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FDI and Total Factor Productivity Growth: New Macro Evidence

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Abstract

Although the role of FDI in facilitating technology transfer is well-known in the literature, empirical evidence regarding the effect of FDI on growth is mixed. The contradictory results in the literature may be due to the failure to account for endogeneity and for the abortive capacity of the hosting countries. Using panel data for 49 countries over the period 1974-2008 and the existence of Investment Promotion Agencies in the receiving countries as an instrument, our results show that increased FDI stock leads to higher productivity growth. We also find a significant positive effect on the interaction between FDI stock and distance to the technological frontier, suggesting that the ability of technologically backward countries in absorbing technologies developed at the frontiers increases as more FDI stock is accumulated.

Keywords: FDI, TFP growth, technological transfer, technology gap, system GMM
JEL codes: F21, F23, O33

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1.1 Introduction

The relationship between Foreign Direct Investment (FDI) and economic growth has been well studied in the literature. A number of studies have focused on exploring the channels of technological diffusion from multinational corporations (MNCs) to the recipient countries. In principle, knowledge can be transmitted through the following channels: imitation of the technological production process of multinationals by the local firms (Das, 1987; Wang & Blomstrom, 1992); skills acquisition which relates to hiring of workers of FDI-firms by the local ones which can bring new knowledge and advanced managerial skills (Dasgupta, 2012; Fosfuri, Motta, & Røndee, 2001); and competition from multinationals, which can force domestic firms to use their existing technologies more efficiently (Glass & Saggi, 1998). All of these studies suggest that more foreign presence leads to higher productivity of domestic firms.

Interestingly, despite these theoretical propositions, there is still a lack of consensus in the literature. While some studies report a positive effect of FDI on growth (see, for example, Bitzer & Gorg, 2009; Liu *et al.*, 2000; Woo, 2009) others find that foreign presence negatively affects growth or productivity, or at best, its impact is unclear (See, Aitken & Harrison, 1999; Alfaro *et al.*, 2004; Ang, 2009; Azman-Saini *et al.*, 2010; Haddad & Harrison, 1993). In their analysis of the manufacturing industry data on 17 OECD countries, Bitzer and Gorg (2009) find that inward FDI increases industrial productivity. On the other hand, using firm-level panel data for Venezuela, Aitken and Harrison (1999) discover that more foreign presence in the same industry decreases the productivity of domestic firms, casting doubt on the idea of horizontal spillovers. At the macro level, Li and Liu (2005) and Woo (2009) both show that the share of FDI inflows in GDP increases income and TFP growth respectively. De la Porterie and Lichtenberg (2001) have analyzed OECD country level data for technological spillovers of foreign knowledge through various channels, including FDI, and reported an insignificant effect from inward FDI flows. Several other cross-country studies have also failed to find direct positive technological externalities from FDI to host countries (See Alfaro *et al.*, 2004; Borensztein et. al., 1998; Durham, 2004; Hermes & Lensink, 2003; Herzer, 2012).

We argue that these conflicting results are due to a lack of consistent estimation. Three examples of this are: the problems of endogeneity have been ignored (Borensztein *et al.*, 1998; Busse & Groizard, 2008; De la Porterie & Lichtenberg, 2001; Woo, 2009); foreign presence measures have been obtained from FDI flows (Alfaro *et al.*, 2004; Borensztein *et al.*, 1998) and the analysis has been concentrated on economic growth. Also, despite the theoretical emphasis (Glass & Saggi, 1998; Wang & Blomstrom, 1992), there has not been sufficient consideration of the importance of the distance to technology leader[1] to benefit from FDI. We develop a new instrument for FDI based on Investment Promotion Agency data and exploit the system GMM technique to consistently estimate technological spillovers from FDI. We also test if countries benefit from FDI if they have more absorptive capacity (more potential to benefit from FDI due to larger technology gaps).

The endogeneity problem should properly be dealt with in order to consistently estimate the effect of FDI on growth. The econometric models that specify only FDI affects growth, but not vice versa, can fail to account for the possibility of reverse causality, such as when FDI is influenced by higher rates of growth. By using a simultaneous equations model which solves reverse causality, Li and Liu (2005) report positive results from FDI on economic growth in a sample of 84 countries. They also show that there is a significant endogenous relationship between FDI and economic growth. But the simultaneous equations method does not account for a source of endogeneity through other control variables in the estimation, which are often correlated with high income growth rates. Another cross-country study which employs the Granger causality test shows that the effects of causality are more apparent from growth to FDI rather than from FDI to growth (Choe, 2003). These findings clearly indicate that endogeneity should be taken into account. One way to overcome the endogeneity problem is to run the instrumental variables regression. It is a challenging task, however, to find good instruments for FDI which are correlated with FDI but not the error of income growth. Alfaro *et al.* (2004), for example, have used real exchange rates. Although FDI can be instrumented with real exchange rates, a decision to set up a MNC is determined by many other factors, and real exchange rates can still be a very weak instrument.

A second issue has to do with the measurement of FDI. In most of the cross-country studies, FDI is measured as the share of inward FDI flows in GDP rather than the stock. FDI flows can be volatile due to business cycles. The measurement of FDI in stock instead of flow can yield different results on a country's TFP growth. Perhaps the effect of FDI on growth is ambiguous because it indirectly works through TFP and factor accumulation. Whether FDI crowds domestic factor accumulation in or crowds it out is not theoretically clear. Another

[1] The term *distance to technology leader* is used interchangeably with the terms *technology gap* and *distance to technology frontier*. All three terms refer to exactly the same concept.

justification for using the stock of FDI is that it captures already established multinationals in the host country, which might be benefiting the local firms through various channels of spillovers identified in theory as well as through backward (vertical) linkages. There is an established positive effect from FDI firms on their suppliers' and buyers' productivity through vertical relationships, as evidenced by Wang (2010) in Canadian manufacturing industries, Blalock and Gertler (2008) in Indonesian manufacturing firms and Bwalya (2006) in Zambian manufacturing firms.

It may also matter whether the dependent variable is income growth or total factor productivity (TFP) growth in cross-country studies. Because technological change is an important determinant of TFP, and most of the theories of spillovers from FDI relate to the improvement of domestic firms' technological progress (Das, 1987; Wang & Blomstrom, 1992), concentrating on TFP growth rather than income should be central to the analysis. Therefore, in the majority of macro-level studies that measure the dependent variable as income growth, we observe that the net income is not changing even though domestic productivity is increasing as a result of increased FDI. Surprisingly, when TFP growth is used as a dependent variable, Woo (2009) finds a significant direct positive effect from FDI in cross-country analysis. Moreover, measuring the dependent variable as TFP growth, rather than income growth, is crucial since most of the income differences across countries are due to differences in TFP (Easterly & Levine, 2001; Klenow & Rodríguez-Clare, 1997).

Several authors report positive indirect spillovers from FDI through absorptive capacities of domestic countries other than the technology gap. Among those factors are the level of human capital (e.g., Borensztein *et al.,* 1998), the level of financial development (Alfaro *et al.*, 2004; Ang, 2009; Azman-Saini *et al.*, 2010) and the level of economic freedom (Azman-Saini *et al.*, 2010). Theoretical studies (Findlay, 1978; Wang & Blomstrom, 1992) strongly indicate that larger distances to technology leaders are good for host countries. The more that domestic firms lag behind the multinationals, the more benefit they can get from the latter because of the 'catching up' effect. So the technological externalities from FDI are an increasing function of the technology gap between the 'backward' region and the 'advanced' region.

Building on the product variety model of endogenous growth, Broensztein *et al.* (1998) propose that more foreign presence reduces the cost of introducing new varieties and hence is good for growth. Moreover, the fewer the variety of capital goods in the host country (the higher the technology gap) the lower will be the adaptation cost of technology, suggesting that such countries will grow faster. Only two studies have explored the importance of the technology gap with a country-level analysis, but with contradictory results.

In one of them, Li and Liu (2005), using annual panel data, discover that a higher technology gap (measured as per capita income ratios) between the domestic economy and the technology leader reduces the positive effect from FDI on income growth. However, Shen *et al.* (2010) find high income levels mitigate the positive impact of FDI, while middle income levels can enhance the positive effect from FDI on income growth, which points towards the acceptability of the advantage of the relative backwardness theory. Micro-level studies also yield conflicting results. Liu *et al.* (2000), for example, find a negative significant impact from the technology gap in the UK manufacturing industry. A recent finding of Blalock and Gertler (2009) demonstrates that Indonesian manufacturing firms with larger technological gaps gain from FDI, whereas FDI alone has no significant effect on a firm's productivity. Perhaps UK manufacturing firms' technology gap is not large enough to generate more spillovers from FDI compared to the Indonesian firms, as reflected in the findings of Shen *et al.* (2010).

