2008

Technology diffusion and total factor productivity growth

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TECHNOLOGY DIFFUSION AND TOTAL FACTOR PRODUCTIVITY GROWTH

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in
The Department of Economics

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DEDICATION

To Buba and Ma.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my advisor Dr. Areendam Chanda for meticulously guiding me in writing my entire dissertation. His guidance also helped me pass through this difficult academic journey. He has been a strong and supportive advisor throughout this entire process and always given me freedom to pursue independent research. Most importantly he has shown faith in my ability to rise to the occasion and do the hard work. In reviewing my writings he has provided painstaking comments but always respected my voice. I am indebted to his comments which reflected detailed attention to my work, and suggested how I can improve my work. He has always taken out time to introduce me to people within the discipline and has always been a strong advocate for me.

I would also like to express my gratitude to the other members of my committee- Dr. McMillin, Dr. Koray and Dr. Unel. They always maintained an open door policy and whenever I went for any suggestion they were more than happy to help me out. I am deeply indebted to them for sharing their knowledge with me. I am also thankful to other faculty members of the department for providing meaningful graduate education which have helped me how to think about economic as well as social problems. It is needless to mention that I am also indebted to Mary Jo Neathery for her continuous flow of information regarding deadlines, renewal of campus work permit, registration etc., which helped me sail through my graduate life comfortably.

In this long process of education, I also benefitted a lot from the support and care which I received from my family and friends. I must admit the support which I received from my father, mother, brother and wife whenever I used to get stressed out. I am extremely thankful to my wife Swetasri for her love, care, sacrifice and kind indulgence. Without her care and support -- I could have never finished my dissertation.

Finally, I would also like to thank my friends (to name a few: Ashok, Somnath, Sukanta, Bibhudutta, Chiranjit, Deepak, Pahuja, Rakesh, Prasun) who always amazed me and inspired me during my difficult times.

Table of Contents

DEDICATION ii

ACKNOWLEDGEMENTS iii

LIST OF TABLES vi

LIST OF FIGURES viii

ABSTRACT ix

CHAPTER 1: FOREIGN DIRECT INVESTMENT AND TOTAL FACTOR PRODUCTIVITY GROWTH: DOES DISTANCE FROM TECHNOLOGY FRONTIER MATTER? 1
1.1 Introduction 1
1.1.1 Related Literature 3
1.2 Theoretical Motivation 4
1.3 Data Sources and Measurement 7
1.4 Results 10
1.4.1 Endogeneity Issues 16
1.4.2 Threshold Estimation 21
1.5 Conclusion 25

CHAPTER 2: CAPITAL GOODS IMPORTS, CATCH-UP AND TOTAL FACTOR PRODUCTIVITY GROWTH 26
2.1 Introduction 26
2.1.1 Related Literature 27
2.2 Data 28
2.3 Results 33
2.3.1 Advantages of Backwardness 39
2.3.2 Endogeneity Issues 43
2.4 Conclusion 45

CHAPTER 3: FOREIGN DIRECT INVESTMENT AND PERFORMANCE OF INDIAN STATES 47
3.1 Introduction 47
3.1.1 Related Literature 49
3.2 Data 51
3.3 Results 54
3.4 Conclusion 59

REFERENCES 60

APPENDIX A: DATA SOURCES 67

APPENDIX B: SOLUTION OF BENHABIB AND SPIEGEL (2005) 68

APPENDIX C: NAME OF STATES AND UNION TERRITORIES 69

VITA 70

LIST OF TABLES

Table 1: FDI facts 1

Table 2: Descriptive Statistics 9

Table 3: Correlations..... 10

Table 4: Initial Distance from Technology Frontier Interacted with FDI (as a Share of GDP) ... 12

Table 5: Initial Distance from Technology Frontier Interacted with FDI (as a Share of Investment) 13

Table 6: Robustness Check: Effect of Initial Distance on TFP growth (FDI as a Share of GDP) 15

Table 7: Robustness Check: Effect of Initial Distance on TFP growth (FDI as a Share of Investment)**.** 16

Table 8: Effect of Initial Distance Compared to Gregorio-Lee Term and Finance (FDI as a Share of GDP) 17

Table 9: Results of Instrumental Variable Regressions (FDI as a Share of Investment) 19

Table 10: Results of Instrumental Variable Regressions (FDI as a Share of GDP) 20

Table 11: Threshold Level Estimation of Initial Distance and Initial TFP..... 23

Table 12: Descriptive Statistics 30

Table 13: Correlations..... 31

Table 14: Descriptive Statistics for Different Types of Capital Goods 32

Table 15: Types of Capital Goods and Its Correlation with Initial Distance..... 32

Table 16: Impact of Capital Goods Imports (as a Percentage of Total Import) on TFP Growth . 34

Table 17: Impact of Capital Goods Imports (as a Percentage of GDP) on TFP Growth..... 35

Table 18: Robustness Check of Capital Imports (as a Percentage of Total Import)..... 37

Table 19: Robustness Check of Capital Imports (as a Percentage of GDP) 38

Table 20: Effect of Capital Goods Imports in Presence of Finance and Manufacturing (as a Share of GDP) 39

Table 21: Catch-up Effect - Capital Import (as a Percentage of Total Import) 41

Table 22: Catch-up Effect - Capital Import (as a Percentage of GDP) 41

Table 23: Catch-up Effect - For Individual Types (Capital Import of Type *i* as a Percentage of Total Import) 42

Table 24: Instrumental Variable Regression Results 44

Table 25: Instrumental Variable Regression Results (By Types) 45

Table 26: Descriptive Statistics 53

Table 27: Correlations 53

Table 28: Growth and Major Variables for Indian States 55

Table 29: Growth and Role of FDI in Indian States 57

Table 30: Robustness Check 58

LIST OF FIGURES

Figure1: Initial Distance as Threshold Variable 22

Figure 2: Initial TFP as Threshold Variable 24

Figure 3: Total Amount of FDI Inflows in India (2000-2005) 52

Figure 4: Total Amount of Statewise FDI Inflows (2000-2005) 52

Figure 5: Average Annual Growth Rate of Indian States and FDI as a Share of SDP 54

ABSTRACT

I investigate the effects of two important channels of technology diffusion (i) Foreign Direct Investment (FDI) and (ii) import of capital goods, on the total factor productivity (TFP) growth. My first essay contributes to the literature by empirically investigating the role of initial distance of a country from the technology frontier in determining the net effect of FDI on TFP growth. In this essay, I find that the net effect of FDI on TFP growth decreases with the increase in distance. In order to take this research a step further, I implement the recently developed threshold regression technique to explore the non-linearity associated with FDI. I find that if initial distance of a country exceeds a threshold level then the leader will have a locomotive effect and can pull the followers along, while in the other situation there is a significant negative impact of FDI that increases with distance as a result of which the net benefit from FDI can be miniscule.

My second essay examines how technological distance affects the impact of capital goods imports on TFP growth. Both, at the aggregate level, and the disaggregated level, I find that distance is a significant determinant of the net effect of capital goods import on TFP growth. Interestingly, this study shows that as distance increases, the benefit from capital goods import also increases. The result is robust to instrumental variable estimation technique which addresses the problem of endogeneity. Thus, the results of my first two essays indicate that the two modes of technology diffusion - FDI and capital imports - play dramatically different role on TFP growth depending upon the initial distance of a country from the frontier.

Final essay examines effects of FDI in Indian States in the post reform (post 1991) era. Since the adoption of New Industrial Policy (NIP) and on going reform process, Foreign Direct Investment (FDI) inflows have increased substantially. Using recent data on FDI our results indicate higher human capital and financial assistance are essential ingredients to reap benefits from FDI for Indian states.

CHAPTER 1: FOREIGN DIRECT INVESTMENT AND TOTAL FACTOR PRODUCTIVITY GROWTH: DOES DISTANCE FROM TECHNOLOGY FRONTIER MATTER?

1.1 Introduction

Since the 1980s, inflows of foreign direct investment (FDI) increased rapidly. As table 1 depicts, from only $53.7 billion in 1980, annual FDI flows continued to increase to $1.2 trillion in 2006.[1] The upsurge in FDI significantly changed the international economic landscape. The growth rate of world FDI inflows surpassed that of world exports for the same period.[2] The increase in FDI inflows is not only restricted to developed nations but also to developing countries. In fact FDI in developing economies, increased from meagre $7 billion to $367.3 billion in 2006.

Table 1: FDI facts[3]

Economy	Series	1980	1990	2000
World	FDI inflow	55	201	1409
Developed Economies	FDI inflow	47	165	1145
Developing Economies	FDI inflow	7	35	162

One of the reasons for this swift expansion in the inflow of FDI is the 1980s debt crisis (Aitken and Harrison, 1999). With the dramatic drop in commercial bank lending in the 1980s, many developing countries started to offer different fiscal and financial incentives to attract FDI.[4] The underlying principle in attracting FDI stems from the precept that FDI has various positive effects apart from the capital that it brings in. These positive effects include technology transfers, better managerial skills, employee training, acquisition of skills, production networks, introduction of new marketing processes and productivity gains. Although the rise of FDI

[1] World Bank's Global Development Finance (2007).
[2] Source: World Economic Outlook Database, 2006.
[3] Value (Billion US Dollars) Source:World Investment Report (2006) UNCTAD.
[4] By the 1980's, the developing economies were facing huge amount of debt to U.S., European and Japanese bankers. This huge amount of debt, coupled with economic recession and massive drop in prices for raw materials (the main export of many developing economies), presented the big international bankers with the danger that countries would default on their debt.

inflows and positive effects of FDI are identified in the literature, the beneficial effect of FDI on productivity gains or economic growth is not empirically conclusive, making this an active area of research.

Within the growth literature, several studies, like Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), reveal that differences in total factor productivity (TFP) are key to understanding cross-country income differences. Easterly and Levine (2001) also show that it is the "residual" rather than factor accumulation that matters for most of income and growth differences across economies.[5] In principle, FDI can stimulate TFP growth through technology spillovers and externalities. However, a country's ability to absorb these externalities may be constrained by its current technological and institutional capabilities.[6] In investigating the role of FDI on TFP growth, this research emphasizes the role of initial distance from technology frontier. In particular, we examine whether or not benefits of FDI are dependent on a country's initial distance from the frontier.

To investigate the role of FDI on TFP growth, we adapt the approach of Benhabib and Spiegel (2005), who in turn, build upon the model of Nelson and Phelps (1966). Nelson and Phelps postulate that total factor productivity growth depends on the implementation of new discoveries and varies directly with the distance from the technology frontier. In their specification, human capital is assumed to play a major role in growth via two channels. They are (a) by increasing a nation's capacity to undertake domestic innovation and (b) through its capability to improve technology adoption. Along similar lines, this paper introduces FDI as another facilitator of growth in addition to human capital. It was highlighted earlier that apart from the capital FDI brings in, it can be the source of frontier technological know how, better managerial skills, developing linkages with local firms etc., which in turn can stimulate an economy. In order to capture the two fold effect of FDI, this paper clearly distinguishes between the direct capital financing it supplies (direct impact), and the externalities associated with it (indirect impact). It is important to mention here that Blomstorm and Kokko (2003) concluded that spillovers are not automatic, rather they depend on local conditions.[7] In this paper, local conditions are captured as the distance of a country from the technology frontier. The goal of this study is to identify the role of this initial distance in determining the net effect of FDI on TFP growth. To achieve this, the present analysis uses cross-section data on 89 countries for the period 1980-2000. Results indicate that the net effect of FDI significantly depends on country's initial distance from leader. This result holds true even after controlling for a large number of other variables that have a significant influence on TFP growth. Apart from addressing the issue of endogeneity in TFP-FDI

[5] Also see Wei-Kang Wong (2007).
[6] For example Borensztein (1998) focuses on human capital, while Alfaro et. al. (2002) states the importance of local financial development. For more see survey study by Blomstorm and Kokko (2003).
[7] For example, Alfaro. et. al. (2002) defines local condition as the level of financial development of a host country.

regressions, we also address the non-linearity associated with FDI. Using the recently developed sample splitting technique of Hansen (2000) on the dataset, the study finds that if the initial distance of a country exceeds a threshold level, then the technology leader will have a locomotive effect and can pull the followers along, while in the other situation there is a significant negative impact of FDI that increases with distance as a result of which the net benefit from FDI can be miniscule. The rest of the paper is organized as follows: related literature is discussed in scetion 1.1.1, section 1.2 describes the theoretical motivation; data are described in section 1.3; empirical results are discussed in section 1.4; and section 1.5 concludes.

1.1.1 Related Literature

Considerable effort has been devoted to examine the effect of FDI on TFP growth at the firm level, yet the evidence of benefits from FDI remains unclear. Haddad and Harrison (1993) find little or no impact of FDI on TFP growth for Moroccan manufacturing firms. In particular, the authors conclude this result is due to the lack of absorptive capacity of the local firms in high tech sector, which unable them to absorb foreign technology. Aitken, Harrison and Lipsey (1996) approach the issue of technology spillover from FDI through the labor market. The rationale is that technology spillovers increase the marginal product of labor and this in turn increases wages. Using data on manufacturing firms in Venezuela, Mexico and United States, they find no positive impact of FDI on wages. Moreover, Aitken and Harrison (1999), employing annual census data on over 4000 Venezuelan firms, find productivity in domestic plants declines when foreign investment increases, thus seriously questioning the spillover theory. Similarly, Djanov and Hoekman (1999) not only find negative spillover effects of FDI on domestic plants in Czech industry, but also suggest that domestic firms may lack the ability to absorb the technologies introduced by foreign firms due to their low research and development activities. Along similar lines, Kinoshita (2000), using firm level panel data on Czech manufacturing firms between 1995 and 1998, concludes that technology spillovers from FDI occur for firms that are more R&D intensive. On the other hand, Blomström and Sjoholm (1999) using plant level data for 1991 for all Indonesian establishments, find that all domestic firms benefit from spillovers. Similarly, Haskel, Pereira and Slaughter (2002), using British panel data, assert significant positive spillovers of FDI on TFP growth rates of British firms. The authors show that, of the aggregate increase of 11% in British TFP from 1972 to 1992, 5% can be attributed to spillovers from FDI. In a recent paper, Branstetter (2005) examining Japanese FDI in US firms, infers that FDI increases the flow of knowledge spillovers in US firms. This brief discussion of plant level studies indicates that the effect of FDI on TFP growth is unclear.

At the national level, most of the empirical works focus on the effect of FDI on economic growth. To mention a few, Carkovic and Levine (2003) construct a panel dataset for the time period 1960 to 1995 and find that FDI does not exert a positive effect on economic growth. However, using cross section data for forty-six developing countries, Balasubramaniyam et. al. (1996) indicate that growth enhancing effects of FDI are stronger in those countries that follow export promotion rather than import substitution. Borensztein et. al. (1998) and Xu (2000) find

that FDI is more productive than domestic investment only when the host economy has a minimum threshold stock of human capital. Besides human capital and trade regimes, the literature suggests the level of financial development of an economy also facilitates the positive effects of FDI on economic growth. In a recent paper Alfaro et. al. (2002) point out that countries with adequately developed financial markets gain substantially from FDI.[8] Unlike firm level studies, macroeconomic findings generally indicate a positive role for FDI in enhancing economic growth after a country reaches a threshold in the stock of human capital, the level of financial development, and/or maintains open trade regimes. In similar vein, this paper shows that distance from the technology frontier as an important factor in determining the net effect of FDI.

Most of the macroeconomic studies examine the role of FDI on economic growth, although it is a known fact that a large part of cross-country differences in income per capita can be explained by TFP growth. Thus, there is a dearth in the literature assessing the role of FDI on TFP growth. De Mello (1999) provides time series and panel data evidence for a sample of OECD and non-OECD countries for the period 1970-90. He shows that the degree to which FDI is growth enhancing depends on the extent of complementarity and substitution between FDI and domestic investment. Damijan et al (2003) study the importance of FDI on productivity growth for ten transition countries for the period 1994-1998. Their results suggest that only five of these countries benefit from FDI, while for the rest FDI has significant crowding-out effects for local firms in the same industry. On the other hand, Holland and Pain (2000), investigating ten Central and East European countries, find a positive impact of FDI on productivity of these economies, with the benefits being higher in the more-market oriented countries. Likewise, Ng (2006) examines the linkages between FDI and TFP for eight Asian economies and finds little evidence in favor of FDI causing technical change in the sample economies. In a recent study, Girma (2005) shows that there is a minimum absorptive capacity threshold below which effects of FDI are negligible or even negative on TFP growth.

1.2 Theoretical Motivation

A number of different approaches have been employed to study the growth of TFP. It is central to much of the work in this area to view TFP growth as a function of human capital. The well known Nelson and Phelps (1966) hypothesis suggests the rate at which the gap between the technology frontier and the current level of productivity is closed depends on the level of human capital. As explained earlier, the basis for the argument is that a highly educated labor force is expected to be better in creating, innovating and implementing new technologies. Building on this, Benhabib and Spiegel (2005) use a logistic function for technology diffusion to understand evolution of TFP. This is briefly discussed below.

[8] This is analogous to the findings of Hermes and Lesink (2000).

Let us assume a human capital augmented technological production function of Cobb Douglas form, with physical capital and human capital as the only inputs.

$$Y_I(t) = K_i^{\alpha}(A_i H_i)^{1-\alpha} \tag{1}$$

where K_i denotes physical capital stock, H_i refers to stock of human capital augmented labor, α represents share of capital and A_i refers to labor augmented measure of technology. Following Hall and Jones (1999), human capital augmented labor can be expressed as:

$$H_i = e^{\mu(E_i)} L_i \tag{2}$$

The function $\mu(E_i)$ denotes the efficiency of a unit of labor with E years of schooling in country i relative to one with no schooling, and L_i refers to homogeneous labor within a country. In particular, the derivative $\mu'(E_i)$ reflects the return to schooling estimated in a Mincerian wage regression. If data on capital, output, labor and years of schooling are available, total factor productivity for each country can be calculated. Dividing both sides of equation (1) by L_i and rearranging, the expression for TFP is:

$$A_i = \frac{y_i}{h_i \left(\frac{K_i}{Y_i}\right)^{\frac{\alpha}{1-\alpha}}} \tag{3}$$

where y_i and h_i are output per worker and human capital per worker, respectively.[9]

Nelson and Phelps (1966) argue that introducing human capital as just another factor of production misspecifies the role of human capital by restricting its benefit to the marginal product of labor only. It ignores the role of human capital in adopting new technology, which affects overall TFP growth. Consequently, Benhabib and Spiegel (2005) include an interaction term of human capital with distance (catch-up term that depends on human capital). Specifically, Benhabib and Spiegel (2005) formulate TFP growth according to the following equation.

$$\frac{\dot{A_i}(t)}{A_i(t)} = g_i(H_i(t)) + c_i(H_i(t))\left[1 - \frac{A_i(t)}{A_L(t)}\right] \tag{4}$$

where A_L refers to the level of TFP of the leader country and A_i denotes the level of TFP of country i, $g_i(H_i(t))$ represents the growth rate of innovation of country i, which depends positively on the level of human capital i.e., $g_i'(.) > 0$.[10] The catch-up term $c_i(H_i(t))[1 - A_i/A_L]$ depends on level of human capital $H_i(t)$, as well as on country i's initial distance from the technology frontier. Specifically, $[1 - A_i/A_L]$ denotes the initial distance of country i from

[9] Although, technically A_i is a labor-augmenting measure of productivity, the literature has referred it as TFP. For more see, Hall and Jones (1999), Easterly and Levine (2001), Aiyar and Feyrer (2002), Chanda and Dalgaard (forthcoming).

