.058)**	-.004 (-1.940)***	-.004 (-1.768)***
IPRs			.0012 (.318)			-.001 (-.278)
DCdummy	.013 (2.333)**	.013 (2.311)**	.012 (2.215)**	.016 (2.512)**	.016 (2.453)**	.017 (2.425)**
Constant	.020 (1.558)	.020 (1.559)	.021 (1.578)	.0284 (1.963)***	.0283 (1.921)***	.0279 (1.868)***
Observations	188	188	188	47	47	47
Adj. R <sup>2</sup>	.4297	.4266	.4237	.6451	.6362	.6274
F statistic	24.49	20.88	18.19	14.94	12.49	10.68

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 9 - Growth Regression - All Countries  
 Dependent Variable: Growth of Real Per Capita GDP

	(1) Pooled	(2)Pooled	(3) Cross	(4) Cross
INNOV	.589E-05 (1.037)	.589E-05 (1.037)	.519E-04 (.059)	.519E-04 (.059)
FDI	.184E-12 (.554)	.184E-12 (.554)	.168E-12 (.341)	.168E-12 (.341)
GH <sub>DC</sub>	-.277E-05 (-.636)	-.277E-05 (-.636)	-.047 (-1.412)	-.047 (-1.412)
GKStock	.546 (10.110)*	.546 (10.110)*	.546 (6.694)*	.546 (6.694)*
GHK	-.005 (-.098)	-.005 (-.098)	-.009 (-.154)	-.009 (-.154)
RGDP69	-.003 (-1.460)	-.003 (-1.460)	-.0045 (-1.688)***	-.0045 (-1.688)***
IPRs	-.434E-03 (-.101)	-.434E-03 (-.101)	-.0037 (-.886)	-.0037 (-.886)
Ldummy	-.014 (-1.515)		-.020 (-2.182)**	
LMdummy	-.017 (-2.618)**	-.003 (-.625)	-.024 (-3.262)*	-.004 (-.867)
UMdummy	-.008 (-1.321)	.005 (.880)	-.013 (-1.992)***	.006 (1.076)
Hdummy		.014 (1.515)		.020 (2.182)**
Constant	.040 (1.763)***	.025 (1.740)***	.053 (2.353)**	.032 (2.127)**
Observations	188	188	47	47
Adj. R <sup>2</sup>	.4294	.4294	.6634	.6634
F statistic	15.08	15.08	10.07	10.07

(\*), (\*\*) and (\*\*\*) indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 10 - Growth Regression - All Countries  
Dependent Variable: Growth of Real Per Capita GDP

	(1) 2SLS RE	(2) 2SLS RE	(3) 2SLS RE	(4) 2SLS Cross	(5) 2SLS Cross	(6) 2SLS Cross
INNOV	.539E-05 (1.071)	.503E-05 (.981)	.619E-05 (1.155)	.0010 (1.217)	.860E-03 (1.065)	.889E-03 (1.072)
FDI	.264E-12 (.795)	-.345E-13 (-.216)	-.363E-13 (-.227)	-.146E-12 (-.283)	.100E-11 (1.079)	.100E-11 (1.065)
GH <sub>DC</sub>	-.242E-05 (-.559)	-.234E-05 (-.537)	-.176E-05 (-.399)	-.208 (-.007)	-.008 (-.281)	-.009 (-.306)
GKSTOCK	.575 (11.421)*	.577 (11.187)*	.582 (11.192)*	.547 (6.839)*	.511 (7.083)*	.555 (6.874)*
GHK		-.021 (-.413)	-.018 (-.355)		-.025 (-.405)	-.024 (-.380)
RGDP69	.662E-03 (.650)	.873E-03 (.886)	.205E-03 (.155)	-.901E-03 (-.515)	-.735E-03 (-.418)	-.934 (-.461)
IPRs			.003 (.757)			.807E-03 (.206)
Constant	-.004 (-.512)	-.004 (-.582)	-.002 (-.263)	.006 (.516)	.006 (.541)	.007 (.569)
Observations	188	188	188	47	47	47
Adj. R <sup>2</sup>	.4158	.4112	.4098	.5991	.6011	.5914
F statistic	27.62	22.77	19.56	14.75	12.56	10.51