This study contributes to the literature in at least two important ways. First, we control for endogeneity using the system GMM estimation method. In doing so, we construct a new external instrument for FDI based on the census data of Investment Promotion Agencies (IPAs), as conducted by Harding and Javorcik (2011). This instrument is based on whether or not an IPA exists. We assign larger weights to more recent IPAs to account for the importance of recent years. We also incorporate government efficiency into the instrument. We show that our instrument is highly correlated with FDI and we use it for FDI in the analysis. To our knowledge, we are the first to use such an instrument for FDI in cross-country analysis.

Second, we test if larger distances to the technology leader can enhance the benefit from FDI. Our results indicate FDI significantly contributes to TFP growth. We also find that the larger the gap between the technology leader and the host country's technology level, the higher the benefit from FDI. These results remain robust to the reduction of the sample period and changing of sample to a nine-year average. Different measures of TFP growth and the distance to the technology leader, as well as different panel data estimators, still confirm our main findings.

The rest of this chapter is organized as follows: Section 1.2 is the literature review, Section 1.3 discusses the empirical framework and estimation issues, Section 1.4 explains the construction of variables and graphical evidence, Section 1.5 reports the results and Section 1.6 concludes the analysis.

1.2 Literature review

1.2.1 Theories of FDI and technological diffusion

Multinational corporations started to dominate the world economy from the 1970s onwards. Several nations which hosted those giants achieved great economic success by accelerating the 'catching up' process to technology leader countries. As a result, economists began to devise models to analyze the impact of the existence of multinational corporations on the technology level of domestic firms.

Findlay (1978) was one of the pioneers of FDI spillovers theory. His model was based on the earlier ideas of relative backwardness of Gerschenkron (1962) and technological 'contagion'. Since firms in a backward region can not only learn the advanced multinational's technology by imitation but also can be forced to 'try harder', relative backwardness can translate into more spillovers. Also, the 'contagion' effect indicates that the larger the share of multinationals in the backward region, the faster the efficiency of backward firms will grow. Then the change of the backward region's efficiency becomes an increasing function of foreign presence, and a decreasing function of the relative technical efficiency of the backward region to the foreign region (inverse technology gap).

Assuming that the technological transfer is costless, Das (1987) shows that the existence of multinationals in a host country is welfare-improving. Due to the effect of spillovers from multinational's subsidiary which uses better technology, the efficiency of native firms also increases, and overall, the host country benefits.

One important feature of early theories of technological diffusion is the assumption of a costless transfer of technology (externalities) from multinationals to local firms (Das, 1987; Findlay, 1978). In fact, there are always costs associated with transferring technology from a parent company to its subsidiary, and learning investment from native firms. By taking into account these issues, as well as preserving the advantage of relative backwardness in their model (Findlay, 1978), Wang and Blomstrom (1992) show that the rate and modernity of technology transfer through multinationals is positively related to the learning investment of native firms. This has a very important implication: unless domestic firms are devoting enough resources and efforts to learn a multinational's technology, the latter will be transferring to their subsidiaries outdated technologies at a slower rate.

Another theory which stresses the costliness of technology transfer deals with technological spillovers through worker mobility. Fosfuri (2001) postulates that multinational enterprises can transfer advanced technology only after training domestic workers. When those workers are later hired by domestic firms, spillovers can take place. However, multinationals might have to increase the wages of their workers in order to prevent their 'firm-specific assets'. Even so, the domestic economy may benefit in terms of welfare gains through higher earnings. Dasgupta's (2012) recent model of knowledge spillovers through workers finds a similar conclusion. In a dynamic framework, the workers of foreign-owned firms can later move to other domestic firms, or can even establish their own firms, which in steady state would be larger (and more productive) than in autarky. This suggests the importance of the time dimension in determining externalities from FDI, which can be observed through generated FDI stock over time, rather than flows.

At the macroeconomic level Borensztein *et al.* (1998) developed a theory based on the endogenous growth model of 'capital deepening'. In their model an increased variety of capital is costly, and requires the adaptation of technology developed in advanced countries. The fixed set-up cost of producing new capital goods is a decreasing function of the ratio of the number of foreign firms in the host country to the total number of firms. Thus, more FDI reduces the cost of new capital production. Moreover, they further introduce the fixed cost to be positively dependent on the number of capital varieties produced domestically, relative to those produced in advanced nations. The latter assumption is still based on the advantage of relative backwardness: it is cheaper to imitate rather than innovate. In steady state, FDI increases the rate of new capital goods introduction; also, countries producing lower varieties tend to grow faster than the ones close to the technology frontier. Baldwin *et al.* (2005) also base their model on endogenous growth. They define two types of spillovers from multinationals: one through interaction ('osmosis'), the other through observing the knowledge from home-based multinationals. As a result, local firms can increase the varieties (hence productivity) in their domestic economy. In equilibrium, GDP grows with the growth of variety (productivity) which in turn is positively related to the degree of multinationality. Baldwin *et al.* still preserve the assumption that a small country (i.e. one that produces less variety) can benefit more through FDI spillovers.

Most of the models analyzing the knowledge transmission from FDI firms have overlooked the risk involved in the FDI decision. Chang and Lu (2012) have lately considered risk in their model: the failure of FDI in the South would increase with the technology content of FDI and the South's distance to the technological frontier. With this formulation they show that only intermediate technology FDI is undertaken, once a minimum technology level is reached. After the South's technology gap is reduced through intermediate technology FDI, the high-tech FDI will follow due to a lower risk of failure. This is supported empirically with Taiwanese and Chinese manufacturing firm level data. For the purpose of our analysis, this would imply that larger technological distances would not hinder spillovers from FDI, since the technology content of FDI would not be very complex for a backward country to emulate. All these theories point out that FDI is an important channel of technology transfer and serves the improvement of domestic firms' efficiency, and in the end, should improve the country's total factor productivity.

1.2.2 Micro-level studies of FDI and technological spillovers

As has been stated earlier, data analysis results in the search for technological spillovers from FDI are very mixed.

Early empirical works on FDI spillovers have been conducted at the industry level due to the availability of data. Caves (1974), for example, examined manufacturing sector data in Canada and Australia. While not finding any improvement from FDI in the manufacturing sector productivity in Canada (measured as the subsidiary's share of industry sales) he discovered that productivity rose in Australian manufacturing. Earlier industry level analysis used only cross-sectional data, and hence, could not control for fixed industry effects. Some recent analyses with industrial panel data also confirm the existence of technological spillovers for the UK (Liu *et al.,* 2000) and for OECD countries (Bitzer & Gorg, 2009).

Another important line of research on FDI spillovers has been done at the firm level. Using manufacturing sector firm level data in Morocco, Haddad and Harrison (1993) find no evidence that the productivity of domestic firms has risen due to greater foreign presence in the sector. Moreover, as opposed to the advantage of relative backwardness, they find that advanced MNC technology hinder spillovers. Nevertheless, Kokko (1994) discovers that the technological gap alone does not impede spillovers but a large technology gap and high foreign shares in the industry can inhibit technological diffusion from multinationals to native firms. Aitken and Harrison (1999) also find that increased FDI in the same industry decreases the productivity of domestic firms. This happens because multinationals crowd out the latter by the market-stealing effect.

Although some firm-level studies have yielded negative or ambiguous results on spillovers from FDI, recent studies do detect significant positive effects. Keller and Yeaple (2009) report FDI to have positively affected the productivity of US firms between 1987 and 1996. In contrast to Haddad and Harrison (1993), the technological spillovers were very strong in high-tech sectors and absent in low-tech sectors. Liu (2008) argues that there are two effects from FDI: a negative level effect which is seen as a decline in firm productivity and a positive rate effect where FDI increases the long-term productivity growth rate. Chinese manufacturing firm level analysis supports these two effects.