[10] Although one can think of capital as an important factor for innovation, but in this type of framework human capital is assumed to be the main determinant. In endogeneous growth models we get to see that human capital affects knowledge sector and physical capital is required for the intermediate sector.

the technology leader. The stock of human capital influences the rate at which the technology gap $[1 - A_i/A_L]$ is closed. Catch-up of a country i is denoted by c_i and assumed to be positively correlated with the amount of human capital, thus $c_i'(.) > 0$. Assuming g_i and c_i to be constant, the general solution of equation (4) in the limit can be expressed in the following form.[11]

$$\lim_{t\to\infty} \frac{A_i(t)}{\mathrm{A_L\,(t)}}(\mathrm{t}) = \begin{pmatrix} \dfrac{(c_i + g_i - gL)}{c_i}\ if(c_i + g_i - gL) > 0 \\ \dfrac{A_i(0)}{A_L(0)}\ if\ (c_i + g_i - gL) = 0 \\ 0\ if\ (c_i + g_i - gL) < 0 \end{pmatrix} \tag{5}$$

Equation (5) shows that the steady state growth rate depends on the relative magnitude of the catch-up term and the difference in the growth rate due to innovation. To be specific, the difference in growth rate due to innovation is given by $g_i - g_L$, where g_L represents growth rate of the technology leader. Assuming $g_L > g_i$, the solution shows that if the catch-up rate c_i dominates the stated difference $g_i - g_L$ then $A_i(t)/A_L(t) > 0$, and countries will converge. However, if a country is far from the technology leader such that $c_i + g_i - g_L < 0$, then those countries cannot catch-up with the leader. This may happen due to lack of absorptive capacity which creates barriers to adopt new technology or production methods. Thus, this specification allows for the possibility of a very small catch-up effect if a country is too distant from the technology frontier. More importantly, the solution indicates a situation in which countries with very low initial TFP relative to the leader cannot escape the lower "club".

In the last two decades, there has been a huge increase in net inflows of FDI to developing countries. As noted earlier, apart from capital, FDI also brings in various types of externalities that are likely to raise a country's TFP. Besides human capital, this study introduces FDI as another potential avenue of catching up with the leader. Benhabib and Spiegel (2005) assume linear specification of $c_i\big(H_i(t)\big) = ch_i$ and $g_i\big(H_i(t)\big) = gh_i$, where h_i implies human capital per worker in country i. Instead of $c_i\big(H_i(t)\big) = c_1 h_i$, this paper specifies $c_i\big(H_i(t)\big) = c_1 H_i(t) + c_2 X_i(t)$ and similarly, $g_i\big(H_i(t)\big) = g_1 H_i(t) + g_2 X_i(t)$, where $X_i(t)$ represents the amount of FDI as a share of total investment a country is receiving.[12] This formulation indicates that catch-up of country *i,* c_i is not only dependent on human capital, but it also depends on FDI. Similarly growth rate due to innovation g_i has an additional term which depends on FDI. However, this simple specification does not distort the situation where even in absence of FDI but with a certain level of human capital (as in Benhabib Spiegel case) one country can move up along the

[11] Appendix A briefly shows the calculation.

[12] In all regressions we control for aggregate domestic investment in order to capture the importance of domestic investments. Along with FDI as a share of investment the empirical analysis of this study also uses FDI as a share of GDP.

technology ladder. But this formulation opens up another path by which it can move up further, by acquiring knowledge and technology that comes along with FDI.

Specifically, Benhabib and Spiegel (2005) estimates the following expression:

$$\gamma = b + gh_i + ch_i[1 - A_i/A_L] + \varepsilon_i \quad (6)$$

where γ represents the average annual growth rate of TFP in country i, h_i represents the log of country i's stock of human capital, A_i represents the initial level of country i's TFP, A_L represents the level of TFP in the leader nation, and ε_i is an independently and identically distributed error term. The coefficients they estimate are b , g and g respectively. Since in this study $c_i\big(H_i(t)\big) = c_1H_i(t) + c_2X_i(t)$, and $g_i\big(H_i(t)\big) = g_1H_i(t) + g_2X_i(t)$ equation (6) changes to the following specification:

$$\gamma = b + g_1h_i + g_2X_i + c_1h_i[1 - A_i/A_L] + c_2X_i[1 - A_i/A_L] + \varepsilon_i \quad (7)$$

where $c_2X_i[1 - A_i/A_L]$ represents the catch up term due to inclusion of FDI and g_2X_i, captures the portion of FDI which affects innovation. This expression clearly shows that FDI can affect TFP growth in two ways. One, the direct effect of FDI which may arise due to the capital that it brings in, which is represented by g_2X_i, and the second term $c_2X_i[1 - A_i/A_L]$ captures the catch-up associated with FDI that depends on initial distance. Before continuing with the results, the next section undertakes a brief discussion of the data used in this analysis.

1.3 Data Sources and Measurement

Since there has been a rapid increase in the net inflows of FDI over the last two decades, the time period under study is 1980 to 2000. There are different sources for data on FDI. One important source is World Development Indicators (WDI, 2005). We use two alternative measures of net FDI inflow as a percentage of GDP and FDI as a percentage of gross domestic investment.[13] Net inflow of FDI, as measured in WDI, refers to net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Since we focus on technology spillovers from FDI on host economies we prefer net inflows rather than gross FDI figures. Specifically, the average values of FDI as a share of GDP as well as the share of investment for the entire period are used here. It is possible that even though two countries are receiving same amount of FDI as a share of GDP, one country receives higher FDI as a share of investment than the other. For example, in Sierra Leone, FDI is a major

[13] In WDI, gross domestic investment is given under the heading gross capital formation. Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress". Source: World Bank national accounts data, and OECD National Accounts data files.

share in their total investment but it experienced very small growth rate in recent past. Instead, they are suffering from civil unrest and political coups.[14] Thus, after controlling for political and other macroeconomic variables, it will be interesting to check whether an economy with higher FDI as a share of investment experiences higher TFP growth.[15]

In order to calculate TFP for all countries, the stock of capital *K* is generated using the perpetual inventory method.[16] Using the standard values of α from the existing literature, the share of capital is set to 0.3 for all countries, while the depreciation rate and technological growth rate in aggregate is assumed to be 0.05. In growth accounting exercises, the popular practice is now to use microeconomics based Mincerian wage returns and use them along with average years of schooling. This indicates that average human capital per worker can be expressed in the following form,

$$h = \exp(\mu_1 E_1 + \mu_2 E_2 + \mu_3 E_3) \quad (8)$$

where μ_1, $\mu_2$and μ_3 refers to returns to an additional years of schooling at primary, secondary and higher levels, while E_1,E_2 and E_3 stands for average years of schooling at each of these levels. Following Hall and Jones (1999), this analysis assumes a rate of return of 13.4% for first four years of education, 10.1% for the next four years, while for education after eighth year it is assumed to be 6.8%. Finally, using the dataset on average years of schooling from Barro and Lee (2004), TFP of all 89 countries in this sample are calculated.

Alfaro et. al (2002) show that level of financial development of the host economy plays an important role in determining the effect of FDI. To check the robustness of our results we control for the level of financial development. The variables for financial development are obtained from the World Bank database. The paper reports results for private credit, defined as the ratio of private credit by deposit money banks to GDP.[17] From the Hall and Jones (1999) dataset, social indicators like ethnolinguistic fragmentation, the fraction of population speaking any of the major European languages, latitude, economic organization, years of openness, exporters of fuels mainly oil, and Latin American and African dummies are used for robustness check. On theoretical grounds, Alcala and Ciccone (2004) show imports plus exports relative to purchasing power parity GDP is a better measure for trade compared to nominal exports plus imports as a percentage of GDP.[18] This paper uses their measure of trade. The data for this calculation is obtained from WDI (2005).

[14] Globalization and Discontents (2002) by J. Stiglitz.
[15] In regressions with FDI/Inv as main explanatory variable, FDI/GDP is also included.
[16] In this calculation 1960 is assumed to be steady state, so that the initial level of capital does not affect the time period of the study.
[17] We also also used three other measures of financial development. They are liquid liablities of financial system, commercial to central bank assets, and bank credit as a share of GDP. However, the reults remain the same irrespective of choice of these variables.
[18] They show if trade increases productivity, then following the Balassa-Samuelson hypothesis, productivity gains are much higher in manufacturing than in non-tradeable sectors. The relatively greater productivity gains in the manufacturing sector lead to an increase in relative price of services which may result in reducing the value of

Data on average annual TFP growth shows significant variation in the entire sample of 89 countries (refer to table 2). There are 29 countries with negative TFP growth. Apart from the Philippines, all countries in this group are either from Latin America or from Africa. Advanced countries registered positive TFP growth for the time period along with economies like India, China, Srilanka, and Thailand amongst others.[19] In the dataset, the highest TFP growth is experienced by China while Sierra Leone has the lowest TFP growth. Countries like Ireland, China, Cyprus, India, Israel and Thailand also experienced positive TFP growth even in terms of TFP relative to US.

Table 2 reports the descriptive statistics of the major variables used in this study. Human capital, like TFP growth, shows considerable amount of variation in the dataset. The mean value of average annual TFP growth rate is 0.375, but ranges from -9.079 to 6.641. FDI as a share of both GDP and investment also ranges extensively. Table 3 reports the correlations between these variables. Not surprisingly, TFP growth is highly correlated with real GDP per capita. However, the correlation coefficient between FDI/GDP and TFP growth is small. Prima facie, there is little obvious evidence that FDI promotes TFP growth. The next section describes the regression results.

Table 2: Descriptive Statistics[20]

Variable	Obs.	Mean	Std. dev	Minimum	Maximum
Human Capital	89	0.5173	0.2945	0.0460	1.1489
Real GDP per capita	89	6532.7	5889.9	442.02	22319.0
TFP growth	89	0.3753	2.1989	-9.0797	6.641
FDI as percent of GDP	89	1.7863	1.6991	0.0310	10.849
FDI as percent of INV	89	7.770	5.8944	0.0053	28.235
Investment	89	22.089	5.9339	9.6143	47.0139

openness, generally measured by nominal imports plus exports relative to nominal GDP. For more, refer to Alcala and Ciccone (2004).

[19] Mauritius has a very high TFP growth, which might be due to a large and strong tourism sector.

[20] Human capital stands for natural logarithm of initial (1980) human capital. Real GDP per capita is for year 1980. TFP growth stands for the annual average growth rate for the period 1980-2000. FDI as a percentage of GDP, FDI as a percentage of investment is the average value for the entire period. Investment (as a percentage of GDP) is again the average value for the entire period of study.

Table 3: Correlations

Variables (89 Obs.)	Lnh	GDP per-	Inv	FDI/Inv	FDI/GDP	TFP
Human Capital	1.00					
Real GDP per-capita	0.85	1.00				
Investment	0.18	0.10	1.00			
FDI as percent of	0.25	0.13	0.19	1.00		
FDI as percent of	0.19	0.10	0.52	0.89	1.00	
TFP growth rate	0.32	0.24	0.19	0.12	0.10	1.00

1.4 Results

This paper estimates the effects of net FDI inflows on TFP growth after controlling for initial distance of a country from the frontier. As countries are unlikely to be at their steady state, following Mankiw et al. (1992), this paper also looks at transitional dynamics. Hence, instead of levels of TFP, the TFP growth rate is the dependent variable. The following equation is estimated using OLS, with 89 countries for the time period 1980 to 2000:

$$TFPGRW_i = \alpha + \beta_1'(HUMAN_i) + \beta_2'(Distanace_i * HUMAN_i) + \beta_3'(FDI_i) + \beta_4'(Distanace_i * FDI_i) + \beta_5'(CONTROLS_i) + \varepsilon_i$$

where $TFPGRW_i$ stands for annual TFP growth rate, $HUMAN_i$ is the initial level of human capital, FDI_i refers to the FDI as a share of GDP and/or FDI as a share of investment, $Distanace_i$ is the initial distance of a country from the technology frontier, $CONTROLS_i$ is the set of conditioning variables for country *i* and ε_i is the error term.

Table 4 presents the results of baseline regressions.[21] The first column reports the slope coefficient estimates with log of investment as the only control variable. The coefficient estimate of FDI/GDP (β_3=0.345>0) is positive and significant. On the other hand, FDI interacted with initial distance of a country from the leader is negative and significant (β_4=-0.116<0). These results imply that effect of FDI/GDP on TFP growth declines with the increase in the initial distance from the technology frontier. This interaction term can be visualized as catch-up effect tied with FDI. These findings are significant both quantitatively and qualitatively, because the net result of FDI will be quite different for countries based on their initial distance, and, in fact for countries that are far from frontier may end up with very small net benefit of FDI. Both the initial stock of human capital and the catch-up due to human capital are positive and significant in the regression. Column (2) introduces only distance to find its role on TFP growth. Although the coefficient is negative, but it is not statistically significant. Continuing with specification in

[21] As a starting excercise, at first FDI as a percentage of GDP is used as a measure of FDI (since this measure has been extensively used in this literature).

column (1), column (3) includes two dummy variables AFRICA and LATAM, but the coefficients on these dummy variables are not significant and the other results are unchanged. In a recent paper, Alćala and Ciccone (2004) show that international trade is an important determinant of TFP. Their measure of trade as nominal imports plus exports relative to purchasing power parity GDP is included in the baseline regression. However, trade turns out to be statistically insignificant. The statistical significance of FDI and its interaction term do not change, but the magnitude of the coefficients drops from 0.345 to 0.285 and -0.116 to -0.091 for FDI and its interaction term, respectively. In sum, the findings from table 4 suggest that there is a positive and significant effect of FDI on TFP growth, but the effect is weaker the farther a country is from the technology frontier.

Table 5 replicates the main results of table 4 using FDI as a share of domestic investment.[22] The presence of FDI/Inv turns FDI/GDP insignificant in all columns of table 5. After controlling for trade and continental dummies the coefficient of interaction term of FDI with distance is -0.265, whereas it is only -0.091 in table 4 (refer to column (4) of table 4 and 5). This merely points out the fact that in a country which is far from the leader and if FDI is a major share of domestic investment there is a stronger negative effect associated with it.[23] One plausible reason could be that FDI in these countries (where domestic investments are low) is more directed towards the natural resource and mineral sector. The United Nations report (2001) on FDI in the least developed countries clearly states investment flows in these countries are strictly oriented towards resource rich sectors where there is not much scope of technology spillovers to the local firms.[24] Other usual suspects could be lack of basic infrastructure, law enforcement, property rights which are required to jump-start an economy even in presence of FDI. However, the results do not distort the main findings of previous table that net effect of FDI will still be positive on TFP growth, although the contribution can be miniscule.

To get an estimate of how crucial the distance from leader has been in determining the effects of FDI on TFP growth, one can calculate how much a one standard deviation increase in the distance variable would affect the TFP growth rate of a country receiving the mean level of FDI as a share of investment in the sample.[25] It turns out that a one standard deviation increase in distance reduces the impact of FDI on annual TFP growth rate by 0.50% during the 20 year period. The effect is measured by $\beta_4 \times$mean FDI/Inv$\times\sigma\{$dist.$\}$.[26] Thus this exercise confirms the conjuncture that distance from frontier can reduce the net benefit of FDI.

[22] FDI/GDP is always included in all regressions.

[23] In fact results of columns (1)-(3) indicate that for country that is far from the technology leader, the net effect of FDI may be negative, zero or very small. However, after controlling for continental dummies and trade, results indicate that net effect of FDI on TFP growth is always positive but can be very small for countries that are from the leader.

[24] For more reference see UNCTAD report on FDI in Least Developed Countries, 2001.

[25] The study also calculated the same using FDI as a share of GDP, but results are similar.

[26] The mean value for FDI/Inv is 7.770 in the 89 country sample. The standard deviation of distance is 0.247 and β_4=-0.265 which is obtained from column (4) of table 5.

Table 4: Initial Distance from Technology Frontier Interacted with FDI (as a Share of GDP)[27]

Variables	(1)	(2)	(3)	(4)
Ln(Inv)	2.245**	2.134*	1.736	1.759
	(1.124)	(1.148)	(1.316)	(1.318)
Human	3.558***	3.395***	2.959***	3.073***
	(0.832)	(0.795)	(1.049)	(1.070)
Distance*Human	0.272***	0.385**	0.251***	0.233***
	(0.013)	(0.190)	(0.069)	(0.067)
FDI/GDP	0.345**	0.319**	0.287**	0.285**
	(0.142)	(0.141)	(0.135)	(0.142)
Distance*FDI/GDP	-0.116***	-0.105**	-0.097**	-0.091**
	(0.073)	(0.041)	(0.036)	(0.038)
Distance		-2.249		
		(3.424)		
LATAM			-0.859	-0.962
			(0.630)	(0.629)
Africa			-0.698	-0.621
			(0.709)	(0.717)
Trade				-0.215
				(0.442)
Constant	-10.247***	-9.662**	-7.879*	-8.112*
	(3.622)	(3.691)	(4.534)	(4.562)
Observation	89	89	89	89
R-squared	0.291	0.294	0.311	0.314

An alternative method to check how countries performed is to simply plug the estimated coefficients for the sample of countries and calculate the net effect of FDI on TFP growth for each country.[28] It turns out that all countries experienced a net positive effect from FDI. But the net effect has a range from minimum of 0.0008 (Sierra Leone) to maximum of 7.2375 (Singapore) with mean being 1.3382. Countries like Ireland, Belgium, Singapore, Cyprus, Spain, U.K., Netherlands, Canada, France belong to the elite group which benefited most from FDI in terms of TFP growth. Middle tier comprises of countries like Korea, India, China, Argentina, Norway and the lowest group consists of countries like Algeria, Iran, Haiti, Mali, Sierra Leone and Niger among others. Thus, the primary result of the study indicates that distance from technology frontier plays an important role in determining the net impact of FDI on TFP growth.

[27] The numbers in parenthesis represent robust standard errors. Africa and LATAM are dummy variables for African and Latin American countries. Trade and Human is natural logarithm of the trade and human capital variables used in the analysis. Human and trade are values of 1980. Values of FDI-GDP and Investment are average values for entire period of the study (1980-2000). Ln(Inv) refers to the natural logarithm of investment as a share of GDP.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level.

[28] The net effect of FDI is given by $\beta_3(\text{FDI/Inv}_i+\beta_4(\text{Dist}\times\text{FDI/ Inv})$. β_3 and β_4 are used from column (4) of table 5.

Table 5: Initial Distance from Technology Frontier Interacted with FDI (as a Share of Investment)[29]

Variables	(1)	(2)	(3)	(4)
Ln(Inv)	2.917	2.839	2.523	2.833
	(1.921)	(1.931)	(2.123)	(2.152)
Human	2.959***	2.841***	2.421**	2.548**
	(0.814)	(0.777)	(0.968)	(0.980)
Distance*Human	0.287***	0.378**	0.263***	0.228***
	(0.072)	(0.191)	(0.072)	(0.067)
FDI/GDP	-0.659	-0.634	-0.661	-0.727
	(0.542)	(0.547)	(0.565)	(0.568)
FDI/Inv	0.300*	0.284*	0.282*	0.302*
	(0.168)	(0.171)	(0.168)	(0.179)
Distance*FDI/Inv	-0.346***	-0.316**	-0.292**	-0.265**
	(0.110)	(0.126)	(0.113)	(0.109)
Distance		-1.867		
		(3.603)		
LATAM			-0.926	-1.125*
			(0.624)	(0.617)
Africa			-0.626	-0.470
			(0.734)	(0.757)
Trade				-0.384
				(0.307)
Constant	-12.35**	-11.898**	-10.359*	-11.594*
	(6.009)	(6.023)	(6.933)	(7.142)
Observation	89	89	89	89
R-squared	0.298	0.299	0.319	0.329

Table 6 and 7 report the robustness checks of these results.[30] In addition to the present set of control variables, absolute values of latitude of different countries are included in the regression. Sala-i-Martin (1997) identifies latitude as one of the key regressors in growth analysis.[31] Results

[29] The numbers in parenthesis represent robust standard errors. Africa and LATAM are dummy variables for African and Latin American countries. Trade and Human is natural logarithm of the trade and human capital variables used in the analysis. Human and trade are values of 1980. Values of FDI-GDP and Investment are average values for entire period of the study (1980-2000). Ln(Inv) refers to the natural logarithm of investment as a share of GDP.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level.