(\*), (\*\*) and (\*\*\*) indicate statistical significance at  
the 1%, 5% and 10% levels, respectively

Table 11- Growth Regression - Developed Countries  
 Dependent Variable: Growth of Real Per Capita GDP

	(1) 2SLS RE	(2) 2SLS RE	(3) 2SLS RE	(4) 2SLS Cross	(5) 2SLS Cross	(6) 2SLS Cross
INNOV	-.900E-03 (-1.259)	-.185E-03 (-.243)	-.222E-03 (-.261)	-.228E-03 (-.209)	-.286E-03 (-.316)	.611E-03 (.554)
FDI	.212E-12 (2.013)**	.100E-11 (3.054)*	.982E-12 (2.719)*	-.527E-13 (-.139)	.507E-13 (.027)	.736E-12 (.388)
GH <sub>DC</sub>	.050 (4.586)*	.050 (4.773)*	.050 (4.799)*	.0028 (.066)	.0019 (.039)	-.011 (-.226)
GKStock	.486 (5.916)*	.458 (6.052)*	.459 (5.876)*	.393 (3.046)*	.404 (3.714)*	.402 (3.814)*
GHK		.049 (.605)	.049 (.584)		.010 (.149)	.042 (.575)
RGDP69	-.0014 (-.428)	-.002 (-.813)	-.002 (-.813)	-.0035 (-.968)	-.0033 (-.940)	-.0031 (-.912)
IPRs			.603E-03 (.075)			-.012 (-1.338)
Constant	.022 (.773)	.030 (1.063)	.030 (1.047)	.044 (1.395)	.042 (1.359)	.049 (1.623)
Observations	76	76	76	19	19	19
Adj. R <sup>2</sup>	.5820	.5804	.5743	.5989	.5658	.5926
F statistic	21.89	18.30	15.46	6.38	4.91	4.74

(\*), (\*\*) and (\*\*\*) indicate statistical significance at  
 the 1%, 5% and 10% levels, respectively

Table 12 - Growth Regression - Developing Countries  
 Dependent Variable: Growth of Real Per Capita GDP

	(1) 2SLS RE	(2) 2SLS RE	(3) 2SLS RE	(4) 2SLS Cross	(5) 2SLS Cross	(6) 2SLS Cross
INNOV	.521E-05 (.919)	.517E-05 (.931)	.577E-05 (.994)	-.172E-03 (-.116)	.858E-03 (.667)	.958E-03 (.651)
FDI	.302E-11 (.799)	-.487E-13 (-.534)	-.490E-13 (-.544)	.667E-11 (1.299)	.140E-11 (1.174)	.140E-11 (1.140)
GH <sub>DC</sub>	-.319E-05 (-.553)	-.303E-05 (-.521)	-.271E-05 (-.451)	-.056 (-1.286)	-.061 (-1.252)	-.061 (-1.220)
GKSTOCK	.542 (9.213)*	.563 (9.463)*	.567 (9.424)*	.539 (5.202)*	.575 (5.600)*	.578 (5.394)*
GHK		-.027 (-.478)	-.026 (-.456)		-.016 (-.205)	-.015 (-.185)
RGDP69	-.0034 (-1.464)	-.0028 (-1.240)	-.0030 (-1.274)	-.005 (-1.840)***	-.005 (-1.636)	-.005 (-1.587)
IPRs			.0016 .461			.835E-03 (.152)
Constant	.021 (1.407)	.018 (1.277)	.019 (1.291)	.034 (1.736)***	.033 (1.647)	.033 (1.612)
Observations	112	112	112	28	28	28
Adj. R <sup>2</sup>	.3926	.3847	.3794	.6090	.5867	.5666
F statistic	15.35	12.57	10.69	9.41	7.39	6.04

(\*), (\*\*) and (\*\*\*) indicate statistical significance at  
 the 1%, 5% and 10% levels, respectively

## Appendix 1 - List of Countries

### Innovation Regression

Developed Countries: Australia, Austria, Canada, Denmark, Finland, France, Greece, Ireland, Israel, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, United States.