While horizontal spillovers from FDI to competing firms can be mixed, there is empirical support for vertical spillovers through backward and forward linkages of local firms with multinationals. Javorcik (2004) reports that FDI increases productivity of Lithuanian firms in the upstream sectors which supply to the foreign affiliates. But the positive spillovers from FDI come from partially owned foreign firms as opposed to fully owned ones, since the partially owned FDI firms engage in more outsourcing activities. Bwalya (2006) finds a positive significant effect from FDI firms to their suppliers and buyers with Zambian firm-level data. There is also strong evidence on vertical technology spillovers in Canadian manufacturing (Wang, 2010).

When it comes to the advantage of relative backwardness, Girma (2005) discovers the threshold effects of technology gap through which FDI can affect firm productivity. While FDI-related productivity initially increases with more absorptive capacity (the ratio of domestic firm’s TFP to the industry leader’s TFP, i.e. an inverse technology gap), the rate of increase diminishes at higher levels of absorptive capacity. This implies that firms with high levels of technology gain less from FDI. With subsampling Indonesian firm-level data into low and high technology gap sectors, Sjoholm (1999) finds a higher technological gap is good for firms to benefit from FDI by increasing the value added per employee, while the growth of value added per employee benefits from FDI only in industries where the gap is larger. Another Indonesian manufacturing data analysis reports findings which confirm the advantage of the technology gap to benefit from FDI (Blalock & Gertler, 2009). Along with other firm absorptive capacities, Blalock and Gertler (2009) state that larger levels of the technology gap increase a firm’s ability to seize the benefits of advanced technologies brought by MNCs. Moreover, it seems that firms with high technology gaps (hence a greater base for technological progress) can adopt more of the multinationals' technology, in contrast to medium or small technology gap firms. Before we start our discussion of country-level studies, let us summarize the major lessons learnt from micro-level analysis. Direct horizontal spillovers are almost nonexistent, while there is growing support for the role of vertical spillovers. The benefit of technological backwardness is ambiguous.

1.2.3 Country-level studies of FDI and growth

Despite numerous studies conducted at the macro level on the FDI growth nexus, the literature has not yet reached consensus as it has in the case of micro-level analysis. In most cases endogeneity due to unobserved factors and fixed country characteristics were ignored. Although the theoretical literature states that the presence of FDI increases productivity through 'externalities', cross-country analyses have extensively focused on income growth and used the FDI flows to measure foreign presence, which cannot capture the long-term effect from FDI.

In a cross-country regression of data for 69 countries, Borensztein *et al.* (1998) find that the direct effect of FDI on growth is not significant, although it is positive. But when it is interacted with human capital, the interaction term is positive and significant. This implies that the positive effect of FDI depends on the level of human capital. Several other studies have found similar ambiguous exogenous effects from FDI. Alfaro *et al.* (2004) find an unclear effect from FDI flows on growth, but a positive effect of FDI can be facilitated by a better financial system in a cross-section of over 70 countries. Both these studies relied on cross-sectional data, which ignores country-specific factors. Azman-Saini *et al.* (2010) also confirm that the growth-enhancing effect of FDI kicks off only after a certain level of financial development is reached. Durham (2004) also does not detect any direct positive effect from FDI on growth in a cross-section of 80 countries. But the effect of FDI is positive if financial or institutional development is high.

Apart from cross-sectional reliance, FDI flows have extensively been used for the measure of foreign presence, which, as mentioned earlier, does not capture already established firms in the economy and can be prone to volatility. In fact, Lensink and Morissey (2006) show that the volatility of FDI flows leads to the contraction of GDP. One possible reason for such an effect could be the uncertain costs of R&D, which could be the result of uncertain FDI flows, reducing incentives to innovate.[2]

Some country-level analysis even reports negative effects from FDI flows on GDP growth. Herzer (2012), for example, studies a sample of 44 developing countries using panel data and finds, on average, that FDI decreases growth. But the results vary across countries. About 60% of countries have experienced long-run reduction in GDP, while the other 40% have experienced an increase. This suggests the importance of country-specific heterogeneity. Other recent studies, on the other hand, have found a positive effect from FDI on growth. Cipollina *et al.* (2012) find a direct positive effect from FDI stock on the productivity of OECD countries using industry-level data. With cross-sectional data of both developed and developing countries Busse and Groizard (2008) report a positive significant effect from FDI on growth, although it is impossible to say that this is an indirect effect, since the FDI variable is interacted with the regulation dummy variable in all estimation results. But Zhu and Jeon (2007) provide evidence on the direct positive (albeit small) effect of FDI, on the productivity growth in 22 developed countries. The same set of countries used in earlier studies with macro-level data have not benefited from FDI (De la Porterie & Lichtenberg, 2001).

Interestingly, some researchers have discovered a positive effect from FDI when the dependent variable is measured as TFP growth. Woo (2009), for example, analyzed a panel of over 90 countries spanning 30 years. He finds that the share of FDI flow in GDP increases TFP growth of a country, whereas the absorptive capacities do not affect the impact of FDI. Alfaro *et al.* (2009), on the other hand, do not find any direct impact from the same measure of foreign presence on a country's TFP growth, but there is an indirect positive effect through more financial development. It should be noted, though, that these studies have not taken into account the endogeneity problem.

Endogeneity between FDI and growth as well as time-invariant country effects could potentially be the reason for the lack of consensus in the literature (Choe, 2003; Li & Liu, 2005). Using the simultaneous-equations model, which controls for the problem of reverse causality (but not endogeneity due to other control variables), Li and Liu report a positive effect of FDI on growth. In contrast, another study (Azman-Saini *et al.,* 2010) employs the system GMM estimation technique, and hence, controls for both endogeneity and fixed

[2] FDI flows can reduce the cost of R&D, and volatility in FDI flows can create uncertainty in R&D costs.

country effects. It reveals that FDI flow has no direct positive effect on growth, and only becomes positive when there is enough economic freedom.

The analysis of the effect of FDI through the technology gap has received little attention at the macro level, and the limited number of studies has examined it by using the dependent variable as income growth. The idea that a larger distance to technology leaders can augment the impact of factors contributing to growth has been widely explored in the macro literature. Griffith *et al.*(2004) investigate whether countries with larger technological distances to the frontier benefit more from R&D investment and accelerate their catching up process, since they have a greater base to absorb knowledge through R&D. They provide evidence on the importance of the distance to the technology frontier using a sample of OECD countries. In another panel-data analysis of both developed and developing countries, Madsen *et al.* (2010) looked at the effect of research intensity and human capital on TFP growth through the technology gap. They found that countries with larger technology gaps catch up faster through R&D intensity and human capital. But these results vary between developed and developing countries.

In FDI and growth literature, to the best of our knowledge, only two studies have looked at the role played by the technology gap. Li and Liu (2005), for example, measure the technology gap as the ratio of relative income between the US and the country under consideration. They then include the interaction term of the technology gap with the FDI variable (FDI flows in GDP) to test whether the effect of FDI on income growth depends on the level of technology gap. Controlling for simultaneity, they find that larger technology gaps inhibit the positive effects of FDI, as suggested by the negative significant sign of the interaction term. Shen *et al.* (2010), by contrast, provide evidence of the advantage of relative backwardness to benefit from FDI. By confirming the primary effect from FDI to be positive, they further show that high income levels, along with other conditional variables, mitigate the positive impacts of FDI on income growth. The middle income levels enhance the effect of FDI. Their results remain robust when business cycle effects are corrected by eight-year averaged data. In our work, we use the share of FDI stock in GDP rather than flow, and exploit different measures of the technology gap. With the aim of controlling for endogeneity in the best possible way, we construct a new instrumental variable (IV) for FDI and employ the system GMM technique for panel-data studies.

In several respects our work is closely related to the studies conducted by Woo (2009), Alfaro *et al.* (2009), Azman-Saini *et al.* (2010), Li and Liu (2005) and Blalock and Gertler (2009). We analyse the impact of FDI on TFP growth as in Woo (2009) and Alfaro *et al.* (2009). Azman-Saini *et al.* (2010) have also used the system GMM technique to examine the effect of FDI flows on GDP growth, but failed to find a direct positive impact. And finally, both Li and Liu (2005) and Blalock and Gertler (2009) study the importance of the distance to technology frontier to benefit from FDI. From these studies, the direct impact of FDI on TFP growth is ambiguous. The results of the only two studies which analyze the effect of technology gap on FDI spillovers are also inconclusive. In our analysis, we address the following two questions: Is there any direct positive effect from FDI on countries' TFP growth? And, do countries with larger distances to the technology frontier have greater potential to benefit from FDI? We hypothesize that both these effects are positive, and the reason why the previous research has found contradictory results is due to the problems discussed earlier.