[30] Table 6 uses FDI as a share of GDP while table 7 uses FDI as a share of domestic investment.

[31] Export-oil is the dummy variable for countries that are exporters of fuels mainly oil. Years open is fraction of years during 1950 and 1994 that economy has been open and is measured in 0-1 scale. Ecorg stands for type of economic organization measured in 1to 5 scale, with capitalist countries getting a value of 4 or 5. Latitude is the absolute of value of latitude to measure distance from equator. Eurfrac stands for fraction of population speaking any of the four major European languages..*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level.

show (refer to column (1) of table 6 and 7) that both FDI as a share of GDP as well as investment are robust to inclusion of this variable. The interaction term maintains its sign and significance as before. The coefficient estimates also do not change significantly. The absolute value of latitude turns out to play a positive and significant role in TFP growth implying that the farther a country is from the equator, the higher the predicted TFP growth. But in table 7 the significance is lost in presence of FDI as a share of GDP as well as share of investment. Next the set of control variables is expanded by a dummy variable for oil producing and exporting countries in column (2) of table 6 and 7, since a huge amount of FDI is always concentrated in this sector. The main findings of the paper remain the same. In the growth literature much importance has been given to local characteristics which impede growth such as the structure of the economy, language barriers, tariff as well as non tariff barriers, black market exchange rate premium. In order to control for local conditions, columns (3) to (5) include years of openness, fraction of population speaking any of the major European languages, and the type of economic organization.[32] The last column of table 6 show FDI and its interaction with distance are robust to inclusion of all these variables. In table 7 although the FDI/Inv looses its significance, but the interaction term with distance still continues to be significant with same sign as before. This robustness analysis nicely summarizes the empirical evidence of the paper that net effect of FDI indeed depends on the initial technological distance of a country from the technology leader.

Another issue of robustness concerns the interaction between FDI and human capital. In an influential paper Borensztein et al. (1998), using data on FDI flows to 69 developing countries, show that FDI as a share of GDP allows for technology transfer and higher growth only when the host country has a minimum threshold level of human capital.[33] Column (1) [refer to table 8] reports the results for this regression. Both FDI and its interaction with human capital turns out to be significant. Although the interaction term is positive, FDI has a negative sign. Along with the interaction term between human capital and FDI, column (2) introduces initial distance from technology frontier interacted with FDI. The interaction between FDI and human capital is now rendered insignificant. The same results are obtained when the African and Latin American dummies are included in the regression. Throughout, the interaction between FDI and distance remains robust. Alfaro et al. (2003), using cross country data between 1975 and 1995 show that countries with well developed financial markets gain significantly from FDI. Similar results are reported in column (4) which shows FDI itself is insignificant, but its interaction with level of

[32] Years open" is measured as fraction of years during 1950-1994 has been open and is a number between 0 and 1. A country is considered to be open if (a) non tarrif barriers cover less than 40 % of trade, (b) average tariff rates are less than 40% (c) any black market premium less than 20% (d) the country not classifed as socialist and (e) the government does not monopolize major exports. Eurfrac corresponds to the fraction of population speaking one of the major languages of Western Europe: English, French, German, Portuguese, or Spanish. "Ecorg" is the type of economic organization. The value ranges from 1 to 5 with capitalist countries getting a value of 4 or 5.

[33] Although the dependent variable in this study is TFP growth and not growth, the paper checks for these robustness since much of the growth can be explained by TFP growth.

financial development is positive and significant.[34] However, when interaction of FDI with distance is added to the previous regression the role of financial development is no longer significant in determining the effect of FDI. Results continue to be robust to inclusion of continental dummies. This robustness check lends support to the empirical finding that the initial technological distance of a country from frontier plays a substantial role in determining the net effect of FDI on TFP growth.

Table 6: Robustness Check: Effect of Initial Distance on TFP growth (FDI as a Share of GDP)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Ln(Inv)	1.435	1.417	1.164	1.480	1.460
	(1.303)	(1.339)	(1.263)	(1.283)	(1.268)
Human	2.286**	2.296**	1.891*	1.189	1.188
	(1.142)	(1.162)	(1.090)	(1.235)	(1.241)
Distance*Human	0.308***	0.308***	0.355***	0.384***	0.381***
	(0.076)	(0.077)	(0.082)	(0.082)	(0.081)
FDI/GDP	0.459**	0.458***	0.465***	0.448***	0.452***
	(0.162)	(0.163)	(0.168)	(0.152)	(0.152)
Distance*FDI/GDP	-0.103**	-0.102**	-0.108**	-0.117**	-0.118**
	(0.047)	(0.049)	(0.048)	(0.044)	(0.044)
LATAM	-0.415	-0.421	-0.1.97	-0.202	0.196
	(0.710)	(0.721)	(0.765)	(0.838)	(0.843)
Africa	-0.327	-0.329	-0.280	-0.029	-0.028
	(0.746)	(0.753)	(0.796)	(0.776)	(0.783)
Trade	-0.182	-0.190			
	(0.291)	(0.313)			
Latitude	0.043**	0.043**	0.047**	0.054***	0.054***
	(0.016)	(0.017)	(0.018)	(0.016)	(0.016)
Years open			0.822	1.170	1.220
			(0.868)	(0.882)	(0.877)
Export-Oil		0.076	0.229	0.096	0.050
		(0.684)	(0.627)	(0.675)	(0.692)
Eurfrac				1.549*	1.569*
				(0.829)	(0.842)
Ecorg					-0.039
					(0.165)
Constant	-8.813*	-8.783*	-8.425*	-9.781**	-9.586**
	(4.567)	(4.616)	(4.542)	(4.617)	(4.460)
Observation	89	89	89	89	89
R-squared	0.359	0.360	0.363	0.385	(0.386)

[34] Result of only one finance variable, namely private credit (PRCRD) is reported. Private credit is defined as the value of credits by financial intermediaries to private sector as percentage of GDP. Average value of this variable is interacted with FDI-GDP average. This study also included three other measures of financial development variable. They are Liquid liability of financial system, Commercial to Central bank asset, Credit by deposit banks to private sector. Results are same in all the cases.

Table 7: Robustness Check: Effect of Initial Distance on TFP growth (FDI as a Share of Investment).

Variables	(1)	(2)	(3)	(4)	(5)
Ln(Inv)	2.379	2.902	2.583	2.679	2.684
	(2.178)	(2.257)	(2.243)	(2.249)	(2.232)
Human	1.890*	2.617**	2.270**	2.050*	2.050*
	(1.072)	(1.004)	(0.990)	(1.073)	(1.087)
Distance*Human	0.284***	0.242***	0.291***	0.297***	0.297***
	(0.072)	(0.069)	(0.078)	(0.078)	(0.078)
FDI/GDP	-0.560	-0.705	-0.683	-0.679	-0.680
	(0.635)	(0.605)	(0.616)	(0.616)	(0.614)
FDI/Inv	0.285*	0.306*	0.300*	0.290	0.290
	(0.116)	(0.187)	(0.171)	(0.190)	(0.191)
Distance*FDI/Inv	-0.268**	-0.267**	-0.308**	-0.307**	-0.306**
	(0.119)	(0.116)	(0.122)	(0.116)	(0.118)
LATAM	-0.683	-0.846	-0.657	-0.466	-0.462
	(0.697)	(0.734)	(0.771)	(0.864)	(0.881)
Africa	-0.274	-0.195	-0.338	-0.218	-0.216
	(0.772)	(0.704)	(0.718)	(0.705)	(0.712)
Trade	-0.354	-0.390			
	(0.316)	(0.336)			
Latitude	0.008	0.008	0.005	0.007	0.007
	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)
Years open			0.497	0.614	0.606
			(0.947)	(0.935)	(0.934)
Export-Oil		-0.413	-0.518	-0.601	-0.595
		(0.754)	(0.682)	(0.723)	(0.747)
Eurfrac				0.738	0.737
				(0.803)	(0.805)
Ecorg					0.005
					(0.165)
Constant	-11.942*	-12.21*	-11.125	-11.498	-11.538**
	(7.135)	(7.272)	(7.201)	(7.202)	(7.056)
Observation	89	89	89	89	89
R-squared	0.335	0.336	0.330	0.335	(0.335)

1.4.1 Endogeneity Issues

A point of concern in FDI-TFP growth regressions is the endogeneity of FDI. FDI can be an important input for growth, but it is also necessary to understand that FDI can be determined to a large extent by TFP growth itself. More specifically, a country with higher TFP growth can attract more FDI than a country with lower TFP growth. A country with higher TFP growth is expected to be more efficient both in terms of adoption of new technology as well as innovation. Most of the empirical literature on FDI-growth has encountered this problem, and generally they try to solve it by using instrumental variable estimation. Following the existing literature, this section reports the instrumental variable estimates.

Table 8: Effect of Initial Distance Compared to Gregorio-Lee Term and Finance (FDI as a Share of GDP)[35]

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Inv)	2.606**	2.661**	2.123	1.463	1.199	0.988
	(1.323)	(1.275)	(1.498)	(1.176)	(1.055)	(1.208)
Human	1.236	2.198	1.869	3.237***	3.096**	2.833**
	(1.379)	(1.398)	(1.656)	(1.021)	(0.984)	(1.172)
Distance*Human	0.132**	0.248***	0.233***	0.162**	0.313***	0.300**
	(0.060)	(0.071)	(0.071)	(0.068)	(0.110)	(0.118)
FDI/GDP	-0.126*	-0.393	-0.316	0.125	0.408***	0.371***
	(0.067)	(0.593)	(0.628)	(0.143)	(0.133)	(0.129)
FDI/GDP*Human	0.626*	0.391	0.320			
	(0.350)	(0.315)	(0.338)			
Distance*FDI/GDP		-0.104**	-0.089**		-0.191**	-0.180**
		(0.035)	(0.035)		(0.084)	(0.092)
Finance				0.006	-0.730	0.638
				(0.608)	(0.760)	(0.823)
FDI/GDP*Finance				0.341**	-0.221	-0.226
				(0.149)	(0.347)	(0.359)
LATAM			-0.769			-0.484
			(0.663)			(0.705)
Africa			-0.674			-0.477
			(0.712)			(0.834)
Constant	-9.152**	-	-8.414*	-6.782*	-6.251*	-5.277
	(3.941)	(3.766)	(4.730)	(3.638)	(3.294)	(4.033)
Observation	89	89	89	74	74	74
R-squared	0.245	0.300	0.316	0.254	0.308	0.314

Wheeler and Moody (1992) show that FDI is self-determining. They report that existing or present stock of FDI is an important determinant of following investment ventures. In fact, Alfaro et. al. (2003) and Borenzstein et. al. (1998) use one period lagged FDI as instrument for their study. Following this similar line, this paper also employs lagged FDI/Inv as an instrument.[36] The other instrument in this study is the log of Frankel-Romer measure of trade

[35] Finance is logarithm of private credit by deposit banks to GDP. It is the average value for the period 1980-2000. *** implies significant at 1% level, ** implies significant at 5% level,* implies significant at 10% level.

[36] Specifically, this study uses the 1979 value of FDI as a share of investment. For FDI as a share of GDP, we use the 1979 value of FDI as a share of GDP.

variable. Frankel and Romer (1996) constructed this trade share purely based on geographical variables like distance, size of a country, whether a country is landlocked or not, and whether or not a country shares a common border with trading partner. They showed that these variables are largely uncorrelated with income per person, but are good instruments for trade. Their instrumental variable estimates of the impact of trade on income growth turned out to be significantly larger than OLS estimates. They concluded that impact of trade was substantial which was not captured in the OLS results. In many studies trade and FDI have been shown to be positively correlated.[37] Hence an alternative measure of trade constructed from purely geographic variables is a natural candidate as an instrument.

Table 9 and 10 present the results of instrumental variable regressions along with three tests that are needed to be conducted to check validity, relevance and joint significance of the instruments.[38] The Anderson Canonical correlations LR test examines whether the equation is identified or not. This checks for the relevance of excluded instruments. The test statistic is constructed under the null hypothesis that *K-1* will be the rank of the coefficient matrix in the reduced form, where *K* stands for total number of regressors including excluded regressors. A rejection of the null hypothesis implies that the model is identified and instruments are relevant. In order to find out whether the instruments are satisfying the orthogonality conditions or not, the J statistic of Hansen is also provided in the table. Rejection of the null hypothesis implies that the instruments are not satisfying the orthogonality condition required for their employment. Finally, within the framework of IV one can also perform robust inference regarding the joint significance of the endogenous variables. Specifically, the Anderson-Rubin test is done with the null of joint insignificance of the endogenous variables.

Column (1) of table 9 shows that interaction term of FDI with distance is still negative and significant like OLS results.[39] However, the coefficient estimate of the term has increased substantially in magnitude compared with the earlier OLS results in Table 7. This is due to the fact that instrumental variable estimation corrects for classical measurement error. In fact the results do not change after controlling for trade, type of economic organization, fraction of people speaking any of the major European languages and countries that are exporters of fuels mainly oil [columns (2)-(4)]. The Anderson-Canon LR statistic rejects the null hypothesis in all cases suggesting that the model is identified in each case. Apart from that, the Anderson-Rubin statistic fails to reject the null that jointly the endogenous variables, FDI as a share of investment and its interaction term with distance, are insignificant. However, FDI as a share of investment is

[37] For example Aizenman and Noy (2005).

[38] Table 9 and 10 report results of FDI/Inv and FDI/GDP respectively.

[39] FDI-Inv is instrumented by one period lagged value of FDI-Inv and log of Frankel Romer measure of trade which is purely based on geographical characteristics of a country. *** implies significant at 1% level, ** implies significant at 5% level,* implies significant at 10% level

no more significant in this table although it maintains the positive sign as before. The Hansen *J* - statistic indicates the instruments are satisfying the orthogonality condition in all the regressions. Besides this interaction term, human capital and its interaction term with distance continues to enter with positive and statistical significance in all the specification. This clearly indicates the importance of human capital in TFP growth. Results of table 10 are similar to these results.[40]

Table 9: Results of Instrumental Variable Regressions (FDI as a Share of Investment)

Variables	(1)	(2)	(3)	(4)
Ln(Inv)	2.785	3.067	2.990	3.231
	(2.960)	(3.007)	(3.025)	(2.597)
Lnh	2.669**	2.531*	2.664**	2.491**
	(1.359)	(1.396)	(1.324)	(1.252)
Distance*Lnh	0.335***	0.329***	0.309***	0.314***
	(0.100)	(0.096)	(0.103)	(0.101)
FDI/GDP	-0.708	-0.764	-0.707	-0.783
	(1.319)	(1.279)	(1.261)	(1.075)
FDI/Inv	0.372	0.388	0.365	0.387
	(0.447)	(0.430)	(0.420)	(0.358)
Distance*FDI/Inv	-0.463*	-0.469**	-0.440*	-0.456**
	(0.227)	(0.220)	(0.213)	(0.199)
LATAM	-0.722	-0.697	-0.803	-0.723
	(0.584)	(0.582)	(0.648)	(0.677)
Africa	-0.315	-0.257	-0.227	-0.170
	(0.777)	(0.786)	(0.807)	(0.771)
Exports of oil		-0.881	-0.699	-0.840
		(1.141)	(1.081)	(1.059)
Trade			-0.185	-0.166
			(0.428)	(0.447)
Eurfrac				0.414
				(0.947)
Ecorg				-0.007
				(0.182)
Constant	-11.982	-12.702	-12.572	-13.258
	(9.619)	(9.599)	(9.778)	(8.749)
Anderson Canon LR	6.724	7.657	7.846	11.169
P-value	0.081	0.053	0.049	0.018
Sargan-Hansen J stat	1.014	0.866	0.944	0.823
P-value	0.602	0.648	0.623	0.662
Anderson-Rubin stat	1.47	1.45	1.63	1.29
P-value	0.218	0.225	0.174	0.281
Observation	89	89	89	89

[40] FDI/GDP is instrumented by one period lagged value of FDI/GDP and log of Frankel Romer measure of trade which is purely based on geographical characteristics of a country. *** implies significant at 1% level, ** implies significant at 5% level,* implies significant at 10% level.

Table 10: **Results of Instrumental Variable Regressions (FDI as a Share of GDP)**

Variables	**(1)**	**(2)**	**(3)**	**(4)**
Ln(Inv)	2.068	2.175	1.969	2.282
	(1.361)	(1.414)	(1.542)	(1.626)
Lnh	3.223**	3.178***	3.193**	2.938**
	(1.105)	(1.098)	(1.067)	(1.080)
Distance*Lnh	0.295**	0.291***	0.270**	0.306**
	(0.090)	(0.088)	(0.117)	(0.127)
FDI/GDP	0.442*	0.434*	0.428	0.439*
	(0.272)	(0.270)	(0.269)	(0.270)
Distance*FDI/GDP	-1.393*	-1.398*	-1.242	-1.416
	(0.717)	(0.717)	(0.901)	(0.953)
LATAM	-0.709	-0.693	-0.825	-1.077
	(0.632)	(0.636)	(0.796)	(0.760)
Africa	-0.478	-0.452	-0.484	-0.372
	(0.754)	(0.762)	(0.741)	(0.757)
Exports of oil		-0.410	-0.252	-0.506
		(0.989)	(1.066)	(1.202)
Trade			-0.145	-0.047
			(0.511)	(0.547)
Eurfrac				0.751
				(0.769)
Ecorg				-0.020
				(0.167)
Constant	-9.401**	-9.648**	-9.084*	-10.123**
	(4.551)	(4.666)	(4.858)	(5.089)
Anderson Canon	16.789	16.521	10.920	9.954
P-value	0.000	0.000	0.012	0.019
Sargan-Hansen J	0.151	0.137	0.065	0.099
P-value	0.927	0.933	0.968	0.951
Anderson-Rubin	0.94	0.92	0.64	0.69
P-value	0.447	0.454	0.633	0.599
Observation	89	89	89	89

1.4.2 Threshold Estimation

Various empirical studies point out that if a country has a minimum threshold level of human capital or financial development or absorptive capacity, then FDI plays a significant role in growth.[41] Depending upon the objective of the investigation, generally two fundamental approaches are adopted. The first approach is to separate the plants or countries in the study according to some proxies for absorptive capacity and then analyze the degree of spillovers.[42] The alternative approach is to include a linear interaction term between FDI variable and some variable as a measure for absorptive capacity such as human capital, financial development or the initial technology gap. However, both approaches have pitfalls. In first approach, Hansen (2000) demonstrates that estimators that are obtained from such exogenous or ad hoc sample-splitting can face major inference problems. He shows that standard asymptotic confidence intervals are not valid in that case. In the second method, the linear interaction term assumes that spillovers associated with FDI are monotonically increasing or decreasing with the proxy variable that represents absorptive capacity. It may be the situation that countries which have crossed a certain threshold are experiencing positive spillovers (in which case the interaction term with distance is positive) from FDI while the countries that have not yet crossed the threshold distance may experience a negative spillover effect from FDI although the net effect can be positive. Thus, in order to quantify the threshold distance in the sample, this study employs the threshold regression technique developed by Hansen (2000). The method is briefly discussed below.

If initial distance from the technology frontier determines the way FDI generates productivity spillovers, the regression function will not be same for all countries. With no prior information on the way distance affects FDI, the following specification addresses the problem in the best way,

$$TFPGR_i = \alpha_1 X_i + \lambda_1 FDI_i * DIST_i(DIST_i \leq \gamma) + \lambda_2 FDI_i * DIST_i(DIST_i > \gamma) + \epsilon_i \qquad (9)$$

where $TFPGR_i$ stands for TFP growth of country i, X_i represents to the set of variables that are hypothesized to affect TFP growth and ϵ_i is the regression error. The above equation separates the FDI parameters into two "classes" or "regimes" depending on whether the distance is less than or equal to or higher than the threshold level of distance γ. If a country is above the threshold amount γ, the relevant coefficient is $\lambda_1$while λ_2 is the coefficient of the interaction term if the value of distance is below the threshold level. The method also determines whether

[41] For example Borensztein et. al (1998) and Xu (2000) mentions about minimum threshold stock of human capital while Alfaro et. al (2002) and Hermes and Lesink (2000) show that a country with better financial development gains more from FDI. Cohen and Levinthal (1989) report that externalities are dependent on some threshold level of absorptive capacity.