Developing Countries: Algeria, Bolivia, Brazil, Cameroon, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Kenya, Malawi, Malaysia, Mexico, Pakistan, Paraguay, Peru, Philippines, Senegal, Thailand, Uruguay, Venezuela.

### Growth Regression

Developed Countries: Australia, Austria, Canada, Denmark, Finland, France, Greece, Ireland, Israel, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Developing Countries: Algeria, Bolivia, Brazil, Cameroon, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Ghana, Guatemala, Honduras, India, Indonesia, Jamaica, Kenya, Malawi, Malaysia, Mexico, Pakistan, Paraguay, Peru, Philippines, Senegal, Sri Lanka, Thailand, Uruguay, Venezuela.

Countries classified according to their income group (World Bank (1998))<sup>21</sup>:

High Income Countries (OECD and non-OECD): Australia, Austria, Canada, Denmark, Finland, France, Greece, Ireland, Israel, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Upper-Middle Income Countries: Brazil, Chile, Malaysia, Mexico, Uruguay.

Lower-Middle Income Countries: Algeria, Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Indonesia, Jamaica, Paraguay, Peru, Philippines, Thailand, Turkey, Venezuela.

Low-Middle Income Countries: Cameroon, Ghana, Guyana, Honduras, India, Kenya, Malawi, Nicaragua, Nigeria, Pakistan, Senegal, Sri Lanka.

## Appendix 2 - Data Description

### High Technology Imports ( $H_W$ )

This variable is created using data for total imports of capital goods from various issues of the Commodity Trade Statistics published by the United Nations. The commodity groups used in this measurement comprise Standard International Trade Classes 7, 86, and 89 (SITC, Rev.1). Class 7 includes machinery and transport equipment. Class 86 includes instruments (optical, medical and photographic), watches and clocks. And Class 89 includes “miscellaneous manufactured goods”. To express this

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<sup>21</sup>In some regressions, I use a dummy called middle-income countries (Mdummy), which is simply a combination of lower- and upper-middle countries.

variable in real terms the data is deflated by the US Producer Price Index (PPI), for machinery and transport equipment, which are consolidated under the category of capital equipment in more recent years (IFS data -line 63bb- September 99 CD).

Several instrumental variables are used to control for endogeneity of imports in the regressions: earlier import values, the exchange rate (World Development Indicators, 1998), terms of trade shocks (Levine-Loyaza-Beck Data Set, World Bank, 1999), a black market premium (Levine-Loyaza-Beck Data Set, World Bank, 1999), and a measure of free trade openness (defined as the sum of real exports and real imports divided by real GDP, all from the World Bank Development Indicators, 1998).

#### High Technology Imports from Developed Countries ( $H_{DC}$ )

This variable is defined as the real import level of high-technology goods from developed countries. It is created using data for imports of capital goods from developed nations from various issues of the Commodity Trade Statistics published by the United Nations. The commodity groups used in this measurement include Standard International Trade Classes 7, 86, and 89 (SITC, Rev.1). To express this variable in real terms the data is deflated by the US Producer Price Index (PPI) for capital equipment (IFS data -line 63bb- September 99 CD). Because of endogeneity, I use the same instruments described before.

#### Non-High Technology Imports ( $NH_W, NH_{DC}$ )

This variable is defined as total imports minus capital goods imported from developed countries. Specifically, the real value of high technology imports (or high technology imports from DCs, if applicable), as defined earlier, is subtracted from real level of total imports from the World Bank Development Indicators (1998). This measure serves both as a measure of openness and as a means by which to determine if the types of goods imported truly matter to domestic innovation. This variable also suffers from endogeneity problems. Hence, earlier values of this variable along with the instruments for imports described above are used as instruments for non-high technology imports.