1.3 Empirical framework and estimation method

Going back to our earlier discussion of FDI spillovers theory (Findlay, 1978; Fosfuri *et al.*, 2001; Wang & Blomstrom, 1992) we hypothesize that FDI increases the efficiency of firms in the host country, and since we are dealing with macro analysis, increased efficiency will lead to TFP growth. After combining this with the concept of the advantage of relative backwardness, a country's TFP growth becomes a function of FDI (share of FDI stock in GDP), distance to the technology frontier (DTF) and other control variables (X). The following model is estimated:[3]

$$\Delta lnA_{it}=\alpha_0+\alpha_1 lnDTF_{i,t-1}+\alpha_2 FDI_{it}+\alpha_3 FDI_{it}*lnDTF_{i,t-1}+\beta*X_{it}+\mu_i+\varepsilon_{it} \qquad (1)$$

where we specify the effect of foreign presence (FDI) on TFP growth to be dependent on the distance to the technology frontier.

We also include distance to the technology frontier (DTF) separately to capture autonomous technological transfer from advanced countries to technologically backward ones (Griffith *et al.* 2004; Madsen *et al.* 2010). Larger DTF is more likely to be associated with faster catching-up to technology leaders. Technologically backward countries are able to import and exploit the technologies developed in advanced countries. Moreover, backward countries can

[3] We consider a model without dynamics since our dependent variable is TFP growth. Dynamic specification does not change our results and the lagged dependent variable enters insignificantly as shown in the Appendix.

jump over several early stages of technological progress due to extra scales of economies (Gerschenkron, 1962). There is evidence that countries tend to converge to parallel growth rates (Barro & Sala-i-Martin, 1992). We include the first lag of DTF to account for the fact that it might take time to imitate technologies developed elsewhere. This is a measure of convergence and is expected to be positive.

Under the specification in equation (1), an FDI host country with greater distance to the technology leader, will have a greater base to absorb the multinational firm's technology. If α_2 measures the direct impact of foreign penetration, α_3 captures the marginal effect of FDI-based absorptive capacity, i.e. the potential of FDI to generate more technological transfer to technologically backward countries. The net effect from FDI is $\alpha_2+\alpha_3 lnDTF_{i,t-1}$. A positive significant sign on α_2 indicates that FDI increases TFP growth. Positive α_3 would then imply that backward countries have more potential to absorb technology from FDI.

The following control variables are used in this analysis, which are taken from the growth literature. Endogenous growth theories predict R&D input to be an important determinant of TFP growth since new innovations created through R&D can improve ways the final goods are produced, which ultimately raises efficiency (Aghion & Howitt, 1998; Jones, 1995; Romer, 1990). Ha and Howitt (2007) show that among the two competing endogenous growth theories: *semi-endogenous* (Jones, 1995) and *Shumpeterian* (Aghion & Howitt, 1998; Howitt, 1999) only the latter is consistent with real-world data. This is further reinforced by the findings of Madsen *et al.* (2010) and Ang and Madsen (2011). Hence we include R&D expenditure over GDP (RY) as one of the control variables.

Human capital (HK) is also included as higher levels of educational attainment can help countries to develop technologies as well as increase their ability to absorb technologies developed elsewhere (Kneller, 2005; Nelson & Phelps, 1966). Greater human capital obtained from education, training and accumulated through learning-by-doing processes can increase the efficiency of labor and also enhance TFP. Islam (1995) finds that human capital does not significantly affect output, but should impact growth through total factor productivity. Including human capital growth into their output-growth estimation, Benhabib and Spiegel (1994) report either an insignificant or a negative effect from human capital. They conclude that human capital influences growth through its effect on TFP. Miller and Upadhyay (2000) do not obtain any direct positive significant effect from human capital stock on TFP, but human capital remains positive and significant (at 10%) when it enters income estimation. But a recent finding of Ang *et al.* (2011) emphasizes the importance of the composition of educational attainment. In high and middle income countries higher tertiary educational attainment can boost TFP since they are more likely to innovate, whereas in developing countries human capital is not significant due to the fact that they imitate the technologies developed in more advanced countries.

Trade openness (TO) is entered as another control variable in growth regression. Openness to trade can give a country better access to technologies developed elsewhere and enhance their catching-up process through adaptation of advanced foreign technologies (Keller, 2004). Openness to import makes it more accessible to different varieties of capital goods which increases efficiency (Barro & Sala-i-Martin, 1995; Romer, 1990). Miller and Upadhyay (2000) report that trade openness, measured as the share of exports in GDP, positively affects total factor productivity (at the 1% level of significance).

There is a negative association between inflation (INF) and growth. Inflation can reduce the return on capital, and hence decrease investments on capital, which reduces growth (Gillman *et al.*, 2004). In terms of total factor productivity, inflation can make prices a less efficient co-ordination mechanism, thus reducing the information content of prices, and hindering the gains in productivity. High levels of inflation can also create more uncertainty and hinder innovation, which reduces efficiency. Bitros and Panas (2001) discover that inflation reduces total factor productivity growth in the two-digit Greek manufacturing industries in a way which is both statistically and economically significant.

Population growth (POPG) is known to affect growth positively in endogenous growth models, since more people mean more ideas and more innovation (Jones, 1995). Kremer (1993) argues that long-run historical observation provides evidence on the positive relationship between population growth and technological progress. He explains that the peoples of Eurasia, the Americas and Australia, who were all isolated from each other, had levels of technological progress proportional to the size of their population in 1500 BC. Hence higher rates of population growth will increase technological progress. However, some theories predict that the effect of population growth can be either positive or negative, depending on whether households have altruistic or selfish motives (Strulik, 2005).

After including all the control variables and fixed-time effects we derive the following complete model for estimation:

$$\Delta lnA_{it}=\alpha_0+\alpha_1 lnDTF_{i,t-1}+\alpha_2 FDI_{it}+\alpha_3 FDI_{it}*lnDTF_{i,t-1}+\alpha_4 lnRY_{it}+$$

$$+\alpha_5 lnHK_{it}+\alpha_6 lnTO_{it}+\alpha_7 INF_{it}+\alpha_8 POPG_{it}+T_t+\mu_i+\varepsilon_{it} \quad (2)$$

where T_t -time dummies, μ_i is unobserved time-invariant country effects, and ε_{it} is the idiosyncratic error term. Subscripts i and t stand for country and year respectively.

Equation (2) is estimated in five-year differences to filter out the effects of random and cyclical fluctuations on TFP growth (Madsen *et al.*, 2010). We estimate the model in equation (2) with a one-step system GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998). The detailed discussion of the system GMM estimator is available in Appendix A.

1.4 Data and graphical evidence

Annual data covering the period 1974-2008 and averaged over five-year intervals (except for the TFP growth which is in five-year differences and the external instrument explained hereafter) are used in our analysis. The sample includes 49 countries. Thus, data permitting, we have seven observations for each country over a time interval of 35 years. The full list of countries is given in Table 1.1. The criterion to include countries is based on the availability of data. We are limited to the current set of countries due to the observations of IPA and R&D expenditure. Extensive R&D expenditure data is available for only a small set of countries, and we restricted our sample only to those countries which contained at least eight years of observations for R&D expenditure spanning over 20 years.[4] All explanatory variables are in natural logs apart from inflation, population growth and FDI.