[42] For example Haskel, Pereira and Slaughter (2002) and Girma and Wakelin (2001).

the threshold effect in equation (9) is significant or not. The null hypothesis of no threshold effect can be represented as

$$H_O = \lambda_1 = \lambda_2 \tag{10}$$

However, it is to be noticed that the threshold parameter remains unidentified under the null hypothesis of no threshold. In fact Hansen (1996) shows that the asymptotic distribution of a test statistic that is not identified under the null hypothesis hinges on the moments of the sample and the critical values cannot be calculated. But he shows that *p*-values obtained from bootstrap method are asymptotically valid and can be used to make conclusion about the significance of the threshold effect.[43] Therefore, this method satisfies three major needs of this study. They are (i) whether there is any threshold or non-linearity associated with effect of distance on FDI (ii) whether the threshold is significant or not and (iii) if there is significant threshold in the sample what is the magnitude and direction of interaction term of FDI with distance in different regimes.

The method of Hansen (2000) allows for only one threshold variable at a time, hence this study first uses initial distance of country from technology frontier and then the initial TFP of a country as threshold variable. The results show presence of threshold based on initial distance.[44] Using 1000 bootstrap replications, the p-value for the threshold model is 0.033 suggesting a sample split. Specifically, the threshold estimate of initial distance is 57.290.

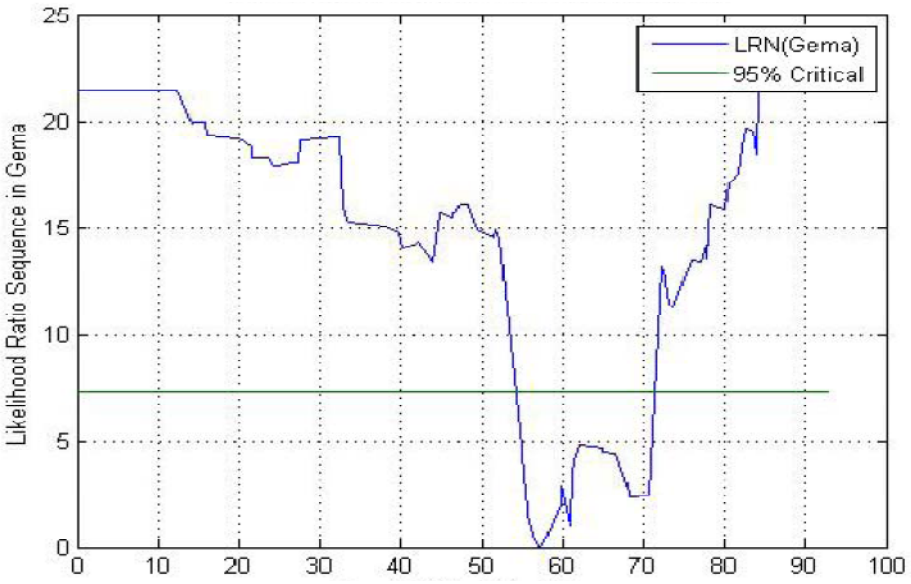

Figure1: Initial Distance as Threshold Variable

Figure 1 displays a graph of the normalized likelihood ratio sequence $LR_n^*(\gamma)$ as a function of the threshold variable, and least square estimate is the value that minimizes the graph

[43] For more refer to Hansen (1996) and Hansen (2000).

[44] See Table 11.

($\hat{\gamma}$=57.290). Figure (1) also plots the 95% critical value of 7.35 (the horizontal line), thus one can find the 95% asymptotic confidence set $\hat{\gamma}^*$=[54.89,70.68] from the figure where $LR_n^*(\gamma)$ crosses the dotted line.

Table 11: Threshold Level Estimation of Initial Distance and Initial TFP

Threshold variable	Threshold est.	LM stat for no threshold
Distance	γ=57.290	13.30 [p-value=0.031]
Variables	Regime-1 [γ≤γ]	Regime 2 [γ>γ]
Initial TFP	-0.007	-0.398***
	(0.159)	(0.126)
Lnh	0.586***	0.706*
	(0.140)	(0.296)
Ln(Inv)	0.559***	-0.048
	(0.166)	(0.267)
Distance*FDI/Inv	0.111***	-0.197***
	(0.031)	(0.052)
Constant	3.647**	5.206***
	(1.692)	(1.657)
Observations	50	39
R-Squared	0.534	0.340
Threshold variable	Threshold est.	LM stat for no threshold
Initial TFP	γ=2130.189	14.358 [p-value=0.022]
Variables	Regime-1 [γ≤γ]	Regime 2 [γ>γ]
Initial TFP	-0.527***	-0.218
	(0.131)	(0.231)
Lnh	0.575***	0.635***
	(0.280)	(0.149)
Ln(Inv)	-0.007	0.651**
	(0.237)	(0.245)
Distance*FDI/Inv	-0.539***	0.365*
	(0.170)	(0.203)
Constant	4.947***	2.783*
	(1.660)	(1.919)
Observations	38	51
R-Squared	0.358	0.264

Results show enough evidence for a two regime specification.[45] Based on the threshold estimate, the sample is split into two groups. The first group consists of those countries that have initial distance less than or equal to 55.290 (50 countries) while the second group comprises of countries with higher initial distance than the threshold estimate (39 countries). Results (refer to Table 11) reveal an interesting role of distance for these two groups. For first group the interaction term of FDI with distance is positive and statistically significant [λ_1=0.11], implying that once a country crosses the threshold distance then FDI generates positive spillovers which rises with distance. Another implication can be for countries that are operating very close to frontier might not gain much from the leaders in terms of spillovers. For the second group the interaction term of FDI is negative and significant [λ_2=-0.19], pointing out the fact that if a country is below the threshold level distance, then the negative impact of FDI increases with distance.[46] As a next step the method searches for any further sample splits in these groups. However, there was no evidence of any further sample splits in these groups.

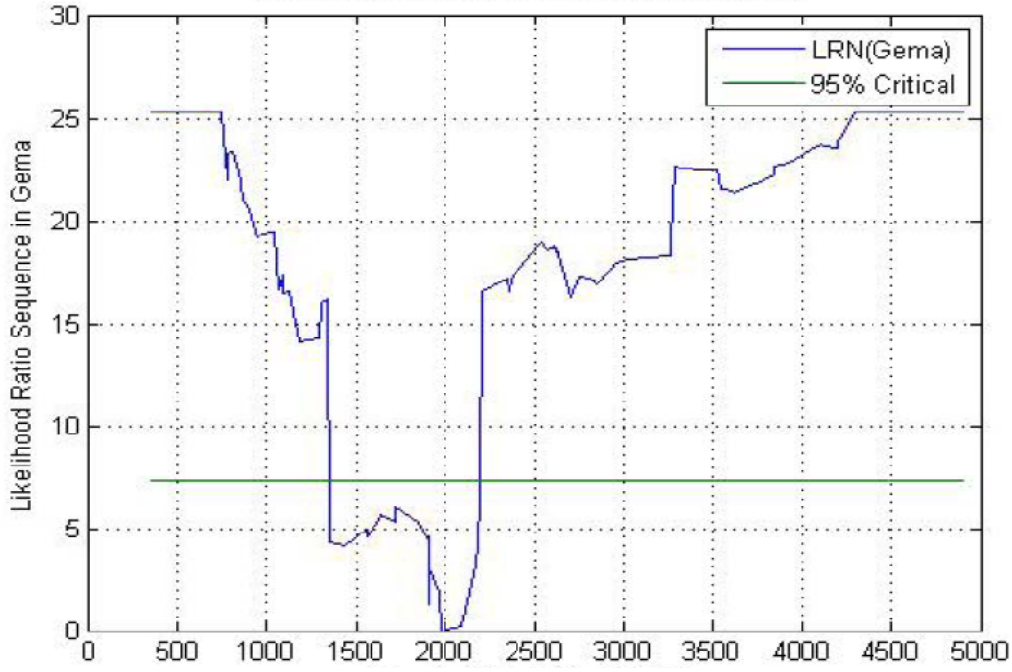

Figure 2: Initial TFP as Threshold Variable

The same exercise repeated with initial TFP as threshold variable. Figure (2) again confirms the presence of a sample split at threshold estimate of 2130.18 with bootstrap *p*-value of 0.022. The second half of table 11 reports the results, which are essentially same as the first half.

The sample splitting method clearly indicates non-linearity associated with FDI and distance. Results show that the relationship is not monotonic over the entire sample. Rather it points out

[45] >*** implies significant at 1% level, ** implies significant at 5% level,* implies significant at 10% level

[46] The regressions control for the basic variables that are expected to affect TFP growth such as human capital, investment as well as the initial TFP levels.

that if a country is below the threshold level there is negative effect associated with FDI. It may be the case that in these countries FDI is targeted towards the natural resource or agricultural sector. To illustrate, Alfaro (2003) shows that FDI in the primary sector tends to have a negative effect on growth. Since, most benefits such as technology transfer, employee training, introduction of new techniques etc., mostly occur in manufacturing and service sector, FDI in agriculture sector fails to generate these spillovers. Another plausible reason can be the extractive nature of FDI as mentioned by Albert Hirschman (1958). In his book he states the negative impact of FDI also originates due to the ability of primary products to move out of a country without leaving much trace in rest of the economy. Apart from these, countries that are far from leader also lack in terms of property rights, institutions, market structure etc., which are essential ingredients to extract most from FDI.

1.5 Conclusion

One reason for attracting FDI is that it is thought of as a composite bundle of capital stocks, different technology know how, training of the labor force, managerial skills, networks and other spillovers and externalities, which is expected to benefit a country in different ways. With the upsurge of FDI and race for FDI among countries, the natural question that comes to policy makers is, can an economy grow faster by attracting more FDI? Both the macro and micro empirical literature in this area finds little or no evidence in favor of FDI.

Using a sample of 89 countries, the primary result of this paper shows that the initial distance from the technology frontier is an important determinant of the net effect of FDI on TFP growth. Empirical evidence of this study shows that the positive externalities that are expected to be realized in presence of FDI vary inversely with distance. Thus, a country whose initial technology profile is low compared to the leader cannot reap the benefits associated with FDI. Rather, the results indicate that countries that are far from the leader experience a negative impact which reduces the net positive effect of FDI on these economies. These countries can enhance their productivity level by importing capital goods before attracting FDI from advanced countries. It is shown in the trade literature that developing countries benefit substantially by importing capital goods from technology leaders.[47] As a further step, the paper also explores any non-linearity associated with FDI by employing the recently developed threshold estimation technique. It is found that if a country is below a threshold initial distance, then there is a negative outcome of FDI, although the net effect may be positive. However, if a country is above the initial threshold level, then the country enjoys the positive externalities that are mentioned in the literature. Thus, the main finding of the paper implies that before entering the race for FDI by offering different financial and fiscal incentives to a foreign affiliate, it should review its present technological profile relative to the leader in order to gain the maximum benefit from FDI.

[47] For more see Coe,Helpman and Hoffmaister (1997), Mazumdar (2001).

CHAPTER 2: CAPITAL GOODS IMPORTS, CATCH-UP AND TOTAL FACTOR PRODUCTIVITY GROWTH

2.1 Introduction

A small group of countries account for almost the entire research and development (R&D) activity in the world economy. Most of these R&D activities occur in developed economies. In fact all developing countries together contribute even less than 20% of world R&D expenditure.[48] Further, within OECD countries, the seven largest economies accounted for more than 75% of R&D in 2000.[49] This R&D activity generates new technologies, improves the existing manufacturing techniques, develops new products and materials which enhances economic growth. Although only a few countries engage in R&D, the benefits spread around the world through imports of capital goods that embody advanced technology. Trade data shows that developing countries import most of their capital goods from these small number of R&D intensive exporters.[50] Thus a country's productivity growth then hinges to a large extent on its imports of these newly developed capital goods and its capability to use them efficiently.

Previous research in the theory of international trade and growth has shown a number of ways through which international trade can affect productivity. An important channel is the import of capital goods which enables an economy to employ new technologies embodied in machines and equipments. This in turn raises the productivity of domestic resources both in terms of quality and quantity. This study focuses on capital goods imports as it is an important channel for technology transfer across borders. Using a broad sample of 77 countries, we examine the role of capital goods imports on total factor productivity (TFP) growth for the period 1975-1995. The choice of examining TFP growth is also based on evidence since seminal work of Robert Solow (1957) that one should look beyond factor accumulation for an explanation of growth. Recent growth accounting exercises conclude that increases in capital to labor ratio explains less than half of last 50 year's growth in per capita incomes. For example, Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), reveal that differences in total factor productivity (TFP) are key for understanding cross-country income differences. Easterly and Levine (2001) also show that it is the "residual" rather than factor accumulation that matters for most of income and growth differences across economies. Considering the fact that most of the countries, tend to import huge amount of their capital goods from few large exporters raises the question whether imports of capital goods has played any role in TFP growth variation. Secondly, this analysis

[48] Source: UNESCO, UIS Bulletin, April 2004.

[49] Source: UNESCO, 2005.

[50] See Eaton and Kortum(2000).

also tests the "catch-up" hypothesis.[51] The hypothesis is that countries that are far from the technology frontier have the potential to adopt existing technologies and catch-up with the leader country. As an economy catches up to the frontier, the technological gap reduces and eventually the gap disappears. The speed of catch-up is positively related to the distance from technology frontier. However, Abramovitz (1979, 1986) and Nelson and Phelps (1966) conjecture that there exists some threshold level of development below which a country may not be in a position to adopt new technologies.

This paper uses initial distance of a country relative to the leader to examine the role of backwardness in determining the net impact of capital goods import on total factor productivity. To start with this study poses a simple question: do capital goods imports play a significant role in TFP growth? The basic presumption is, that most countries, by importing advanced capital goods from R&D intensive exporters, can use domestic resources more effectively and efficiently. Our regression analysis shows that capital goods imports enhances TFP growth in this sample of 77 countries. Results indicate that 10% increase in both share of capital goods imports to GDP and total imports is associated with approximately 0.4% increase in TFP. The second objective of the paper is to test if Abramovitz (1979)-Nelson-Phelps (1966) catch-up hypothesis prevails in the context of capital goods imports. Indeed, we do find evidence in favor of catch-up hypothesis. The results indicate that a country which is far from the technology leader benefits substantially by importing capital goods from technologically advanced countries. The estimated coefficient of the interaction term between initial distance from technology leader and capital goods imports as a share of GDP as well as imports are always positive and significant. These results are robust after controlling for other relevant variables that can potentially affect TFP growth. The paper also addresses the issue of endogeneity and finds that results remain unchanged. This clearly suggests that countries which perform very little or zero R&D gain by significant amount from imported capital goods in terms of TFP growth. Finally, this analysis also uses disaggregated capital goods imports data (4 digit SITC, 2nd version) to show that depending upon a country's initial technological profile a country can benefit more from importing a particular type of capital goods. The rest of the paper is organized as follows: Section 2.1.1 briefly discusses the related literature, data are described in Section 2.2; empirical results are discussed in Section 2.3; and Section 2.4 makes the concluding remarks.

2.1.1 Related Literature

Capital goods imports have long been considered as a channel of technology transfer. In an earlier study Lee (1994) confirms that the share of imported capital goods to its local counterparts plays a significant and positive role on economic growth rates across economies. Based on the theoretical models of growth that considers commercial innovation as technological

[51] For example Veblen (1915), Gerschenkron (1952), Nelson and Phelps (1966), and Abramovitz (1979, 1986) and others.

progress, Coe and Helpman (1995) present a study where a country's total factor productivity not only depends on domestic R&D but also on foreign R&D capital. The authors examine two predictions. First, whether an economy's productivity is increasing in the extent to which it imports from high R&D countries as opposed to low R&D countries. Second, whether a country's productivity and overall import share are directly proportional. Their regression analysis provide evidence for both predictions. On similar lines, Coe, Helpman and Hoiffmaister (1997), using data for 77 developing countries examine the extent to which developing countries benefit from importing capital goods from the industrial countries. They find that a developing country can gain in productivity by importing intermediate and capital goods which embody recent technologies. In a more recent study, Mazumdar (2001) using panel data finds evidence that investment in domestically produced capital goods reduces the growth rate while imported capital goods leads to higher growth in developing countries. On the theoretical side, Eaton and Kortum (1995) develop and estimate a model of technological innovation and its role on productivity growth at home and abroad. They show that spatial distance inhibits the flow of technology while trade enhances them.[52] However, Eaton and Kortum (1995) in their study find that the critical factor determining a country's productivity depends on ability to adopt new technology. Similarly, Caselli and Coleman (2001) using data on computer equipment imports find that computer adoption is related to higher level of human capital, trade openness and good property right protection. In a more disaggregated analysis Caselli and Wilson (2004) provide evidence of marked differences in capital imports composition. They document that these differences are due to each equipment type's degree of complementarity with other factors that varies across countries. They conclude that composition of capital can explain some of the unexplained differences in cross-country income per worker. In a recent study, Acharya and Keller (2007) also show similar results. They show that imports are often a major channel of technology diffusion, however their analysis also highlights that technology transfer differs across industries as well as countries. In another study Eaton and Kortum (2000) develop a model of trade in capital goods and estimate the barriers to trade in equipment.[53] They conclude that nearly a fourth of cross-country productivity differences to variation in relative price of capital goods. Building upon this literature, this study contributes by examining the role of initial technological distance from the leader in determining the impact of capital goods import on TFP growth.

2.2 Data

This paper uses the import data from Caselli and Wilson (2004). This dataset provides aggregate capital import data along with the total import of a country. At the disaggregated level (4 digit SITC, Revision 2, level) it has data for eight different types of capital goods which are

[52] This is consistent with results of Keller (2001), who shows that the amplitude of technology diffusion is severely limited by distance. Specifically, Keller (2001) reports that geographic half-life of technology is estimated to be only 1,200 kilometers.

[53] Barriers to trade include costs arising from marketing overseas, transportation costs, negotiating foreign purchases, distribution costs, tariff barriers, non-tariff barriers etc,.

used in this analysis. [54] These eight capital type categories are listed and described in appendix. Using this dataset, capital goods imports as a share of total import is calculated at aggregate level as well as each capital goods type as a share of total capital goods imports. The study also uses share of total capital goods imports to GDP as an explanatory variable. These two measures have been used to pick up particular aspects of the dataset. Capital goods imports as a share of total imports is used to capture the composition of imports while share of capital imports to GDP is employed to find out the overall importance of capital goods for the economy. It can be the scenario that although capital goods import as a percentage of GDP increases, but as a percentage of total imports remains the same. This situation may simply arise due to increase in entire import of a country. The alternative situation can be an increase in capital goods imports as a share of total import while as a share of GDP remains the same, thus reflecting a lower importance of capital goods in that country. The regression analysis reports results with both these variables. Specifically, we use the average values of both these variables for the entire period of study. The data for real GDP is obtained from World Development Indicators (WDI, 2005).