#### Intellectual Property Rights (IPRs)<sup>22</sup>

To control for varying enforcement of IPRs across countries, I use a time varying index of intellectual property rights enforcement developed by Ginarte and Park (1997) for 110 countries. This index is based on five categories of patent laws: extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms, and the duration of protection. The Park and Ginarte index has two main advantages over other time-invariant indices of intellectual property rights [Rapp and Rozek (1990) and Mansfield (1994)]. First, it covers more countries and a larger time period than the other indices, since it follows these countries over five-year periods from 1960 to 1990. Second, the index considers broader categories of the patent system, consequently yielding greater variability in the measurement of IPRs across countries.

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<sup>22</sup>I would like to thank Prof. Walter Park for providing me with an electronic version of this data.

Several instruments are used for this variable: membership in the Paris Convention (WIPO statistics), secondary school enrollment ratio in 1967, infant mortality rate in 1967 and fertility rate in 1967 ( all from the World Bank Development Indicators 1998)<sup>23</sup>.

#### Foreign Direct Investment (FDI)

Data on FDI net inflows comes from the World Bank Development Indicators (1998). The data is reported in current US dollars, so I use the US CPI to deflate it. Several instruments are used for this variable: the 1965 level of intellectual property protection (Ginarte and Park, 1997), the CPI inflation and the exchange rate (both from the World Bank Development Indicators, 1998).

#### Capital Stock (KStock)

Capital stock data comes from Nehru and Dharehwa (1998). They compile investment series from 1950 onward for as many countries as possible and aggregate these series according to a perpetual inventory method.

#### Human Capital Stock (HK)

Human capital stock data, defined as mean years of secondary education, also comes from Nehru and Dharehwa (1998).

#### Commercial Energy Production (Energy)

Data on commercial energy production (kt of oil equivalent) comes from the World Bank Development Indicators (1998). It refers to commercial forms of primary energy petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and primary electricity all converted into oil equivalents.

#### Real GDP (RGDP)

Data on real GDP in constant dollars (expressed in 1987 international prices) comes from the World Bank Development Indicators (1998). To express this variable in per capita terms, I divide it by total population (also from the World Bank Development Indicators (1998)). Whenever GDP is used as an explanatory variable in the innovation regression, the average GDP level from 1965-69 is used as its instrument.

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<sup>23</sup>These instruments are suggested by Maskus and Penubarti (1995) when considering the Rapp and Rozek (1990) index.

## Appendix 3 - Descriptive Statistics

### INNOVATION REGRESSION

Descriptive Statistics					
Variable	Mean	Std. Deviation	Minimum	Maximum	No. of Obs.
LNINNOV	2.85051	335.001	-1.60944	10.8463	162
LNENERGY	8.59214	187.665	0	14.2746	174
LNRGDP	24.2449	1.99754	19.66	29.1464	180
LNNRH <sub>DC</sub>	22.6008	330.943	19.4537	26.449	163
LNRH <sub>DC</sub>	21.8829	297.375	18.4763	25.999	166
LNHK	-.46309	150.968	-4.16048	1.27759	176
LNIPR	.813364	.458999	-1.09861	1.50935	180
FDI	1.32E+09	4.31E+09	-3.43E+08	4.67E+10	172

### GROWTH REGRESSION

Descriptive Statistics					
Variable	Mean	Std. Deviation	Minimum	Maximum	No. of Obs.
LNINNOV	2.8342	306.46	-1.6094	10.8462	172
GRGDP <sub>69</sub>	.01885	.02346	-.05887	.08803	188
GRH <sub>DC</sub>	.03073	374.12	-.56145	.40927	165
GRH <sub>W</sub>	.00380	374.13	-.47321	.58482	165
GHK	.03575	.02634	-.02288	.14001	188
GKstock	.03097	.02635	.03642	.11046	188
FDI	.129E+10	.425E+10	-.343E+09	.467E+11	177

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