TFP growth (ΔlnA_{it})*:* In order to obtain the calculations of TFP growth, firstly, we construct TFP from the following relation in the Cobb-Douglas production function:

$$A=\frac{Y/L}{(K^{\alpha}L^{1-\alpha})/L}=\frac{Y/L}{[\left(\frac{K^{\alpha}}{L^{\alpha}}\right)(L^{1-\alpha}/L^{1-\alpha})]}=\frac{Y/L}{\left(\frac{K^{\alpha}}{L^{\alpha}}\right)}=\frac{y}{(k^{\alpha})} \quad (3)$$

Where y and k are per labor real output and real capital stock respectively. We take capital's share α as 0.3 (see, e.g., Ang & Madsen, 2011). Equation (3) is used to calculate TFP (A) and the data are available from Penn World Tables 6.3 (Heston *et al.*,2009). The initial level of capital stock is constructed from the following Solow model steady-state relationship:

[4] Excluding R&D intensity from the model does not change the results (see Appendix C).

$$K_0 = \frac{I_0}{\delta + g} \qquad (4)$$

where I_0 is the initial level of investment,[5] δ is the depreciation rate which is assumed to be 5% (as in Bosworth & Collins, 2003), g is the average geometric growth of real investment over the period 1974-2008. Perpetual inventory method is then used to estimate the capital stock for the following years from the available investment data:

$$K_{it} = (1 - \delta)K_{i,t-1} + I_{it} \qquad (5)$$

Then, once we have derived TFP, we can calculate TFP growth as:

$$\Delta lnA_{it} = lnA_{it} - lnA_{i,t-5} \qquad (6)$$

Foreign Direct Investment (FDI). FDI is measured over five-year averages as the stock of real FDI in real GDP. We prefer the stock variable over the flow as it captures already established foreign firms rather than newly arrived ones. We obtain the FDI stock data from the *Updated and extended version of the External Wealth of Nations Mark II database* developed by Lane and Milesi-Ferretti (2007). This database provides FDI liabilities for countries (equivalent to inward FDI stock) in nominal amounts. 2007 and 2008 data were obtained from UNCTAD (UNCTADstat, 2010). To get a relative measure of foreign penetration in an economy, we divide the corresponding real FDI stock by real GDP data from Penn World Tables, version 6.3. The real FDI is calculated by deflating the FDI stock by the investment deflator, calculated from the Penn World Tables data (Heston *et al.,* 2009).

Distance to Technological Frontier (DTF). We include the distance to the technological frontier $(A^{max}/\mathrm{A_i})_{\mathrm{t-1}}$ as the ratio of the technology level in the 'leader' country to the technology level of the country under consideration. Baseline results are based on the ratio of the US labor productivity to a country's labor productivity. The reason for using labor productivity rather than TFP is because of the correlation of DTF, calculated from TFP, and the error term. However, in the robustness section, we also consider the measure of DTF based on TFP when the dependent variable is income growth. One calculation is derived from dividing the US TFP by a country's TFP. The other is based on a basket of 'leaders' which we take as the G7 countries.[6] We calculate the G7 TFP by weighting the TFP of each country by their share of total G7 output. For DTF, we divide the weighted G7 TFP by the TFP of the

[5] The initial year is taken as 1974.

[6] G7 countries are Canada, France, Germany, Italy, Japan, United Kingdom and United States.

country for which DTF is being generated. DTF is also in five-year averages and enters into regression with a one-period lag. Data were obtained from PWT 6.3.

R&D expenditure (RY). The ratio of R&D input to product variety is known as *R&D intensity* in Schumpeterian endogenous growth models, and as Ha and Howitt (2007) put it, the product variety can be equated to labor or GDP. For our R&D intensity measure (RY), we use the ratio of R&D expenditures (R) to GDP (Y), and average it over five years. The observations for some missing years are interpolated. Data for R&D expenditures are obtained from UNESCO.

Human capital (HK) is measured as the average years of schooling for the population over 25 years of age. Missing years are interpolated. This data is in five-year averages and is available from Barro and Lee (2010).

Trade openness (TO) is also in five-year averages, and is obtained as the value of the component of Globalization Index (Dreher, 2006). It is the value of the restrictions on trade, the part of economic globalization index, which cover hidden import barriers, mean tariff rate, taxes on international trade and capital account restrictions. A higher index for a country means higher openness to trade.

Inflation (INF) is also measured in five-year averages and calculated as the change in GDP deflator which, in turn, is calculated by the ratio of nominal GDP to real GDP, available from PWT 6.3.

Population growth (POPG) is measured as the average percentage growth rate of the total population. This data is obtained from World Development Indicators.

External Instrument. Although the system GMM method controls for endogeneity by using the lagged variables for FDI as instruments, our results are based on the external instrument of FDI since they are more exogenous. Another reason to use an external instrument is the lagged values of FDI may not contain as much information about the current levels and our results significantly improve with the external instrument. We exploit the recent panel data from the World Bank Census of Investment Promotion Agencies (Harding & Javorcik, 2011, Forthcoming) to build our external instrument. In that census, countries were surveyed for the presence of an Investment Promotion Agency (IPA) and whether those agencies were involved in industry targeting. As an external instrument for FDI we employ the existence of national IPA.[7] Harding and Javorcik (2011), for example, show that sector targeting by IPAs lead to more than doubling of FDI flows to that particular sector. Hence the existence of an IPA (which is a dummy variable) can be a proxy for FDI flows. We construct the following measure of external instrument for FDI stock.

The length of the existence of IPA (CumDIPA). For the construction of CumDIPA, we first attach higher weight (w_t) to the recent years of existence (from 1 to 35) since IPAs in later years can attract more FDI flows than 20 years ago. The reason is increasing levels of trade liberalization and multinationalisation over time. Next, we calculate the length of the weighted period of existence (Cum_{it}). This is a proxy for FDI stock with adjusted years. We have checked the database for the possibility of countries having an IPA for some years, ceasing them for some time interval and re-establishing them again, which could make CumDIPA unreliable. As it turns out it is not the case.

$$Cum_{it} = \sum_{t=1}^{T} DIPA_{it} * w_t, \quad w_t = 1,2,\ldots,35$$

$$CumDIPA_{it} = Cum_{it} * GE_{it} \qquad (7)$$

The final step in the construction of IV is to account for the efficiency of IPAs in attracting FDI. As they are mostly government bodies their efficiency will be highly correlated with government efficiency, and thus, we use *Government Effectiveness (GE)* from the World Governance Indicators (Kaufmann et.al., 2010). By incorporating government efficiency to our instrument we are able to create better IV for FDI stock. But GE data are available only from 1996 onwards, and for this reason we assign a value of 1 for years preceding 1996.[8] Finally, we multiply GE by years-adjusted-FDI-stock IV to obtain CumDIPA. For five-year averaged FDI stock we take the value of annual CumDIPA in the middle of the five-year-average term. As shown in Table B2 in the Appendices, the pairwise correlation between FDI and CumDIPA is 46% and significant at the 5% level.

It is also important to note that our instruments for FDI stock are orthogonal to the idiosyncratic shocks to TFP growth. Since our measure of TFP growth is in five-year differences, our IV is not correlated with errors in TFP growth. Also, as has been stated earlier, if a country establishes an IPA, it remains active until the end of our analysis. This,

[7] We thank Beata S. Javorcik for providing these data.
[8] We use the ranking data on Government Efficiency available in WGI.

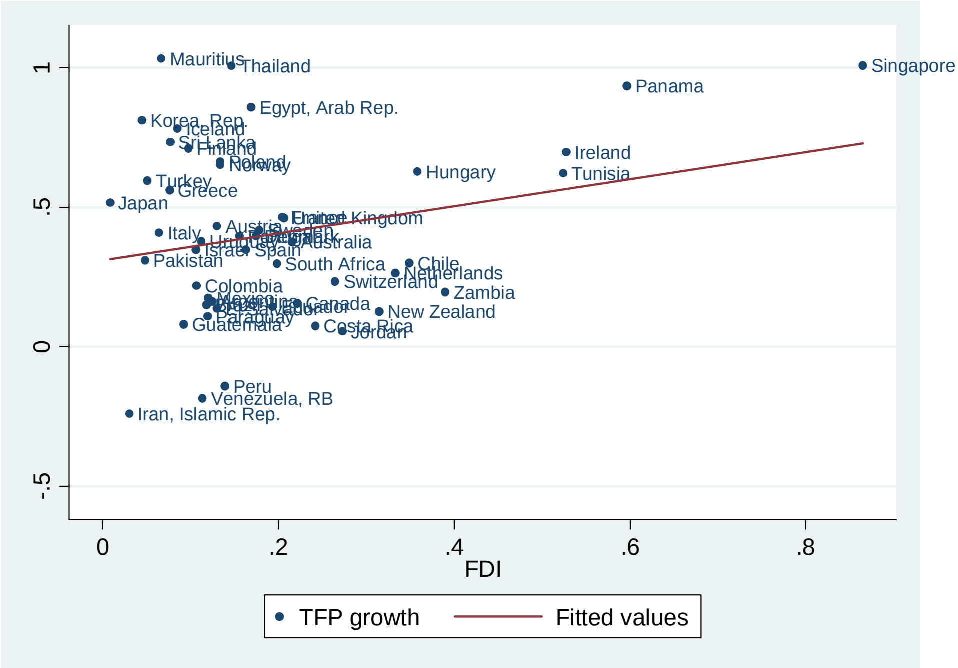
consequently, ensures the length of the period of the existence of IPA (CumDIPA) is not related to idiosyncratic errors. In Table 1.1 we report the summary statistics for the countries in the analysis. The average share of the FDI stock in GDP is 22.5% in real terms with almost similar standard deviation. The mean value for FDI-based absorptive capacity is 0.196 and it has a higher variance as suggested by the standard deviation: almost twice the size of the mean. Throughout the sample, the mean value for CumDIPA is 509.9 with a variance of 824. The maximum years of existence of an IPA for any country, is 33. Because of this, we can conclude that no country in the analysis had an IPA at the beginning of the sample period, i.e. in 1974.