To compute TFP, this paper assumes a human capital augmented technological production function of Cobb Douglas form, with physical capital and human capital as the only inputs.

$$Y_i(t) = K_i^{\alpha}(A_i H_i)^{1-\alpha} \tag{11}$$

where K_i denotes physical capital stock, H_i refers to stock of human capital augmented labor, α represents share of capital and A_i refers to labor augmented measure of technology. The expression of TFP is then given by the following expression:

$$A_i = \frac{y_i}{h_i \left(\frac{K_i}{Y_i}\right)^{\frac{\alpha}{1-\alpha}}} \tag{12}$$

where, y_i and h_i are output per worker and human capital per worker respectively.[55] With availability of data on capital, output, labor and years of schooling total factor productivity for each country can be calculated. In the growth accounting exercise, the recent practice to measure human capital is to use microeconomics based Mincerian wage returns and use them along with average years of schooling. This implies that average human capital per worker can be expressed in the following form,

$$h = \exp(\mu_1 E_1 + \mu_2 E_2 + \mu_3 E_3) \tag{13}$$

where μ_1, μ_2,and μ_3 refers to returns to an additional years of schooling at primary, secondary and higher levels, while E_1,E_2 and E_3 stands for average years of schooling at each of these

[54] The dataset can be obtained from Francesco Caselli's website http://personal.lse.ac.uk/casellif/. In this dataset raw import data is obtained from Feenstra (2000).

[55] Although, technically A_i is labor-augmenting measure of productivity, the literature has referred it as TFP. For more see, Hall and Jones (1999), Easterly and Levine (2001), Aiyar and Feyrer (2002), Chanda and Dalgaard (forthcoming).

levels. Following Hall and Jones (1999), this analysis assumes a rate of return of 13.4% for first four years of education, for next four years rate of return is assumed to be 10.1%, while for education after eighth year it is assumed to be 6.8%. The stock of capital K is generated using the perpetual inventory method.[56] Following the standard values of α from the existing literature, share of capital is set to 0.3 for all countries, while depreciation rate and technological growth rate is assumed to be 0.02 and 0.06, respectively. Finally, using the dataset on average years of schooling from Barro and Lee (2004), TFP of all 77 countries in this sample is calculated.

The variables for financial development are obtained from World Bank database (2006). The paper reports result of private credit, defined as a share of private credit by deposit money banks to GDP.[57] From the Hall and Jones dataset, social indicators like ethnolinguistic fragmentation, fraction of population speaking major languages, economic organization, years of openness, exporters of fuels mainly oil, Latin American and African dummies are used for robustness check. Data for government consumption as a share of GDP, manufacturing as a share of GDP, trade as a share of GDP and inflation rate are taken from WDI. Finally the data for life expectancy is obtained from the UN database.

Table 12: Descriptive Statistics[58]

Variable	Mean	Standard Deviation	Minimum	Maximum
TFP growth	0.321	2.127	-6.590	6.897
INV/GDP	15.534	2.163	10.794	20.497
$Human_{75}$	0.497	0.280	0.017	1.096
Capimp/Total import	31.395	9.502	16.667	71.774
Capimp/GDP	10.462	10.466	1.475	37.543

Table 12 presents descriptive statistics for the main variables. For all 77 countries, capital goods imports as a percentage of total imports have a mean of 31.39%, while it ranges from minimum of 16.67% to maximum of 71.77%. Similarly, capital goods imports as a percentage of GDP shows considerable variation in the data with mean being 10.46%. Other variables such as

[56] In this calculation 1960 is assumed to be steady state, so that the initial level of capital does not affect the time period of the study.

[57] Paper also used three other measures of financial development. They are liquid liablities of financial system, commercial to central bank assets, and bank credit. However, the reults remain the same irrespective of inclusion of these variables.

[58] TFP growth is the average annual growth rate, $Human_{75}$ is the natural logarithm of initial human capital. All else are avergae values of the entire period (1975-1995). INV/GDP, Capimp/Total import and Capimp/GDP are in percentages.

human capital, investment as a share of GDP, TFP growth rate have wide range of variation in the sample. Raw correlations between these major variables are reported in table 13.

Table 13: Correlations

Variables (77 Obs.)	TFP growth	INV/GDP	LnH_{75}	Capimp-to-Timp	Capimp-to-GDP
TFP growth	1.00				
INV/GDP	0.431	1.000			
$Human_{75}$	0.376	0.571	1.00		
Capimp/Total import	0.333	0.376	0.321	1.00	
Capimp/GDP	0.245	-0.029	0.118	0.634	1.00

It shows that there exists some positive correlation between TFP growth and two measures of capital imports. Not surprisingly, both human capital and investment as a share of GDP are also positively correlated with TFP growth. The descriptive statistics, by capital type as a share of total import (average values for entire period) are documented in table 14.

A bird's eye view to the table makes it clear that there is substantial variation both in a particular type of capital goods imports as well as among the 8 different types used in the analysis. As a matter of fact the coefficients of variation are particularly high for aircraft, office computing and accounting machineries, railroad and non-electrical equipments. These high coefficients of variation show that there is immense amount of cross-country variation in the capital goods imports.

Finally, table 15 lists raw correlations with initial distance from the technology leader. It reveals that professional goods, measuring and controlling equipments, communication equipments, semiconductor wire, computers, calculators etc., are negatively correlated with initial distance of a country from the leader.[59] On the other hand non-electrical equipment, railroad equipment, motorcycle, bicycle, electrical equipment excluding communication equipment etc., are positively related with the initial distance.[60] From this table we provide some evidence that countries which are close to the frontier tend to import more sophisticated capital goods compared to those countries which are far from the frontier.

[59] Type 3, 5, 6 and 7 have negative correlation coeffeicnet with initial distance.

[60] Type 1, 2, 4 and 8 have positive correlation.

Table 14: Descriptive Statistics for Different Types of Capital Goods[61]

Types	Mean	Std.dev	Min.	Max
Non electrical equip.	4.31	3.07	0,15	17.23
Aircraft and related parts.	4.04	2.82	0.14	12.19
Professional goods.	7.41	2.23	3.38	15.71
Electrical equip.	13.13	4.02	8.13	31.58
Motor vehicles	24.12	7.23	6.69	44.32
Communication equip.	9.69	2.45	5.14	20.25
Computing equip.	5.06	3.47	0.93	20.75
Railroad equip.	3.58	2.32	1.14	13.47

Table 15: Types of Capital Goods and Its Correlation with Initial Distance

Types	Correlation
Non electrical equip.	0.16
Aircraft and related parts	0.20
Professional goods	-0.38
Electrical equip.	0.40
Motor Vehicles	0.09
Communication equip.	0.10
Computing equip.	-0.57
Railroad equip.	0.53

[61] All values for each type are given as a percentage of total import. The values are average values for the period 1975 -1995.

2.3 Results

The cross-sectional analysis employs import data averaged from 1975-95. Since most countries are unlikely to be at their steady state, the dependent variable is TFP growth rate rather than the level.[62] Before exploring the "catch-up" hypothesis, this section first examines whether capital goods imports benefit TFP growth. The baseline regression is:

$$TFPGRTH_i = \alpha' + \beta' TFP_{i,75} + \gamma' CAPIMP_i + \eta' CONTROLS_i + \epsilon_i \quad (14)$$

where $TFPGRTH_i$ stands for average annual TFP growth rate, TFP_{75} is the initial TFP level, $CAPIMP_i$ refers to the capital import as a share of total import in table 4 and capital import as a share of GDP in table 5, $CONTROLS_i$ is the set of conditioning variables for country i and ϵ_i is the error term. The set of conditioning variable consists of continental dummies for Latin American and African countries, initial human capital, exporters of fuels mainly oil, and investment as a share of GDP.[63]

Column (1) shows that human capital and investment play a significant and positive role on TFP growth. In column (2) capital imports is included in the regression and results indicate a significant and positive effect of capital goods imports on TFP growth. The significant effect of capital goods import prevails even after controlling for continental dummies in column (3). Finally, dummy variable for exporters of fuels mainly oil is introduced in the last column. The variable of interest, capital import, both as a share of total import and GDP, remains significant and positive. The estimated coefficient of capital import from table 17 (column 4) implies that a 1 unit increase in the capital goods imports as a share of GDP is associated with approximately 0.04 unit increase in growth rate of TFP. Both tables also report a significant and negative coefficient of initial TFP.

Following the "convergence literature", we know that if the partial correlation between growth rate and its initial level is negative, then it is evidence of β convergence. Since the focus of this paper is TFP growth rather than convergence, the paper does not further get into detailed implications, but makes the reader aware of the fact that in this dataset there is evidence of convergence among these wide ranges of economies. The main result of table 16 and 17, in a nutshell, is that capital goods imports enhance TFP growth. An alternative way to calculate how important is capital goods imports for TFP growth, is to ask the hypothetical question: how much would a one standard deviation increase in capital goods imports as a share of total import would affect the TFP growth rate of an economy importing the mean level of capital goods in the dataset? It turns out that a one standard deviation increase in the capital goods imports can raise the annual TFP growth rate by as much as 0.56% points during 20 year period.[64]

[62] For more see Mankiw, Romer and Weil (1992).
[63] Results do not change even after controlling for other continental dummies.
[64] The coefficient for capital import is used from the column (4) of table 5. The same exercise is repeated with capital import as a share of GDP. However, the paper reports only one result since in the other case the result is similar.

Table 16: Impact of Capital Goods Imports (as a Percentage of Total Import) on TFP Growth[65]

Variables	(1)	(2)	(3)	(4)
TFP_{75}	-2.076***	-2.043***	-1.947***	-1.914***
	(0.429)	(0.429)	(0.385)	(0.414)
$Human_{75}$	3.147***	2.946***	1.927**	1.844*
	(0.947)	(0.972)	(0.927)	(0.972)
INV/GDP	0.434***	0.391***	0.295***	0.300**
	(0.100)	(0.100)	(0.104)	(0.106)
Capimp/Timp		0.032**	0.040**	0.039**
		(0.017)	(0.013)	(0.013)
LATAM			-0.993**	-0.998**
			(0.463)	(0.464)
AFRICA			-1.470**	-1.472**
			(0.574)	(0.576)
Exportersoil				-0.307
				(0.617)
Constant	7.880***	7.368**	8.906**	-8.656**
	(3.318)	(3.365)	(3.143)	(3.348)
Observation	77	77	77	77
R-squared	0.465	0.483	0.535	0.536

Table 18 and 19 report the robustness check of these results.[66] As expected with the increase in the set of control variables the magnitude of the coefficient on capital goods imports decreases but remains significant and positive through out. The conditioning set is first expanded by controlling for inflation which often captures the general macroeconomic environment. The Results indicate that countries with high inflation rates are expected to have a lower TFP growth rate. Although introduction of inflation does not distort the importance of capital goods imports, it is to be noted that the negative coefficient of inflation is robust throughout table 18 and 19. This probably implies that inefficiencies associated with inflation have a strong negative impact on TFP growth.

In column (2) of both tables, trade as a share of GDP is added to the control variables.[67] The estimated coefficient of trade is positive but not significant at conventional levels. However, the

[65] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. We use natural logarithm of initial TFP, INV/GDP, Human capital and Capimp/Timp. Human stands for log arithm of human capital. LATAM and AFRICA are continental dummy variables. Exportersoil is also a dummy variable which takes a value of 1 if the country is a primary exporters of fuels mainly oil. Except human capital, all values are avgerage values for period 1975-1995.

[66] Table 6 uses capital goods imports as a share of total import while table 7 reports the results for capital goods imports as a share of GDP.

[67] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Govtcons, Trade and Inflation are average values

coefficient of capital goods imports is still significant. The implication of this result could be that it is not the overall trade but equipment imports that matters more in TFP growth. Amongst the other control variables, the government consumption (refer to column 3 of table 18 and 19) seems to exert a negative impact on TFP growth, although the impact is statistically insignificant. As a further measure of openness, type of economic organization and social infrastructure are also included in the set of control variables in the next two column.

Table 17: Impact of Capital Goods Imports (as a Percentage of GDP) on TFP Growth[68]

Variables	(1)	(2)	(3)
TFP_{75}	-2.075***	-2.045***	-2.007***
	(0.421)	(0.387)	(0.416)
$Human_{75}$	2.784***	2.072**	1.977**
	(0.920)	(0.892)	(0.943)
INV/GDP	0.467***	0.404***	0.407***
	(0.098)	(0.103)	(0.106)
Capimp/GDP	0.048***	0.042***	0.042***
	(0.008)	(0.007)	(0.007)
LATAM		-0.572	-0.582
		(0.448)	(0.446)
AFRICA		-1.207**	-1.212**
		(0.567)	(0.567)
Exportersoil			-0.334
			(0.600)
Constant	7.020***	8.565**	8.290**
	(3.239)	(3.105)	(3.311)
Observation	77	77	77
R-squared	0.520	0.550	0.551

for period 1975-95. They are all in natural logarithms. Life-exp is the value for year 1975 in year of birth. Ecorg is the type of economic organization on a scale of 1 to 5. Capitalist countries get a value of 4 or 5. Socinf is average value of GADP and openness.

[68] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. We use natural logarithm of initial TFP, INV/GDP, and Capimp/GDP. Human stands for log arithm of human capital LATAM and AFRICA are continental dummy variables. Exportersoil is also a dummy variable which takes a value of 1 if the country is a primary exporters of fuels mainly oil. Except human capital, all values are avgerage values for period 1975-1995.

Finally, life expectancy as a measure of health status is controlled in the regression. Kalemli-Ozcan (2002) shows a formal framework that connects health outcomes to economic growth. In particular, the model implies a decline in mortality rate increases economic growth via fertility and education channels. The coefficient of life expectation turns out to be significant in both the tables and enters with correct sign. But the main result remains the same. The positive and significant effect of capital goods imports on TFP growth still remains robust.

In a recent study, Alfaro and Hammel (2006) show that developed financial market encourages more capital goods imports.[69] They particularly focus on the relation between equity market liberalization and capital goods imports. After controlling for trade liberalization, other policy variables and fundamentals, they find that equity market liberalization is associated with a substantial increase in import of capital goods. Thus, it is interesting to check whether countries with well-developed financial markets gain significantly from capital goods imports. The first three columns of table 20 report the regression results with financial development indicator.[70] The regression includes financial development indicator as well as its interaction term with capital goods imports. The results show no such effect of financial development on TFP growth even after controlling for continental dummies and exporters of fuels mainly oil.[71]

It is also mentioned in the literature that if a country has comparative advantage in manufacturing sector, they tend to import more capital goods.[72] Thus a country with larger share of manufacturing in GDP is expected to gain more from capital goods imports at least in terms of TFP growth. The rest of table 21 reports the results after introducing manufacturing share in a country's GDP and its interaction term with capital goods imports. However, we find no such evidence that a country with high manufacturing share benefit more from capital goods imports. The capital goods imports as a share of total import still continues to be positive and significant.[73] The interaction term as well as manufacture as a share of GDP fails to enter the table with any statistical significance. Both continental dummies enter significantly and with correct sign.

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[69] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Finance is natural logarithm of average value of private credit by deposit money banks as a share of GDP. Paper uses four different measures of financial development, but reports only one here. Manufacturing is also the average value of manufacturing share in GDP.

[70] Result of only one finance variable, namely private credit (PRCRD) is reported. Private credit is defined as the value of credits by financial intermediaries to private sector as percentage of GDP. This study also included three other measures of financial development variable. They are Liquid liability of financial system, Commercial to Central bank asset, Credit by deposit banks to private sector. Results are same in all the cases.

[71] However, it is to be noted that these results are not directly comparable with Alfaro and Hammel (2006). Their dependent variable is capital goods import itself and they use a different measure of financial development indicator than this study.

[72] For example see Eaton and Kortum (2000).

[73] We also repeat the same exercise with capital goods imports as a share of GDP. Results are similar and not reported in the paper.

Table 18: Robustness Check of Capital Imports (as a Percentage of Total Import)

Variables	(1)	(2)	(3)	(4)	(5)
TFP_{75}	-1.963***	-1.980***	-1.980***	-2.204***	-2.388***
	(0.373)	(0.384)	(0.384)	(0.449)	(0.419)
$Human_{75}$	1.873**	1.759*	1.761*	1.257	-1.381
	(0.941)	(1.009)	(1.029)	(1.004)	(1.137)
INV/GDP	0.286**	0.316**	0.317**	0.304	0.138
	(0.108)	(0.151)	(0.161)	(0.195)	(0.167)
Capimp/Timp	0.036**	0.035**	0.035**	0.027*	0.022
	(0.012)	(0.013)	(0.014)	(0.016)	(0.014)
LATAM	-0.028	-0.005	-0.004	-0.154	-0.136
	(0.507)	(0.523)	(0.527)	(0.553)	(0.517)
AFRICA	-1.153**	-1.150**	-1.148**	-1.041*	-0.301
	(0.546)	(0.548)	(0.570)	(0.576)	(0.595)
Exportersoil	-0.300	-0.332	-0.333	0.068	-0.262
	(0.559)	(0.586)	(0.595)	(0.813)	(0.689)
Inflation	-0.517**	-0.499**	-0.498**	-0.456**	-0.424*
	(0.191)	(0.213)	(0.213)	(0.222)	(0.225)
Trade		0.150	0.155	0.090	-0.473
		(0.463)	(0.533)	(0.632)	(0.550)
Govtcons			-0.006	-0.086	-0.104
			(0.224)	(0.235)	(0.251)
Ecorg				0.090	0.138
				(0.167)	(0.175)
Socinf				1.455	0.972
				(1.769)	(1.555)
Life-exp					0.141***
					(0.040)
Constant	10.484**	9.572**	9.520**	10.795*	9.514*
	(3.256)	(4.289)	(4.769)	(6.092)	(5.198)
Observation	77	77	77	77	74
R-squared	0.595	0.596	0.596	0.608	0.678

Table 19: Robustness Check of Capital Imports (as a Percentage of GDP)[74]

Variables	(1)	(2)	(3)	(4)	(5)
TFP_{75}	-2.037***	-2.033***	-2.028***	-2.244***	-2.425***
	(0.384)	(0.392)	(0.391)	(0.447)	(0.418)
$Human_{75}$	2.019**	2.048**	2.063**	1.486	-1.198
	(0.924)	(1.009)	(1.028)	(1.009)	(1.169)
INV/GDP	0.380***	0.373**	0.380**	0.354*	0.180
	(0.107)	(0.142)	(0.150)	(0.195)	(0.168)
Capimp/GDP	0.031***	0.031***	0.031***	0.024**	0.015*
	(0.007)	(0.006)	(0.006)	(0.009)	(0.008)
LATAM	0.204	0.197	0.187	0.295	-0.012
	(0.510)	(0.519)	(0.523)	(0.546)	(0.523)
AFRICA	-0.984*	-0.983*	-0.966*	-0.903	-0.205
	(0.544)	(0.547)	(0.563)	(0.572)	(0.587)
Exportersoil	-0.348	-0.340	-0.352	0.057	-0.268
	(0.568)	(0.593)	(0.597)	(0.819)	(0.698)
Inflation	-0.458**	-0.462**	-0.456**	-0.423*	-0.401*
	(0.207)	(0.222)	(0.220)	(0.226)	(0.228)
Trade		0.039	0.006	0.017	-0.530
		(0.456)	(0.519)	(0.597)	(0.521)
Govtcons			-0.056	-0.126	-0.141
			(0.228)	(0.240)	(0.259)
Ecorg				0.095	0.140
				(0.166)	(0.173)
Socinf				1.440	1.060
				(1.785)	(1.584)
Life-exp					0.139***
					(0.041)
Constant	10.089**	10.315**	9.845**	10.995*	9.694*
	(3.293)	(4.306)	(4.710)	(5.978)	(5.071)
Observation	77	77	77	77	74
R-squared	0.595	0.596	0.596	0.607	0.676

[74] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Govtcons, Trade and Inflation are average values for period 1975-95. They are all in natura logarithms. Human stands for log arithm of human capital. Life-exp is the value for year 1975 in year of birth. Ecorg is the type of economic organization on a scale of 1 to 5. Capitalist countries get a value of 4 or 5. Socinf is average value of GADP and openness.