Table 1.1. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
TFP growth *(ΔlnA)*	248	0.066	0.111	-0.375	0.636
Distance to the Technological Frontier *(DTF)*	248	3.515	4.197	0.883	34.921
Foreign Direct Investment *(FDI)*	248	0.224	0.240	0.003	1.535
R&D Intensity *(RY)*	248	0.011	0.010	0.000	0.045
Human Capital *(HK)*	248	7.717	2.423	1.827	12.642
Trade Openness *(TO)*	248	65.767	20.320	13.930	95.798
Inflation *(INF)*	248	0.212	0.999	-0.015	14.657
Population Growth *(POPG)*	248	1.205	0.916	-0.295	5.627
FDI based Absorptive Capacity *(FDI*lnDTF)*	248	0.196	0.344	-0.034	3.273
Cumulative Existence of IPA *(CumDIPA)*	248	509.863	824.414	0.000	3267.805
*CumDIPA*lnDTF*	248	369.984	714.264	-0.642	4285.288

Notes: (i) Variable specification: ΔlnA= Total factor productivity growth; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP; RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; CumDIPA=the length of the existence of IPA in the middle of averaged five years which is adjusted for recent years and government efficiency. (ii) Estimation period is 1974-2008; (iii) ΔlnA (TFP growth) is calculated in five-year differences; (iv) All other variables are calculated in five-year averages except for CumDIPA. (v) Countries in the sample: Argentina, Australia, Austria, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, Ecuador, Egypt, El Salvador, Finland, France, Greece, Guatemala, Hungary, Iceland, Iran, Ireland, Israel, Italy, Japan, Jordan, Korea Rep., Mauritius, Mexico, Netherlands, New Zealand, Norway, Pakistan, Panama, Paraguay, Peru, Poland, Portugal, Singapore, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, Uruguay, Venezuela, Zambia.

Figure 1.1 Average FDI and TFP growth



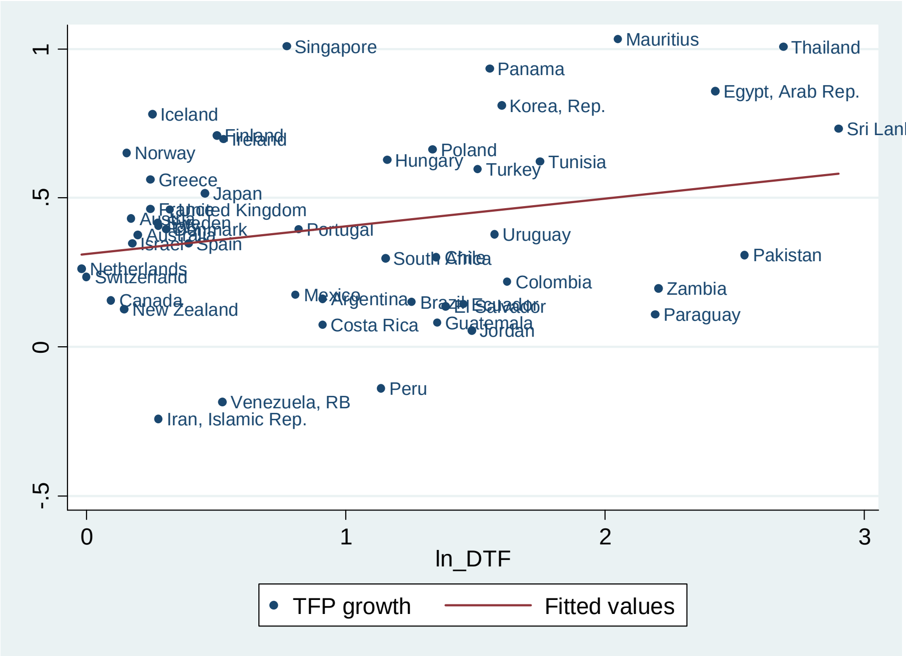
Notes: FDI is the average share of FDI stock in GDP between 1974 and 2008. (Captures average foreign penetration over the given time period). TFP growth calculated as the difference between log TFP in 2008 and 1974.

Average TFP growth over the five-year intervals has been 6.6%. Mean distance to the technology leader in our sample is 3.5, which implies that the labor productivity for countries on average was three and half times lower than that of the US. However, there are some countries with greater labor productivity than the US, due to the minimum value of DTF being 0.88.

Figure 1.1 shows graphical evidence of the relationship between FDI and TFP growth. The line has been drawn from an OLS regression of TFP growth on FDI. We can see that the relationship between FDI and TFP growth is positive although with clustering around the value of FDI at 0.2, which is also the mean value for FDI. Countries with larger average shares of FDI have also experienced higher TFP growth over the sample period. Singapore is a vivid example of such a country, with one of the highest levels of TFP growth, thanks to the largest level of FDI in its economy.

In Figure 1.2, TFP growth is plotted against the initial distance to the technology leader. This graph illustrates the 'catching up' effect for countries. As evidenced by the upward sloping line, we observe autonomous convergence in the technology level. Countries with greater technological gaps at the start of the sample period have seen higher increases in total factor productivity. This is more evident in Thailand, Egypt and Sri Lanka. The final scatterplot in

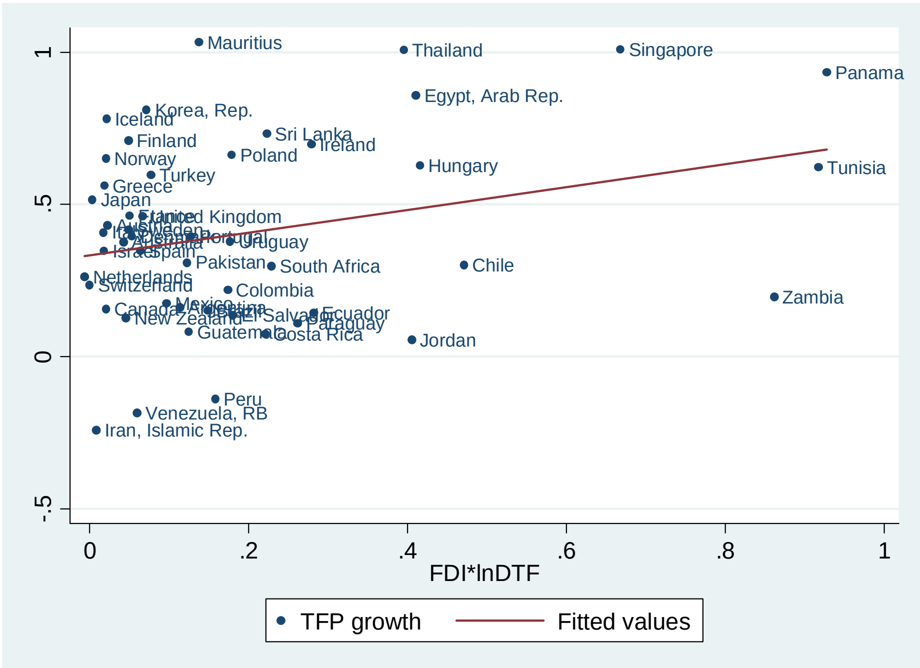
Figure 1.2 Initial Distance to Technology Leader and TFP growth



Notes: lnDTF is log of the distance to the technology leader in 1974 calculated as the ratio of US labor productivity to the labor productivity of a country. TFP growth is the same as in Figure 1.

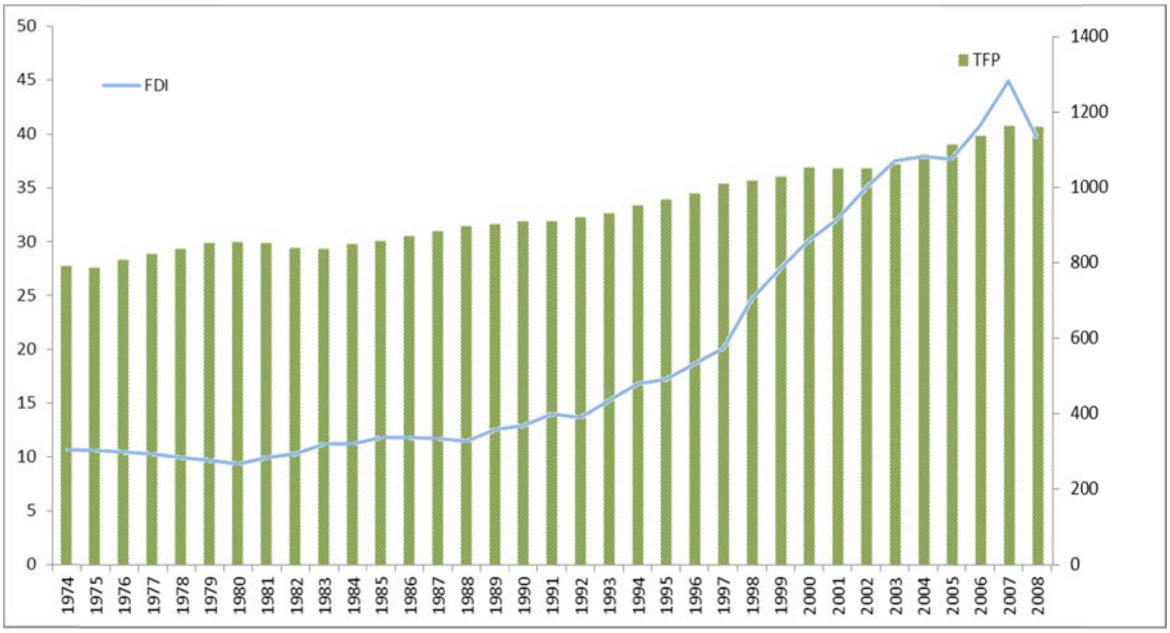
Figure 1.3 looks at the relationship between FDI-based absorptive capacity (the interaction of the average FDI with the log of initial distance to the frontier) and TFP growth. We test whether the effect of FDI depends on the absorptive capacity of countries in the form of technological backwardness.

Figure 1.3 The realtionship between FDI-based absorptive capacity and TFP growth



Notes: FDI-based absorptive capacity is calculated as FDI*lnDTF.

Figure 1.4 The evolution of FDI and TFP



Notes: FDI is the average FDI (share of FDI stock in GDP) across countries in the sample and TFP is the average level of TFP for the sample.

Here too, as in Figure 1.2, we detect a positive relationship supporting the importance of relative backwardness to technological transfer from multinationals. Iran and Venezuela have both declined technologically with smaller FDI-based absorptive capacities. But many countries have still advanced their technologies despite having similar absorptive capacity. This suggests the importance of country-fixed effects and other determinants of TFP.

Finally, we provide graphical illustration of the evolution of FDI and TFP in Figure 1.4. The lefthand side axis measures the share of average FDI stock in GDP (which is a dark line) and the bars are the average levels of TFP. Both variables are obtained from the sample of 49 countries in the analysis. There is one tendency deserving attention: TFP level tends to fall following a decline in average FDI penetration in all host countries, and tends to grow after FDI increases. But that tendency seems to have changed after the late 1990s after which TFP has not increased much, despite an enormous rise in FDI. There can be several explanations for this including other determinants of TFP. Of course, one can also argue that both variables follow business cycles. The graphical relationships discussed highlight the fact that both FDI and FDI-based absorptive capacity are important for TFP. But they do not control for other determinants of TFP growth. To better analyze the effects of FDI on TFP growth and whether this effect is dependent on the level of technology gap, we conduct a more detailed study in the next section.

1.5 Discussion of empirical results

1.5.1 Baseline results

This section reports the results of regression analysis. Our main estimation method is a one-step system GMM without dynamics. But we also consider a two-step system GMM method and a dynamic set-up to check if our findings remain robust. We examine five different sub-models which are the restricted forms of the econometric model given in equation (3). In model (1) TFP growth is regressed on FDI along with other explanatory variables (α_3 is assumed to be zero); in (2) we test whether countries with higher technological distances to leaders can absorb more technological spillovers from FDI. From (3) to (4) we exclude either FDI or lnDTF to check if the effect of the interaction term is robust to possible multicollinearity in the model. Multicollinearity can occur when two variables are interacted to generate a third variable where the interaction term can highly correlate with one of the variables from which it has been created. In restricted model (4) the marginal effect of DTF on TFP growth depends on the level of FDI, whereas in (5) it is vice versa, i.e. the effect of FDI depends on DTF. And in the final estimation model (5) we exclude both the interaction term and the measure of technology gap to see if the positive effect of FDI remains significant. All regressions have been run by including time dummies and a constant term (which are not reported to save space). All the p-values of the t-test have been obtained from robust standard errors which correct for heteroscedasticity and within sample autocorrelation.

In Table 1.2 we present our baseline result.[9] We find a statistically significant positive effect from FDI on TFP growth in (1). This clearly indicates that FDI is an important source of technological transfer. Our positive finding on the effect of FDI contrasts with the findings of Alfaro *et al.* (2004), Durham (2004) and Azman-Saini *et al.* (2010) who do not find any direct positive effect from FDI on growth. On the other hand, our results support the empirical findings of Li and Liu (2005) and Woo (2009) which reveal positive significant effects from FDI on income and TFP growth respectively. The coefficient for the effect of FDI is 0.167 which is significant at the 5% level. For any country in the sample a 10% point increase in the level of five-year-average FDI will lead to about a 1.7% rise in the growth rate of TFP over those five years. Since the mean share of FDI stock in GDP is 22.4%, a 10% point increase implies that the share of FDI stock increases to 32.4% in the average country. This contributes to an extra TFP growth of 1.7%.

[9] This result is obtained using only the external IV for FDI. Our results do not change when both internal and external instruments are included for FDI as evident in Table 1.3.

Table 1.2. TFP growth regression

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.125***	0.075**	0.066*		
	(0.000)	(0.042)	(0.072)		
FDI_{it}	0.167**	0.112		0.061	0.180**
	(0.020)	(0.148)		(0.393)	(0.022)
$FDI_{it}*lnDTF_{i,t-1}$		0.100**	0.136***	0.164***	
		(0.037)	(0.002)	(0.000)	
$lnRY_{it}$	0.026*	0.031**	0.036**	0.011	-0.026*
	(0.058)	(0.029)	(0.012)	(0.470)	(0.055)
$lnHK_{it}$	-0.012	-0.035	-0.039	-0.050	-0.054
	(0.842)	(0.604)	(0.526)	(0.480)	(0.448)
$lnTO_{it}$	0.127*	0.073	0.086	0.048	0.069
	(0.053)	(0.301)	(0.282)	(0.404)	(0.289)
INF_{it}	-0.013**	-0.014**	-0.014**	-0.013**	-0.014**
	(0.037)	(0.039)	(0.036)	(0.032)	(0.012)
$POPG_{it}$	-0.045**	-0.049**	-0.040	-0.039*	-0.042*
	(0.023)	(0.020)	(0.103)	(0.070)	(0.065)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.847	0.853	0.808	0.674	0.680
AR(1) p-value	0.009	0.007	0.006	0.008	0.016
AR(2) p-value	0.870	0.817	0.989	0.572	0.344

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2nd lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

This is an enormous increase and seems unrealistic because it is rarely the case that countries can have a 10% point increase in FDI penetration. To give a more likely example of an increase, let us consider a 5% point increase in average FDI over five years, i.e. the share of FDI stock in GDP increases from 10% to 15%. Then TFP would grow around 0.84% due to FDI alone over those five years. For a country with mean TFP growth rates, this would make about a 13% contribution to its growth. This can be compared to the findings of Woo (2009), who reports a 1% point increase in the annual share of FDI flow in GDP (i.e. FDI flow from 1% of GDP to 2%) would lead to an additional 0.2% growth of annual TFP growth. From the example of a 5% FDI increase, we can obtain an approximate annualized TFP growth, which turns out to be 0.17% after a 5% point increase in FDI per annum.