Table 20: Effect of Capital Goods Imports in Presence of Finance and Manufacturing (as a Share of GDP)

Variables	(1)	(2)	(3)	(4)	(5)
TFP_{75}	-1.991***	-1.920***	-1.895***	-1.974***	-1.970***
	(0.422)	(0.390)	(0.420)	(0.380)	(0.398)
$Human_{75}$	2.563**	1.493*	1.434	1.867	1.856**
	(0.924)	(0.853)	(0.898)	(1.923)	(0.966)
INV/GDP	0.322***	0.236**	0.240**	0.334**	0.334**
	(0.119)	(0.116)	(0.119)	(0.116)	(0.118)
Capimp/Timp	0.038**	0.031*	0.030*	0.103*	0.104*
	(0.019)	(0.018)	(0.018)	(0.061)	(0.062)
Finance	0.486	1.056	1.047		
	(0.908)	(0.817)	(0.824)		
Finance*Capimp	0.001	-0.018	-0.018		
	(0.022)	(0.021)	(0.021)		
LATAM		-0.794	-0.800	-0.997**	-0.999**
		(0.602)	(0.605)	(0.486)	(0.481)
AFRICA		-1.536**	-1.537**	-1.487**	1.488**
		(0.570)	(0.572)	(0.562)	(0.556)
Exportersoil			-0.232		-0.033
			(0.580)		(0.829)
Manufacture				0.033	0.034
				(0.056)	(0.061)
Manufacture*Capimp				-0.001	-0.001
				(0.001)	(0.001)
Constant	8.536**	10.550**	10.351**	7.349*	7.307*
	(4.181)	(3.876)	(4.104)	(3.227)	(3.408)
Observation	77	77	77	77	77
R-square	0.504	0.551	0.552	0.546	0.548

2.3.1 Advantages of Backwardness

Our results till now provide strong evidence that capital goods imports are beneficial for economies in terms of TFP growth. At this point, the paper moves on to emphasize the role of distance from technology frontier in estimating the effect of capital goods imports on TFP growth. More specifically, in the next half, the paper investigates for any evidence of catch-up effect associated with capital goods imports. Essentially, "catch-up" in the paper refers to the interaction term between initial distance from technology leader and capital goods imports. On the same sample of countries, the following regression is estimated:

$$TFPGRTH_i = \alpha' + \theta' HUM_i + \beta' CAP_i + \gamma' CAP_i * (DIST_i) + \eta' CONTROLS_i + \epsilon_i \quad (15)$$

where CAP_i represents capital import, $DIST_i$ is the initial distance, and control variables for country i are represented by $CONTROLS_i$. In the above equation distance from technology frontier, $DIST_i$ is measured as ($1-A_i/A_{US}$), where A_i and A_{US} are initial TFP of country i and US, respectively.[75] Particularly, the interaction term between capital import and distance is employed here to capture any presence of catch-up effect arising from imports of capital goods.

The primary results are reported in table 21 and 22.[76] As shown in both tables, the interaction term is statistically significant at conventional levels and positive in all columns. On the other hand, the capital imports variable by itself is insignificant. Both tables start with initial level of human capital and investment as control variables. In the following column continental dummies for Latin American and African countries are included. Both dummy variables enter with correct sign and statistical significance. The set of control variables are then expanded by introducing trade, inflation, share of government consumption in column 4, 5 and 6, respectively. However, our variable of interest - the "catch up" term remains positive and significant. In the last two columns, life expectancy and remoteness are also controlled.[77] We note that even in the last column the coefficient estimate of the interaction term is significant and positive. From these results we conclude that there is definitely some "catch up" effect which arises from capital goods imports. The significant and positive coefficient of the interaction term implies that as distance from the technology leader increases, countries benefit more by importing capital goods from advanced countries. Thus, countries which are close to the frontier are not going to benefit by as much amount as the countries which are far off. One plausible explanation could be that economies which are closer to frontier may have already developed the technology embodied in the capital goods. Hence, further import of capital goods may not be substantially beneficial. Developing countries on the other hand which are far from the frontier benefit by a great extent from importing capital goods. Finally, table 23 reports the results of regressions with eight different capital types after controlling for all other relevant variables.[78] The main result is in all the cases the interaction term between type of capital goods and distance remains significant and positive. As expected, there is huge variation in the coefficient estimates of the interaction term. This in turn implies that catch-up effect varies with the type of capital goods. Specifically, the

[75] A Similar measure of distance from technology frontier is used in Benhabib and Spiegel (2005).

[76] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Remoteness is measured on a scale of 1 to 10, with higher value implying more remote area. Catchup*Capimp/Timp and Catchup*Capimp/GDP refers to the interaction term between initial distance and capital import as a percentage of total import and GDP respectively.

[77] Remoteness is an index and defined as distance from the "rest of the world", where distances to other countries are weighted by GDP. For more see Santos-Silva and Tenreyro (2003). Caselli and Wilson (2004) finds remoteness as an important variable in determining the impact of capital goods imports.

[78] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Catchup*$Capimp_i$/Timp refers to the interaction term between initial distance and capital import f $type_i$ as a percentage of total capital import.

coefficient estimate of the catch-up term ranges from low of 0.19 (Motor Vehicles, automobiles and related parts) to high of 1.91 (Railroad equipment, motorcycle, bicycle, wagons and carts).

Table 21: Catch-up Effect - Capital Import (as a Percentage of Total Import)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Human75	3.361***	2.200**	2.055**	2.161*	2.531**	2.490**	2.382**	1.904*
	(1.071)	(1.024)	(1.070)	(1.132)	(1.140)	(1.175)	(1.236)	(1.120)
INV/GDP	0.272***	0.212***	0.220***	0.207**	0.160**	0.153*	0.167***	0.191**
	(0.068)	(0.070)	(0.073)	(0.079)	(0.081)	(0.084)	(0.092)	(0.086)
Capimp/Timp	-0.037	-0.026	-0.025	-0.026	-0.035*	-0.035	-0.029	-0.026
	(0.025)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.022)	(0.022)
Catchup*Capimp/Timp	0.151***	0.145***	0.141***	0.142***	0.150***	0.151***	0.154***	0.141***
	(0.031)	(0.028)	(0.030)	(0.031)	(0.030)	(0.030)	(0.031)	(0.029)
LATAM		-1.410***	-1.412**	-1.446***	-0.438	-0.418	-0.031	-0.707*
		(0.465)	(0.468)	(0.485)	(0.447)	(0.463)	(0.436)	(0.426)
AFRICA		-1.412**	-1.418**	-1.417**	-1.034**	-1.060**	-1.359**	-1.394**
		(0.562)	(0.560)	(0.563)	(0.531)	(0.546)	(0.538)	(0.555)
Exportersoil			-0.496	-0.462	-0.354	-0.335	-0.551	-0.697
			(0.583)	(0.621)	(0.545)	(0.559)	(0.663)	(0.623)
Trade				-0.126	-0.521	-0.577	-0.426	-0.361
				(0.313)	(0.345)	(0.386)	(0.333)	(0.348)
Inflation					-0.591***	-0.599***	0.340***	-0.035***
					(0.196)	(0.197)	(0.070)	(0.007)
Govtcons						0.093	0.029	0.200
						(0.254)	(0.291)	(0.279)
Remote							-1.301*	-1.289*
							(0.801)	(0.762)
Life-exp								0.006
								(0.011)
Constant	-6.428***	-4.638***	-4.622**	-3.969**	-4.004	1.124	9.266	-2.569
	(0.958)	(1.054)	(1.069)	(1.838)	(2.179)	(2.6470	(7.309)	(2.288)
Observation	77	77	77	77	77	77	77	77
R-squared	0.460	0.536	0.539	0.539	0.611	0.622	0.641	0.624

Table 22: Catch-up Effect - Capital Import (as a Percentage of GDP)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Human75	2.229**	1.419	1.098	1.086	1.200	1.221	1.577	1.508
	(1.058)	(1.066)	(1.075)	(1.095)	(1.118)	(1.146)	(1.289)	(1.275)
INV/GDP	0.262**	0.215**	0.236**	0.215**	0.176*	0.180*	0.154	0.150
	(0.099)	(0.093)	(0.094)	(0.096)	(0.101)	(0.104)	(0.110)	(0.123)
Capimp/GDP	-0.761	-0.742	-0.663	-0.263	-0.291	-0.282	-0.605	-0.601
	(0.520)	(0.466)	(0.473)	(0.777)	(0.867)	(0.871)	(0.978)	(0.979)
Catchup*Capimp/GDP	0.210***	0.193***	0.180***	0.162**	0.154**	0.153**	0.191**	0.190**
	(0.069)	(0.065)	(0.065)	(0.071)	(0.075)	(0.076)	(0.091)	(0.091)
LATAM		-1.110**	-1.125**	-1.216**	-0.446	-0.460	-0.060	-0.068
		(0.524)	(0.516)	(0.545)	(0.515)	(0.519)	(0.581)	(0.581)
AFRICA		-1.110 *	-1.141**	-1.148*	-0.870	-0.858	-0.780	-0.778
		(0.629)	(0.617)	(0.614)	(0.619)	(0.637)	(0.625)	(0.628)
Exportersoil			-1.212*	-1.129*	-1.118*	-1.126*	-1.073	-1.089
			(0.661)	(0.671)	(0.630)	(0.635)	(0.692)	(0.694)
Trade				-0.465	-0.699	-0.670	-0.602	-0.606
				(0.740)	(0.802)	(0.829)	(0.859)	(0.864)
Inflation					-0.466**	-0.462**	-0.451**	-0.449**
					(0.233)	(0.230)	(0.227)	(0.230)
Govtcons						-0.052	-0.140	0.120
						(0.236)	(0.269)	(0.290)
Remote							-1.148	-1.160
							(0.888)	(0.904)
Life-exp								0.003
								(0.011)
Constant	-4.064***	-2.449	-2.635*	-1.223**	1.385	1.077	1.148	1.153
	(1.413)	(1.586)	(1.588)	(2.466)	(2.979)	(3.335)	(3.914)	(4.399)
Observation	77	77	77	77	77	77	77	77
R-squared	0.360	0.406	0.421	0.424	0.469	0.469	0.482	0.483

Table 23: Catch-up Effect - For Individual Types (Capital Import of Type *i* as a Percentage of Total Import)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Human75	1.389	1.651	2.132*	2.023	1.922*	1.844	1.928	1.217
	(1.156)	(1.169)	(1.277)	(1.259)	(1.148)	(1.214)	(1.482)	(0.977)
INV/GDP	0.225	0.236	0.295*	0.276*	0.332**	0.300*	0.271	0.361**
	(0.185)	(0.181)	(0.156)	(0.166)	(0.156)	(0.153)	(0.170)	(0.145)
Capimp-*i* /Timp	-0.284*	-0.251*	-0.273**	-0.210**	-0.114**	-0.085	-0.333**	-1.544**
	(0.149)	(0.149)	(0.118)	(0.101)	(0.031)	(0.094)	(0.131)	(0.335)
Catchup*Capimpi/Timp	0.586**	0.570**	0.681***	0.383**	0.196***	0.508***	0.972**	1.918***
	(0.223)	(0.217)	(0.159)	(0.114)	(0.052)	(0.122)	(0.276)	(0.420)
LATAM	-0.206	-0.070	0.207	0.131	0.058	0.001	-0.135	0.959
	(0.724)	(0.709)	(0.625)	(0.686)	(0.606)	(0.613)	(0.617)	(0.732)
AFRICA	-0.625	-0.349	-0.677	-0.782	-1.061*	-0.663	-0.489	-0.509
	(0.610)	(0.592)	(0.582)	(0.564)	(0.611)	-0.621	(0.660)	(0.502)
Exportersoil	-1.164**	-1.124**	-0.622	-0.682	-0.698	-0.408	-1.038*	-0.204
	(0.562)	(0.501)	(0.607)	(0.632)	(0.612)	(0.651)	(0.561)	(0.451)
Trade	0.002	0.005	0.0003	-0.002	-0.004	0.008	-0.001	0.005
	(0.011)	(0.011)	(0.010)	(0.010)	(0.009)	(0.010)	(0.011)	(0.008)
Inflation	-0.466*	-0.445	-0.512**	-0.515**	-0.583**	-0.453**	-0.544**	-0.553**
	(0.277)	(0.280)	(0.234)	(0.237)	(0.209)	(0.214)	(0.247)	(0.210)
Govtcons	-0.026	-0.355	0.067	0.191	0.097	0.083	-0.142	-0.014
	(0.455)	(0.472)	(0.420)	(0.416)	(0.409)	(0.430)	(0.442)	(0.500)
Remote	-0.657	-0.557	-1.169	-0.982	-0.653	-0.977	-1.019	-1.588*
	(0.927)	(0.964)	(0.809)	(0.763)	(0.764)	(0.729)	(0.888)	(0.804)
Life-exp	0.013	0.012	0.012	0.010	0.010	0.006	0.013	0.008
	(0.015)	(0.014)	(0.014)	(0.017)	(0.013)	(0.013)	(0.013)	(0.010)
Constant	2.047	0.282	5.781	5.683	2.244	3.143	4.796	10.453
	(9.059)	(9.215)	(7.892)	(7.478)	(7.598)	(7.261)	(9.059)	(8.094)
Observation	77	77	77	77	77	77	77	77
R-squared	0.411	0.415	0.531	0.493	0.521	0.550	0.470	0.552

Results also reveal that office computing machineries, professional goods such as measuring and controlling equipments are associated with substantial catch-up effect. However, relatively low estimate of the interaction term for communication equipment, semiconductor, suggests that a country which is far from frontier do not gain much from these imports compared to other imports such as railroad equipments. Thus, results indicate that countries which are far from the frontier gain significantly from imports of less sophisticated capital goods compared to complex capital goods such as semiconductor.

2.3.2 Endogeneity Issues

Theoretically it is possible that capital goods imports can be determined to a substantial amount by TFP growth itself. A country with higher TFP growth may import more capital goods and flows from capital goods imports leads to TFP growth. This section addresses the endogeneity of capital goods imports and TFP growth through instrumental variable estimation. Apart from affording a general solution to endogeneity it has an advantage of testing various tests for validity of instruments and quality of fit.

One commonly used instrument for trade in the literature is the Frankel and Romer (1996) measure of trade. They show that geographic characteristics have important effects on trade and are very likely to be uncorrelated with other determinants of income. Hence, this gives them the platform to construct measures of trade purely based on geographic components of a country.[79] Using this measure they show that trade has a large, significant and robust positive impact on income. In absence of good instruments for capital goods imports, this paper uses their measure of trade as instrument varaiable. Although it is not a perfect instrument for capital goods imports, it performs well in terms of tests that are required to employ a variable as an instrument.

Table 24 and 25 present the results of instrumental variable regressions along with tests that are performed to check validity and relevance of the instruments.[80] Anderson Canonical correlations LR test examines whether the equation is identified or not. This check for the relevance of excluded instruments. The test statistic is constructed under null hypothesis, that K-1 will be rank of the coefficient matrix in reduced form, where K stands for total number of regressors including excluded regressors. A rejection of null hypothesis implies that the model is identified and instruments are relevant. Table 24 shows the instrumental variable estimation results of the aggregate capital goods imports as a share of total import and GDP.[81] The first half of the table, columns (1)-(4) uses capital goods imports as a share of total import while column (5)-(8) reports the results with same set of variables but employs capital goods imports as a share of GDP in regressions. Results show that interaction term between distance with capital import (the catch-up term) always remains significant and positive. The table starts with controlling human capital, investment and two continental dummies and then the set of control variables are increased. Results show that even after controlling for the full conditioning set, the variable of interest remains robust with same sign as before. In terms of relevance and validity of instruments in all cases the instruments perform well. Specifically, the Anderson and Canon LR statistic rejects the null hypothesis in all cases suggesting that the model is identified in each case.

[79] For more see Frankel and Romer (1996).
[80] We use Frankel and Romer (1996) measure of trade as instrument varaiable.
[81] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level.

Table 24: Instrumental Variable Regression Results

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Capimp/Timp	-0.044	-0.049	-0.045	-0.522				
	(0.060)	(0.060)	(0.054)	(0.050)				
Catchup*Capimp/Timp	0.160***	0.157***	0.160***	0.181***				
	(0.030)	(0.031)	(0.028)	(0.027)				
Capimp/GDP					1.312	1.311	0.961	-0.718
					(0.851)	(0.853)	(1.129)	(0.612)
Catchup*Capimp/GDP					0.163***	0.163***	0.159***	0.186***
					(0.038)	(0.042)	(0.038)	(0.040)
Human75	2.331**	2.252**	2.272**	2.557**	0.882	0.862	1.270*	2.700**
	(0.983)	(0.991)	(0.993)	(0.963)	(1.101)	(1.149)	(1.062)	(1.249)
INV/GDP	0.320**	0.335**	0.307**	0.263**	0.439***	0.441***	0.377**	0.063
	(0.132)	(0.135)	(0.123)	(0.124)	(0.136)	(0.136)	(0.156)	(0.139)
LATAM	-1.205**	-1.178**	-0.264	0.140	-1.026**	-1.025**	-0.507	0.044
	(0.502)	(0.503)	(0.554)	(0.545)	(0.505)	(0.505)	(0.519)	(0.478)
AFRICA	-1.303**	-1.298**	-0.976*	-0.922*	-1.227**	-1.227*	-1.005**	-1.122**
	(0.546)	(0.545)	(0.532)	(0.515)	(0.589)	(0.587)	(0.516)	(0.487)
Exportersoil		-0.441	-0.396	-0.299		-0.071	-1.220	-0.090
		(0.792)	(0.737)	(0.728)		(0.604)	(0.548)	(0.601)
Inflation			-0.522**	-0.511**			-0.360	-0.598
			(0.153)	(0.149)			(0.235)	(0.189)
Govtcons			-0.048	-0.150			-0.151	0.088
			(0.300)	(0.300)			(0.353)	(0.308)
Remote				-1.402**				-1.816**
				(0.715)				(0.885)
Life-exp				0.008				0.009
				(0.011)				(0.009)
Constant	-6.292***	-6.274**	-4.950**	7.237	-11.75**	-11.74**	-9.605*	14.477*
	(1.577)	(1.574)	(1.659)	(6.578)	(3.485)	(1.902)	(5.219)	(8.920)
Anderson Canon LR stat	10.933	10.652	11.320	12.243	14.385	14.015	8.902	15.190
P-value	0.012	0.013	0.010	0.006	0.000	0.000	0.002	0.000
Observation	77	77	77	77	77	77	77	77

Although human capital, investment as a share of GDP and inflation enters significantly and with correct signs in most of regressions. However, capital imports both as a share of GDP and total import do no not gain any statistical significance. But, this does not distort the main finding of the paper which shows the presence of positive catch-up effect by importing capital goods from technologically advanced countries.

Table 25 reports the results of the IV regressions for eight different types of capital goods imports.[82] For all types of capital goods the interaction term still turns out to be significant and positive. Thus these results continue to support the finding that capital goods imports is associated with positive catch-up effect. Also, in all columns the estimated coefficient of the interaction term has increased considerably in values compared to earlier OLS results. The coefficient estimate of the catch-up term varies from minimum of 0.23 to maximum of 3.79. The increase in the coefficient estimates may be due to the fact that instrumental variable estimation corrects for classical measurement error. Human capital, investment as a share of GDP, and inflation are significant and have the expected sign in all of the columns except the last one. Anderson Canon LR statistic fails to reject the null hypothesis in four cases out of eight.

[82] In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level.

Table 25: Instrumental Variable Regression Results (By Types)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Capimp_i/Timp$	-0.687**	-0.900**	-0.604	-0.190**	-0.102**	-0.087	-0.946**	-4.306*
	(0.290)	(0.415)	(0.391)	(0.085)	(0.048)	(0.292)	(0.414)	(2.505)
Catchup-$Capimp_i$	1.275***	1.363***	0.712***	0.447***	0.233***	0.632***	0.699	3.792**
	(0.251)	(0.296)	(0.175)	(0.076)	(0.039)	(0.104)	(0.670)	(1.734)
Human75	2.877**	2.775*	3.031**	2.581**	2.017**	2.420**	6.742*	1.759
	(1.262)	(1.568)	(1.056)	(0.997)	(0.937)	(1.030)	(3.694)	(1.912)
INV/GDP	0.285**	0.316**	0.445**	0.337**	0.466***	0.357**	0.616**	0.196
	(0.116)	(0.138)	(0.185)	(0.102)	(0.123)	(0.105)	(0.257)	(0.219)
LATAM	0.080	-0.345	0.181	0.257	0.064	0.120	0.358	0.489
	(1.173)	(1.358)	(0.606)	(0.580)	(0.610)	(0.639)	(0.888)	(1.238)
AFRICA	-0.920	-0.958	-0.740	-0.625	-1.308**	-0.787	-0.368	2.656
	(0.816)	(1.002)	(0.559)	(0.580)	(0.623)	(0.527)	(0.847)	(3.007)
Expotersoil	-0.514	-0.812	-0.723	-0.326	-0.455	0.061	-1.967	0.544
	(0.978)	(1.105)	(0.938)	(0.792)	(0.745)	(0.900)	(1.563)	(1.667)
Inflation	-0.508**	-0.501**	-0.525**	-0.418**	-0.554**	-0.432**	-0.69**	-0.285
	(0.190)	(0.197)	(0.171)	(0.179)	(0.155)	(0.177)	(0.278)	(0.381)
Govtcons	-0.222	-0.058	-0.247	-0.030	-0.128	-0.013	-0.422	-1.724
	(0.456)	(0.468)	(0.331)	(0.325)	(0.350)	(0.362)	(0.490)	(1.460)
Remote	-1.096	-0.065	-1.217	-1.280*	-0.732	-1.177*	-1.268	-3.704
	(1.558)	(1.750)	(0.800)	(0.732)	(0.677)	(0.694)	(1.144)	(2.413)
Life-exp	0.018	0.021	0.018	0.010	0.004	0.004	-0.010	-0.008
	(0.016)	(0.017)	(0.015)	(0.012)	(0.011)	(0.013)	(0.026)	(0.027)
Constant	4.467	-4.308	4.882	5.445	-0.332	2.981	4.006	34.536
	(12.641)	(14.789)	(7.156)	(6.646)	(6.844)	(6.652)	(10.360)	(25.325)
Anderson Canon LR stat	7.553	5.781	3.465	32.617	26.145	3.868	2.453	1.703
P-value	0.056	0.102	0.325	0.000	0.000	0.276	0.483	0.636
Observation	77	77	77	77	77	77	77	77

It is highlighted earlier that due to paucity of good instruments for capital goods imports these instruments have been used which are not perfect. The last point to be noted in this table is capital import of type *i* as share of total import enters with negative sign and statistical significance. This may be due to forcing a linear relationship on what actually may be a non-linear one. This remains as a point of concern. Finally, the results show that even after controlling for various policy and fundamental variables which can affect TFP growth, the main results of this study remains robust. Thus strengthening the confidence that there exists positive catch-up effect which arises from capital goods imports.

2.4 Conclusion

It has been documented in the literature that only a small group of countries engage in R&D activities. Although, only few countries perform R&D the benefits of R&D are not restricted to these nations only. Countries can gain substantially by importing capital goods from these countries. This paper uses data on 77 countries for the time period 1975-1995 to examine the effect of capital goods imports on TFP growth and it also investigates whether countries that are

far from technology frontier experience any catch-up effect by importing capital goods from technologically advanced countries.

The results of this paper show that capital goods imports is beneficial for TFP growth. The estimated coefficients imply that a 10% increase in capital goods imports can enhance TFP growth by 0.4%. The results are robust to inclusion of other control variables. The analysis also accounts for the endogeneity of TFP growth and capital goods imports. The results remain unchanged. Moreover, the main contribution of the paper is the evidence of positive catch-up effect associated with capital goods imports. Results indicate that countries that are far from technology frontier can catch-up with the leader by importing capital goods. Again, the results are robust to inclusion of other variables and alternative estimation technique. Further, this analysis employs disaggregated capital imports data to capture the divergent catch-up effect of each type of capital goods on TFP growth. Results confirm that each type of capital imports affects catch-up term in its own way. Specifically, the estimated coefficient of the catch-up term varies from minimum of 0.19 to maximum of 1.91. To conclude, the findings of this paper suggest that capital goods imports is an important determinant of TFP growth and most importantly, countries can catch-up with the leader by importing capital goods.

CHAPTER 3: FOREIGN DIRECT INVESTMENT AND PERFORMANCE OF INDIAN STATES

3.1 Introduction

The stable macroeconomic fundamentals, increasing size of the economy and improving investment climate has attracted multinational corporations to invest in India. An important outcome of economic reform process aimed at opening up the economy and embody globalization in 1991 has led to massive increase in Foreign Direct Investments (FDI) inflows to the subcontinent. In fact, UNCTAD's World Investment Report 2006 ranks India as the second most attractive spot amongst multinational corporations. The strong economic fundamentals driven by economic reforms for 17 years has helped India to attract FDI from meager US $103 million in 1991 to US $ 29 billion in 2006.[83]

India being a resource poor country, particularly in capital resources, was always receptive to foreign investment (see Kumar, 2003). However, the government adopted a restrictive attitude towards foreign capital in late 1960s as local industries started to develop. Private savings financed most of India's investment, but by the mid-1980s further growth in private savings was difficult because they were already high level.[84] As a result, during the late 1980s India relied increasingly on borrowing from foreign sources. Increased borrowing from foreign sources in the late 1980s, which helped economic growth, led to pressure on the balance of payments. The problem became an exogence in August 1990 when Iraq invaded Kuwait, and the price of oil soon doubled. The direct economic impact of the Persian Gulf conflict was exacerbated by domestic social and political developments.[85] The cumulative impact of these events shook international confidence in India's economic viability, and the country found it increasingly difficult to borrow internationally. As a result, India made various agreements with the International Monetary Fund (IMF) and other organizations that included commitments to speed up liberalization. Thus, in the early 1990s, considerable progress was made in loosening government regulations, especially in the area of foreign trade. Many restrictions on private companies were lifted, and new areas were opened to private capital.

Amongst other sources, FDI is a major source of private capital in India. FDI is allowed in almost all sectors, except those of strategic interest such as manufacture of arms and

[83] Source: Reserve Bank of India.

[84] For more see Sasidharan (2006).

[85] In the early 1990s, there was violence over two domestic issues: the reservation of a proportion of public-sector jobs for members of Scheduled Castes and the Hindu-Muslim conflict at Ayodhya. The central government fell in November 1990 and was succeeded by a minority government.

ammunitions.[86] Under current policy multinational firms can set up 100% subsidiaries in India without prior approval from exchange control authorities (Reserve Bank of India, RBI). According to the policy, FDI can enter into India in two ways. The first one is automatic route that does not require any approval from either by Government or RBI. This includes sectors like power, manufacture of drugs and pharmaceutical, road and highways, airports, hotels and tourisms.[87] Apart from these FDI upto 100% is permitted for establishment of Special Economic Zones (SEZ) and Export Oriented Units (EOUs). They are specifically designed duty free areas and are targeted to attract foreign firms for the purpose of trade operations. The second route requires prior government approval. The list includes important sectors like telecommunication, agricultural sector, trading, broadcasting, mining, and postal services.[88] Apart from this small list of sectors which require prior approval, India also offers various fiscal incentives in forms of tax breaks or tax holidays to Multi National Corporations (MNCs). Tax holidays are particularly available in SEZs to make industry globally competitive. In order to improve infrastructure, infrastructure sector projects also enjoy special tax treatment and holidays. In addition, foreign nationals working in India are taxed only on their income in India. And they further have the option of utilitizing tax treaties that India may have signed with their country. Thus, in a nutshell India like other developed and developing nations provides various fiscal and financial incentives to attract FDI. The primary reason for alluring FDI is not only the capital it brings in but along with capital it is also an important source of various technologies knows how, better managerial skills, labor training and other externalities which generate increasing return in production.

The primary focus of this paper is to investigate whether Indian states have benefitted from FDI after offering such financial and fiscal incentives. In this paper we aim to make a major contribution to the literature by examining the effects of FDI in Indian States in the post reform (post 1991) era. The use of Indian states as a data set provides an excellent platform to undertake this analysis. By choosing states within a single country, one already controls for differences in macroeconomic environments which can only be corrected imperfectly in a cross-country analysis. Further, in the case of Indian states, the growth of FDI was driven by a common exogenous shock that affected all states (the balance of payments crisis in 1991). Finally, Indian states despite facing the same macroeconomic environment and judicial system, display considerable heterogeneity in human capital, labor regulations, infrastructure availability, business friendly environments, access to seaports, etc.

[86] Source: Manual on Foreign Direct Investment in India - Policy and Procedures, May 2003, SIA, Government of India, New Delhi.

[87] For complete list refer to Manual on FDI in India - Policy and procedures, Annexure IV.

[88] FDI is not at all allowed in the following sectors (1) retail trading (except for single brand product retailing) (2) Atomic energy (3) lotteries and (3) gambling and betting.

The rest of the paper is organized as follows: related literature is discussed in next sub-section; data are described in section 2; empirical results are discussed in section 3; and section 4 makes the concluding remarks.

3.1.1 Related Literature

At the cross country level, there exists a large literature that studies impact of FDI on economic growth. Based on the popular cross section regression approach, Balasubramaniyam et. al. (1996) emphasize that effects of FDI on growth are stronger in those countries that follow export promotion rather than import substitution. Carkovic and Levine (2003) using a panel dataset for the time period 1960 to 1995 find that FDI does not exert any positive effect on economic growth. Nevertheless, Borensztein et. al. (1998) and Xu (2000) show that FDI is more productive than domestic investment only when the host economy has a minimum threshold stock of human capital. Besides human capital and trade regimes, the literature also suggests the level of financial development of an economy can enhance the positive effects of FDI on economic growth. In a recent paper Alfaro et. al. (2002) point out that countries with adequately developed financial markets gain substantially from FDI.[89] Thus at national level, empirical findings generally indicate a positive role for FDI in enhancing economic growth after a country reaches a threshold in the stock of human capital, the level of financial development, and/or maintains open trade regimes.

Various studies relating FDI and growth of Indian economy fail to document a robust and positive link between them. Agarwal and Sahahani (2005) conclude that for a country like India the quality of FDI is more important than quantity. Unless FDI inflows change their prsent target of producing for the domestic economy and displacing local firms in India, the subcontinent is not going to get any fruitful result from FDI. On the contrary, Bhat et al (2004) stress on lack of local skills which are required to initiate spillovers. Sharma (2000) hypothesizes export as one of the channels through which FDI influences growth. Using annual data for 1970-98 he finds that FDI has no significant impact on export performance and thus on growth. On similar lines, Chakrabarty and Nunnenkamp (2006) show that FDI is unlikely to do wonders in India unless remaining regulations are relaxed and more industries open up to FDI. In a more recent study Stracke and Nunnenkamp (2007) show that FDI in India is only concentrated in a few relatively advanced regions which may have prevented FDI effects from spreading across India. They mention " FDI is likely to increase regional income diparity in India." However, in a comparative study between India and China, Liu and Wei (2004) find that FDI and its interaction with labor quality improvement play a significant role in economic growth of India. Jha (2003) stresses that increasing investments along with FDI is an essential input for India to reap benefits from FDI. Similarly, Nagraj (2003) states "what is needed is a strategic view of foreign investment as a means of enhancing domestic production and technological capability .... as China has precisely done". Pradhan (2002) estimates a production function for the Indian economy and shows that

[89] This is analogous to the findings of Hermes and Lesink (2000).

FDI stock has contributed positively to the national production. The study concludes that the effect of FDI is not significant for the overall period, but during the liberal policy phase FDI plays a significant impact on production of India.

Researchers have also documented several obstacles to increased flows of FDI to India. For example, Menon and Sanyal (2005) examine how labor conflict, credit constraints and indicator's of state's economic health affect foreign investment. They find that labor unrest is the most important factor in determining the effect of foreign investment. Their results indicate that labor unrest has a strong negative effect on foreign investment and also labor unrest is endogenous across Indian states. Bajpai and Sachs (2000) identify lack of infrastructure, FDI-friendly policies as main obstacles for attracting FDI. They summarize "India has the resource base, it has the entrepreneurship, has the access to the sea, a vast labour force, it has everything that coastal China has had except the interest of the Government which even today underemphasizes the role of industrial facilities, of infrastructure, of land area, of effective port facilities". Tybout (2000) while discussing manufacturing sectors states that institutional barriers, labor market market regulations, poorly functioning financial market and limited domestic demand create inefficiencies in developing economies like India. This in turn can reduce foreign investment.

Although there are studies on effect of FDI on overall performance of India, there is lack of research which focuses at state level impact.[90] The variation across these states and territories is huge in regard to demography, language, ethnicity and economic conditions. Also, some states have achieved rapid economic growth in recent years, while others have not. In this paper, we ask a simple question whether FDI has benefitted these states over the period ? If yes, does this benefit depend on any particular factor or independent of any such factors? Primarily, our results indicate that a state with larger enrollments in engineering, MBBS, and other professional degrees and higher financial assistance benefits more from FDI than the other ones. In a way our results are similar to Schumpeterian growth model presented by Aghion et al. (2006). They show that more trade or FDI is associated to positive growth effects in regions and sectors that are initially close to the technological frontier. This is primarily due to higher absorptive capacities of these regions or sectors and their engagement in R&D when foreign competitors enter the market.[91] In another study Agrawal (2005) reports that growth effects of FDI in India may also be choked by concentration of FDI in some advanced locations. In fact Agrawal (2005) mentions that FDI may have contributed to regional divergence rather than enhancing convergence among Indian states. The next section describes the data.

[90] Ther are studies which focus on determinants of FDI. For example, Nunnenkamp and Stracke (2007), Aggarwal (2005) and Singh (2005).

[91] Kathuria (2002) also show that FDI related spillovers are restricted to those domestic firms which perform R&D.

3.2 Data

Data for this study is obtained from Indiastat database.[92] This database is constructed by pooling information and data from various sources. It includes economic survey of India, Reserve bank of India, census, different parliamentary questions, and policy papers amongst many other important sources.

To investigate the influence of FDI on the growth of Indian states for period 2000-2005, we focus on FDI as a share of SDP (State Domestic Product) as the main explanatory variable. In order to control for the "financial health" of a state we use financial assistance provided by all financial institutions. All financial institutions include IDBI (Industrial Development Bank of India), IFCI (Industrial Finance Corporation of India), ICICI (Industrial Credit and Investment Corporation of India), SIDBI (Small Industries Development Bank of India) and IIBI (Industrial Investment Bank of India).[93]

Previous studies have shown that a country with higher human capital reaps more benefit from FDI.[94] To address the potential effect of human capital, we use literacy rates and the enrolment rates in professional studies at state level. Professional studies refer to bachelor of engineering, science, architecture, polyechnique institutes and M.B.B.S. Aggregate enrolment rates as a share of total population of the state is also employed in the regression analysis. As mentioned earlier, Menon and Sanyal (2005) show that labor unrest has a strong negative impact on foreign investment. In order to capture labor unrest we use statewise mandays lost resulting in work stoppages due to both industrial disputes as well as reasons other than industrial disputes.[95] Other variables which are used in the analysis include aggregate Research and Development (R&D) expenditure as a share of SDP, statewise total power supply and few demographic variables.[96]

Figure (3) shows the total amount of FDI inflows in India during 2000-2005 while Figure (4) displays FDI inflows for 26 states and union territory for the same period. A glance at the diagram clearly reveals that over these years FDI inflows have increased rapidly. Within a short span of 5 years amount of FDI in India has increased by 4 times. Figure (4) indicates that all states have not been equally successful in attracting FDI. One possible reason as per Sachs, Bajpai and Ramiah (2002) is differences across states in the area of policy reforms. They show that those states that have been more reform oriented attracted more FDI compared to others. According to figure (4) top four states in terms of attracting FDI are Maharashtra, Delhi, Karnataka and Tamil Nadu. At the same time, states like Bihar, Madhyapradesh, Rajasthan, Uttarpradesh have lagged behind. Along with them North Eastern states like Nagaland, Manipur,

[92] www.indiastat.com

[93] This paper uses the total amount actually disbursed than amount sanctioned.

[94] For example, see Borenzstein et. al (1998) and Xu(2000).

[95] Again we use this measure as a share of total population of a state in the emprical analysis.

[96] Demographic variables include Land area, agricultural workers as a share of total workers, urban popupation as a share of total population.

Meghalaya and Assam also have failed miserably in attracting FDI. However, states like West Bengal, Haryana, Gujarat and Andhrapradesh got some share of the aggregate FDI inflows.

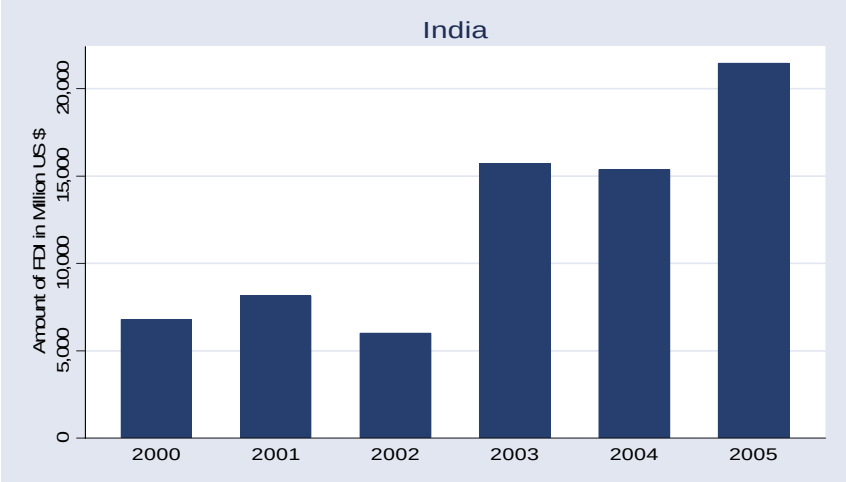

Figure 3: Total Amount of FDI Inflows in India (2000-2005)

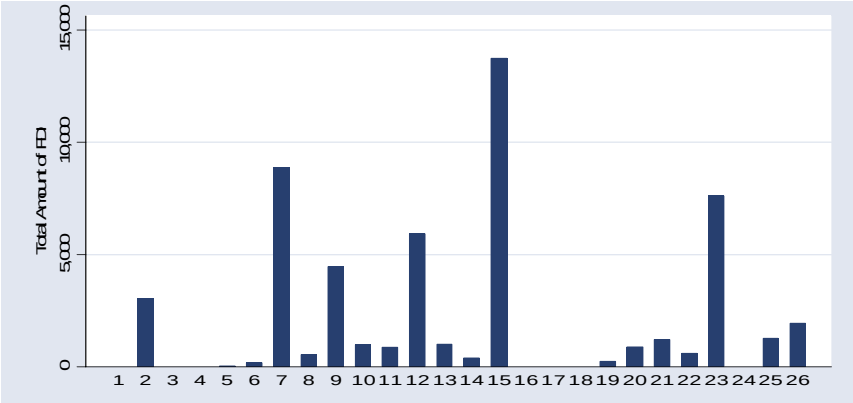

Figure 4: Total Amount of Statewise FDI Inflows (2000-2005)

Table 26 provides the descriptive statistics of the major variables used in the analysis. There is considerable variation in the dataset. Growth rate of SDP per capita ranges from minimum of -0.7% to maximum of 6%. Similarly, FDI as a share of SDP varies from minimum value of 0 to as high as 39%. Amongst two measures of human capital, enrolment rates display huge variation compared to literacy rates. Measures of financial assistance also demonstrates marked variation across states.

Table 27 reports correlation coefficients between these variables. Although not very strong, growth rate is positively correlated with FDI as a share of SDP. But FDI is strongly related with enrolment rates and initial percapita. To be noted, literacy rate is more correlated with growth than enrolment rates. Not surprisingly, literacy rate is positively correlated with enrolment rates.

Table 26: Descriptive Statistics[97]

Variables	Mean	Standard Deviation	Minimum	Maximum
Growth	0.033	0.017	-0.007	0.060
Humancap	0.001	0.001	0.000	0.006
Literacy	0.698	0.102	0.475	0.909
FDI/SDP	0.069	0.093	0.000	0.392
Finassist/SDP	0.017	0.018	0.000	0.087

Table 27: Correlations

Variables	Growth	Humancap	Literacy	FDI/SDP	Finassist/SDP
Growth	1.00				
Humancap	0.169	1.000			
Literacy	0.345	0.657	1.00		
FDI/SDP	0.190	0.649	0.545	1.00	
Finassist/SDP	0.171	0.091	0.438	0.480	1.00

[97] Note: Growth represents annual average growth rate of Indian states for period 2000 to 2005. Humancap stands for total enrollment in engineering, MBBS other technical studies as a share of total population of a state. Literact is the literacy rate. FDI/SDP is the average value of FDI as a share of SDP. Similarly, Finassist/SDP is the avreage value for the entire period.

Finally, figure (5) shows the relationship between FDI as a share of SDP and growth rates. Prima facie there is little or no obvious evidence that FDI promotes growth in Indian states. The next section reports the regression results.

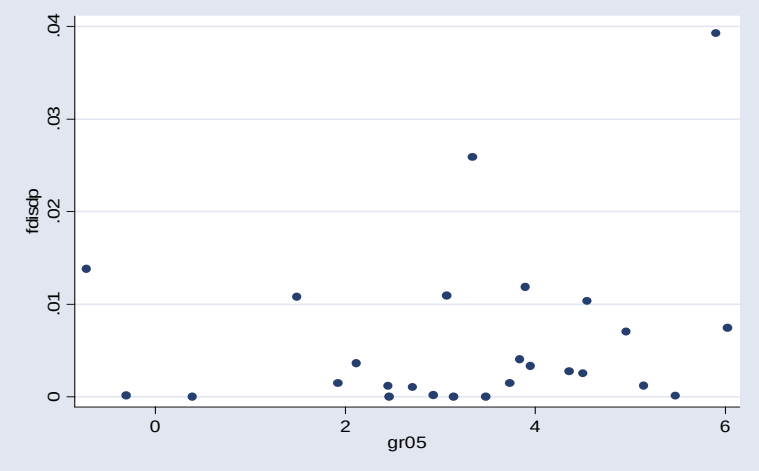

Figure 5: Average Annual Growth Rate of Indian States and FDI as a Share of SDP

3.3 Results

This section considers FDI and growth in a cross-sectional dataset. The central issue of this study is whether FDI has a robust effect on economic growth of Indian states. If so does it depend on any other macro-economic variable or simple presence of FDI can enhance growth. There are 23 states and union territories that are considered in this study.[98] The cross-sectional analysis employs data averaged over 2000-2005 and the baseline regression is:

$$GRTH_i = \alpha' + \beta' SDP_{i,2000} + \gamma' FDI_i + \eta' CONTROLS_i + \epsilon_i \quad (16)$$

where $GRTH_i$ stands for average annual growth rate, $SDP_{i,2000}$ is the initial per capita income of each state, FDI_i refers to the FDI as a share of SDP, $CONTROLS_i$ is the set of conditioning variables for state i and ϵ_i is the error term.

To start our analysis, we report results of regressions which only use the major variables that are expected to affect growth. Table 28 presents regression results using literacy rate, human capital, financial assistance, initial per capita income, research and development expenditure, labor dispute and power.[99]

The results indicate that even after controlling for broad range of variables we cannot explain a significant amount of growth of these states. In fact if we follow the conventional R-square,

[98] The list is given in Appendix 1.

[99] There is no systematic data available for investment in Indian states. We use financial assistance as a proxy for investment. Power stands for over all power supply in each state.

only 30% of growth can be explained. In addition, it is also to be noted that none of these variables are statistically significant. However, this insignificance can arise due to very small sample size. But, results of table 28 provide motivation for our work. Results clearly indicate that apart from human capital, research and development expenditure, financial assistance etc., there is room for some other explanatory variables which can explain the growth. Since the primary objective of this paper is to identify the impact of FDI on Indian states, we introduce FDI as a probable candidate to account for growth of Indian states.

Table 28: Growth and Major Variables for Indian States[100]

Variables	(1)	(2)	(3)	(4)	(5)
$Percapita_{2000}$	-1.006	-1.042	-1.522	-1.808	-1.334
	(1.101)	(1.185)	(1.343)	(1.481)	1.333
Finassist	0.117	0.122	0.195	0.131	-0.086
	(0.245)	(0.255)	(0.297)	(0.306)	(0.384)
$Literacy_{2000}$	0.096	0.095	0.091	0.106	0.132
	(0.043)	(0.046)	(0.051)	(0.067)	(0.075)
Humancap		0.004	0.001	0.009	-0.004
		(0.004)	(0.004)	(0.008)	(0.007)
Labordisp			0.005	0.001	-0.002
			(0.004)	(0.007)	(0.009)
RDexp				0.119	0.222
				(0.201)	(0.273)
Power					0.035
					(0.038)
Constant	-0.023	-0.018	-0.008	-0.018	-0.078
	(0.026)	(0.050)	(0.054)	(0.062)	(0.098)
Observation	23	23	23	23	23
R-squared	0.185	0.186	0.255	0.271	0.302

Table 29 shows results for regressions including FDI as an explanatory variable and its interaction with literacy rate, human capital and financial assistance. The basis for introducing these interaction terms stem from the existing literature on FDI and economic growth. It has been documented in the literature that a country with higher level of human capital reaps more benefit from FDI.[101] Similarly, Alfaro et. al (2004) find that a country with well developed financial markets gain substantially from FDI. In order to capture these effects we introduce only FDI as an explanatory variable in column 1 (of table 29) and then in following columns interaction terms are included. In all regressions we control for initial per capita income, financial assistance, literacy rate and human capital. In column 1, other than literacy rate none of the other variables turn out to be significant at conventional level. The coefficient estimate of literacy rate is 0.095 and significant at 10% level. Although coefficient of FDI is positive but it fails to gain any statistical significance. In the following column we interact FDI with literacy rate. But

[100] Note: In ALL regressions robust standard errors are reported in parenthesis. Labordisp represents statewise mandays lost resulting in workstoppage due to both industrial and non-industrial disputes. We use the average value for the entire period. RD exp is teh average value of R&D expenditure as a share of SDP. Power stands for the overall power supply in a state.

[101] See Borenzstein et. al. (1998), Xu (2000).

results remain the same qualitatively. Like previous, literacy rate is positive and significant and both FDI and its interaction term remain insignificant. Results of column (1) and (2) clearly suggest that literacy rate is an important determinant of growth of Indian states. This definitely indicates that literacy in India is an indispensable means for effective social and economic participation. At the same time results also imply simple presence of high literacy rate is not enough to extract benefits from FDI. According to the official definition of literacy in India: "A literate person is one who can with understanding both read and write a short simple statement relevant to his everyday life".[102] Thus, it is highly unexpected from a "literate" person to adopt new technology, production methods, and/or skill which are bundled with FDI.

To investigate whether human capital enhances effects of FDI on growth we employ sum of statewise enrolment in Bachelor of Engineering, science, architecture, polytechnic and M.B.B.S. interacted with FDI.[103] It is needless to mention that it is not a perfect measure of human capital but we are handicapped due to unavailability of data. In the dataset neither the enrolment ratio nor the total number of engineers, doctors etc., are available for the time period of this study. Thus, to achieve our goal we rely on the above mentioned variable and use it as a proxy for human capital. The reult of including this interaction term is reported in the third column of table 29. The interaction term is significant at 5% level and enters with positive sign and magnitude of 0.75. However, the coefficient of FDI itself is -0.43 and significant at conventional level. This in turn implies that FDI has some negative impact in absence of any human capital. But it is clear from the result that a state with higher human capital extracts more from FDI compared to another state which has lower human capital. To evaluate the importance of human capital in enhancing growth effects of FDI, we can calculate by how much a one standard deviation increase in human capital can boost the growth rate of a state receiving mean level of FDI in the sample. It turns out that a state with higher human capital allows it to experience an annual growth rate increase of 0.07%. The effect is calculated by $\beta_{FDI} * FDI_{mean} * \sigma_{hum} + \beta_{FDI*hum} * \sigma_{hum}$.[104] In column (4) we add the interaction term between FDI and financial assistance. The coefficient of interaction between FDI and financial assistance is positive and significant. Thus one can infer that a state with higher financial assistance reaps more benefit from FDI. The interaction term between FDI and human capital still remains positive and significant. We also conduct the F test for the coefficients of interaction terms to be significantly different from zero in each case. Apart from FDI interacted with literacy, (column 2) in all the cases we reject the null hypothesis. To be noted in all regressions (refer to table 29) literacy rate is through out positive and significant. This clearly reinstates the immense importance of literacy rate in growth rate of Indian states. However, for our objective the main result to be noted from this table is that a state with higher

[102] For more see section on UNESCO in the National Literacy Mission Website.
[103] We use number of people enrolled in a state as a share of its population. Nennenkamp et al. (2007) also use similar measures.
[104] The values of βs come form column (3) of table 29.

human capital and financial assistance is expected to gain more from FDI. The next point of concern is robustness of these results.

Table 29: Growth and Role of FDI in Indian States[105]

Variables	(1)	(2)	(3)	(4)
$Percapita_{2000}$	-1.249	-1.015	-1.385	-1.215
	(1.396)	(1.385)	(1.071)	(1.102)
Finassist	0.088	0.023	1.271*	1.145
	(0.250)	(0.244)	(0.698)	(0.711)
$Literacy_{2000}$	0.095*	0.108**	0.083*	0.084*
	(0.047)	(0.051)	(0.044)	(0.042)
Humancap	-0.002	-0.002	-0.002	-0.007*
	(0.004)	(0.004)	(0.004)	(0.004)
FDI	0.034	0.575	-0.435*	-0.494**
	(0.066)	(0.836)	(0.220)	(0.210)
$FDI*Literacy_{2000}$		-0.665		
		(1.030)		
FDI*Humancap			0.753**	0.827**
			(0.345)	(0.332)
FDI*Finassist				0.002**
				(0.001)
Constant	-0.022	-0.048	-0.035	-0.056
	(0.052)	(0.058)	(0.050)	(0.053)
Observation	23	23	23	23
R-squared	0.202	0.218	0.439	0.494

In addition to above variables we include research and development expenditures (as a share of SDP) by the state government in our estimation (refer to column 1 of table 30). We hypothesize that state support for research and development has beneficial effect on growth of a state. Although the coefficient of R&D expenditure turns out to be positive but it does not gain any statistical significance. FDI interacted with human capital and financial assistance still remains positive and significant.

In column 2 we introduce the labor dispute variable. It is measured as statewise mandays lost resulting in work stoppages due to both industrial disputes as well as reasons other than industrial disputes. A state with large number of labor disputes is expected to have low output. In fact Sanyal and Menon (2004) show labor disputes have detrimental effect on firm location and

[105] Note: In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level

investment decisions. Thus, it can also reduce the aggregate investment in a state. The results of column 2 report a negative coefficient estimate for labor dispute but it has no statistical significance. Another important variable in the context of economic growth of Indian states is power tariff. India stands out as an exception with industrial electricity tariffs much higher than domestic rates.[106] Industrial tariffs are comparatively much higher due to cross-subsidisation of agriculture and domestic sectors. At the same time power tariff varies from one state to the other. Since, power is an essential input in the production process we also control for statewise cost of power. Column 3 indicates a negative coefficient for power implying higher cost of power can reduce growth. However, this coefficient is not statistically significant. In our final specification, we control for total number of urban and agricultural workers to total workers in column 4 and 5 respectively. But, results remain the same. Thus the key result of this analysis implies that a state with higher human capital and financial assistance can gain more from FDI compared to others.

Table 30: Robustness Check[107]

Variables	(1)	(2)	(3)	(4)	(5)
$Percapita_{2000}$	-2.103*	-1.990	-2.032	-2.121	-2.077
	(1.129)	(1.187)	(1.206)	(1.283)	(1.415)
Finassist	1.019*	1.020*	1.053	1.105*	1.050
	(0.541)	(0.563)	(0.616)	(0.601)	(0.649)
$Literacy_{2000}$	0.099**	0.113*	0.111	0.116	0.109
	(0.046)	(0.059)	(0.076)	(0.081)	(0.080)
Humancap	-0.007	-0.009	-0.009	-0.007	-0.009
	(0.004)	(0.006)	(0.008)	(0.009)	(0.009)
FDI	-0.440**	-0.518**	-0.527**	-0.414*	-0.529**
	(0.165)	(0.210)	(0.220)	(0.224)	(0.207)
FDI*Humancap	0.772**	0.854**	0.865**	0.670**	0.865**
	(0.255)	(0.292)	(0.279)	(0.314)	(0.290)
FDI*Finassist	0.002**	0.003*	0.003*	0.004**	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
RDexp	0.146	0.250	0.243	0.165	0.243
	(0.094)	(0.205)	(0.257)	(0.292)	(0.269)
Labordisp		-0.005	-0.005	-0.004	-0.005
		(0.008)	(0.010)	(0.011)	(0.010)
Power			-0.003	-0.015	-0.002
			(0.041)	(0.045)	(0.043)
Urban/Total Wks				-0.000	
				(0.000)	
Agri/Total Wks					-0.000
					(0.000)
Constant	-0.061	-0.078	-0.073	-0.055	-0.070
	(0.057)	(0.075)	(0.108)	(0.117)	(0.116)
Observation	23	23	23	23	23
R-squared	0.569	0.580	0.580	0.606	0.580

[106] Source: Indiastat.

[107] Note: In ALL regressions robust standard errors are reported in parenthesis.*** implies significant at 1% level,** implies significant at 5% level,* implies significant at 10% level. Urban/Total Wks and Agri/Total Wks represent total number of urban and agricultural workers to total number of workers respectively.

3.4 Conclusion

In the 1990's Foreign Direct Investment became the major source of private capital flows to developing economies.[108] Due to the sudden disappearance of commercial bank lending in 1980's many developing nations started to offer various fiscal and financial incentives to foreign firms. It is widely believed that the extent to which FDI can affect output growth is not limited to the capital it supplies. Instead, FDI is thought of as composite bundle of capital stocks, technology know how, better managerial skills, labor training and other externalities that benefit output in several ways.

Prior to early 1990's India used to have restrictive and regulated market for foreign capital. During this period, there were various obstacles (red tapes) and procedures for approval of foreign collaborations. However in early 90's, India faced extreme foreign exchange and balance of payments crisis which forced policy makers to opt for liberal policy regime. New Industrial Policy (NIP) in 1991 dissolved industrial licensing and market became less regulated. Due to the adoption of liberalization policies by India since 1990's the FDI inflows have increased consistently from 237 million dollars to 5335 millions dollars in 2004.[109]Given this fact, we investigate whether Indian states (which vary in terms of demography, economy, geography, labor regulations etc.,) have benefitted from the rapid increase in FDI inflows.

Using a cross-sectional dataset on 23 Indian states and union territories for the period 2000-2005 we find that states which have higher human capital and financial assistance gain more benefits from FDI compared to others. Our results remain the same after controlling for other relevant variables. Results also indicate that literacy rate is an important determinant of growth of Indian states, but just being "literate" is not enough for a state to extract externalities from FDI. Rather, intensive financial assistance and higher enrollments in technical studies such as engineering, medicine, architecture etc., are essential ingredients for FDI to enhance growth. Our results re-iterate findings of few cross-country studies which also stresses on financial development and human capital.[110] Thus, primary results of this paper imply that before offering various incentives to foreign firms Indian states should concentrate on their financial environment and human capital.

[108] Source: UNCTAD's World Investment Report 2006.
[109] Source: World Investment Report (Various Issues).
[110] For example see Borensztein et. al. (1998), Alfaro et. al. (2002).

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APPENDIX A: DATA SOURCES

Data on investment, population, export and import for all countries are taken from PWT 6.1

Human capital data has been constructed using Barro and Lee (2004) dataset.

Foreign direct investment as a share of GDP and GCF are from World Development Indicators (2005).

Financial variables are from World Development Indicators (2005).

Exporters of fuel - mainly oil, ethnolinguistic fragmentation, social infrastructure, GADP, economic organization, years of opening, log of Frankel and Romer trade share, Latitude, LAMAR and Africa are from Hall and Jones dataset (1999).

APPENDIX B: SOLUTION OF BENHABIB AND SPIEGEL (2005)

Assuming that the leader is growing at a rate of gL, we can write $\mathrm{A_L}(\mathrm{t}) = \mathrm{A_L}(0)e^{gL^t}$. Thus equation (4) in the text can be rewritten as

$$A_i(t)/\{A_i(t)\}^2 \; - \frac{g_i + \; c_i}{A_i(t)} = \; - \frac{c_i e^{-gL^t}}{A_L(0)} \tag{17}$$

Substituting $y(t) = \; 1/A_i\,(\mathrm{t})$ we get$\big(-y(t)\big) = \; A_i \; (t)/\{A_i(t)\}^2$. Hence equation 9 changes to

$$-y(t) - \; (g_i + \; c_i)y\;(t) = \; - \frac{c_i e^{-gL^t}}{A_L(0)} \tag{18}$$

where $g_i = g(H_i(t))$ and $c_i = c(H_i(t))$

Multiplying both sides by the integrating factor $e^{(g_i + \, c_i)^t}$and integrating we have

$$e^{(g_i + \, c_i)^t} y(t) = \left\{c_i e^{(g_i + \, c_i - gL)^t}\right\}/A_L(0)(g_i + \; c_i - gL) + K \tag{19}$$

as the general solution where K is integrating constant. Evaluating the solution at a value of t=0 generates K, which is equal to $\frac{1}{A_i(0)} - \; c_i/A_L(0)(g_i + \; c_i - gL)$ and $A_i \; (t)$ can be written as

$$A_i(t) = \left[A_i(0)e^{(g_i + \, c_i)^t}\right]/[1 + \{\frac{A_i(0)}{A_L(0)}\}\frac{c_i}{(g_i + \; c_i - gL)}\{e^{(g_i + \, c_{i-gL})^t} - \; 1\} \tag{20}$$

Simplifying further it turns out that

$$A_i(t) = \frac{\mathrm{A_L}(0)e^{gL^t}}{e^{-(g_i + \, c_i - gL)^t}}\{\frac{A_L(0)}{A_L(0)} - \; \frac{c_i}{(g_i + \; c_i - gL)} + \; \frac{c_i}{(g_i + \; c_i - gL)} \tag{21}$$

So that in limit

$$\lim_{t\to\infty} \frac{A_i(t)}{\mathrm{A_L}\,(\mathrm{t})}(\mathrm{t}) = \begin{pmatrix} \frac{(c_i + \; g_i - gL)}{c_i} \; if(c_i + \; g_i - gL) > 0 \\ \frac{A_i(0)}{A_L(0)} \; if \; (c_i + \; g_i - gL) = 0 \\ 0 \; if \; (c_i + \; g_i - gL) < 0 \end{pmatrix} \tag{22}$$

APPENDIX C: NAME OF STATES AND UNION TERRITORIES

Andhra Pradesh

Arunachal Pradesh

Assam

Bihar

Chandigardh

Delhi

Goa

Gujarat Haryana

Himachal Pradesh

Karnataka

Kerala

Madhya Pradesh

Maharashtra

Nagaland

Orissa

Pondicherry

Punjab

Rajasthan

Tamil Nadu

Tripura

Uttar Pradesh

West Bengal

VITA

Subaran Roy was born to Sukomal Roy and Supriya Roy in Kolkata, India. He has an elder brother, Samiran Roy. Subaran is married to a nice lady, Swetasri Roy, who is pursuing her doctorate. Subaran joined Louisiana State University to pursue the Doctor of Philosophy in the year of 2002. He completed his bachelor's degree in economics and Master of Arts in India.