Our analysis of the advantage of relative backwardness supports the theoretical assumptions of Findlay (1978) and Wang and Blomstrom (1992). This is seen from the positive significant sign of the interaction of FDI with the distance to the technology frontier in sub-models (2), (3) and (4). Also, when the interaction term is included in (3), FDI becomes insignificant. This suggests that the positive effect of FDI is important and significant only with larger technology gaps between a country and the technology leader. The implication of this is that the technology diffusion from FDI takes place through technological backwardness, as proposed in the theoretical literature. To calculate the marginal impact of FDI through technological backwardness we could work with $\alpha_2 + \alpha_3 lnDTF_{i,t-1}$, but $\alpha_2 = 0$, so we only have $\alpha_3 lnDTF_{i,t-1}$. We can insert the mean values for DTF which is 3.5. Then the coefficient of the interaction term, which also takes into account the advantage of backwardness, becomes 0.13. Furthermore, this value increases as the gap becomes larger, since countries will have a greater base to absorb FDI-specific technology. A 1% point increase in FDI in an average DTF country will lead to 0.13% rise in TFP growth, whereas the same increase in a country with DTF of 7 (double the average) will cause 0.20% more TFP growth.

The significance of the interaction term is not due to multicollinearity as suggested by models (4) and (5). Notably, both the size and significance increase when we drop either FDI or DTF. One can interpret model (3) as a ‘catching-up’ process taking place through the adoption of FDI technologies although direct autonomous catching up is also present (as suggested by the 10% level positive significant sign of DTF). When we drop both the interaction term and DTF from the complete model, FDI still remains positively significant at 5%.

DTF is positive and significant in all sub-models included in Table 1.2, which is consistent with the findings of the convergence literature. The coefficient of autonomous technological transfer is 0.125 and significant at the 1% level in model (1). This can be compared to the finding of Griffith *et al.* (2004) who report an estimate of 0.08 on DTF with annual data. Regarding other control variables we find R&D intensity to be positively significant in sub-models (1) to (3) but in (5), it becomes negatively significant. In most of the sub-models the coefficient for RY is around 0.03. It can be deduced from the coefficient of RY that a 10% point increase in the ratio of R&D expenditures to GDP would increase TFP growth by 0.3%. Our estimated coefficient for RY is more than three times higher than what Madsen *et al.* (2010) report in their analysis. The sign of human capital variable is negative although insignificant. This suggests that human capital, measured as the average years of schooling for the population over 25 years of age, does not affect TFP growth. Trade openness, however, is positive, as has been expected, but significant at the 10% level in (1) only. We find inflation to reduce TFP growth at the 5% significance level in all sub-models. In contrast to the proposed benefits of population growth for TFP, we find that higher rates of population growth reduce the growth rates of TFP.

The diagnostic tests at the bottom of Table 1.2 suggest that the performance of the estimator is satisfactory. The F test rejects the hypothesis that all the coefficients are zero. Hansen tests do not reject the hypothesis that the instruments are not correlated with the residual. This makes our instruments valid. We detect first-order autocorrelation which is expected by the set-up of system GMM estimators. However, we do not want second-order autocorrelation as it makes it invalid to use the second lag of the independent variables as instruments. The AR (2) test results indicate no second-order autocorrelation in the residuals.

The results in the next part of the regression analysis will be based on the one-step system GMM estimation with only external instruments for FDI, as in Table 1.2. However, we also test the robustness of our results under a different set-up, the tables for which are attached to Appendix C. In Table C1, for example, we estimate the same model in Table 1.2 by a two-step system GMM estimator. Table C2 also considers a dynamic framework by including the lagged dependent variable into the regressors, while Table C3 excludes RY from the model to see if results are robust when the variable limiting our sample is omitted. As shown in Table C2, the lagged dependent variable enters insignificantly in the model. This means that the growth rates of TFP in the previous five-year period do not affect current TFP growth. Thus, we are working with a static model.

1.5.2 Robustness

We conduct several robustness checks with our main results in Table 1.2. In Table 1.3 we also include the internal instruments for FDI along with the external IVs. The reason for excluding the internal instruments for FDI in the baseline result is because of the over-identification problem which surfaces due to the large number of instruments when both internal and external instruments are used. This can generate Hansen test p-values equal to 1. As can be seen, the results remain significant and similar to Table 1.2, although the significance of FDI goes up to 1% in (1). Both Hansen and Arellano-Bond AR-test results validate our model.

To explore the possibility of the post-1988 data being more reliable, we also run regressions with a shorter sample period, which starts from 1989, in Table 1.4. Here we can check if there has been a surge in FDI since 1988 which can amplify its effects. Another reason to restrict the sample period is because our IV uses the government efficiency index, which is available only after 1994. The results in Table 1.4 can be contrasted to Table 1.2. We do not observe much difference with the shorter and more recent sample, but the economic significance for both FDI and FDI*lnDTF increases. This may be due to the improvement in the data for more recent years, especially in our IV. As for the control variables R&D intensity now becomes significant from models (1) to (4) and the negative sign is now insignificant in (5). Among other controls only inflation now remains significant.

For the next robustness check we work with an alternative nine-year averaged sample to account for the possibility of business cycles not being properly dealt with in the five-year averaged sample. Explanatory variables are calculated as the averages over each nine-year period (we have four of them) and TFP growth as the growth over nine years. CumDIPA will take the value in the middle of the average nine-year term. We report these regression results in Table 1.5. The economic significance of the coefficients for FDI and its interaction with the distance to the technology frontier now decrease. So does the statistical significance: the effects of both direct FDI and FDI-based absorptive capacity are significant at the 10% level only compared to the 5% in Table 1.2. Other variables become significant in very few models in Table 1.5. It is possible that lags over a longer time period become very weak instruments for them, and hence they lose significance in most models. The same explanation could apply to the reduction of the coefficient and the statistical significance of FDI and FDI-based absorptive capacity.

Table 1.3. TFP growth regression (including both internal and external instruments for FDI)

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.139***	0.075*	0.065*		
	(0.001)	(0.064)	(0.090)		
FDI_{it}	0.142***	0.074		0.043	0.143***
	(0.002)	(0.181)		(0.400)	(0.002)
$FDI_{it}*lnDTF_{i,t-1}$		0.111**	0.132***	0.172***	
		(0.025)	(0.008)	(0.000)	
$lnRY_{it}$	0.031	0.035**	0.036**	0.021	-0.024*
	(0.104)	(0.031)	(0.025)	(0.176)	(0.088)
$lnHK_{it}$	-0.012	-0.034	-0.033	-0.053	-0.050
	(0.864)	(0.648)	(0.644)	(0.475)	(0.473)
$lnTO_{it}$	0.133	0.065	0.075	0.006	0.042
	(0.117)	(0.469)	(0.417)	(0.910)	(0.500)
INF_{it}	-0.014**	-0.014**	-0.014**	-0.014**	-0.015**
	(0.046)	(0.037)	(0.037)	(0.023)	(0.010)
$POPG_{it}$	-0.049**	-0.056**	-0.044*	-0.051**	-0.048**
	(0.017)	(0.017)	(0.087)	(0.037)	(0.040)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.898	0.985	0.917	0.979	0.922
AR(1) p-value	0.008	0.006	0.006	0.007	0.016
AR(2) p-value	0.972	0.896	0.996	0.675	0.393

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (along with internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2nd lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

Table 1.4. TFP growth regression in the years after 1988

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.146***	0.074	0.058		
	(0.000)	(0.106)	(0.190)		
FDI_{it}	0.173**	0.092		0.034	0.174*
	(0.047)	(0.352)		(0.683)	(0.074)
FDI_{it}*$lnDTF_{i,t-1}$		0.126**	0.160***	0.185***	
		(0.011)	(0.001)	(0.000)	
$lnRY_{it}$	0.049***	0.055***	0.060***	0.035**	-0.013
	(0.009)	(0.003)	(0.002)	(0.015)	(0.385)
$lnHK_{it}$	-0.028	-0.070	-0.088	-0.104	-0.086
	(0.658)	(0.333)	(0.157)	(0.139)	(0.208)
$lnTO_{it}$	0.120	0.056	0.070	0.053	0.074
	(0.115)	(0.469)	(0.371)	(0.468)	(0.336)
INF_{it}	-0.015*	-0.016*	-0.017**	-0.016**	-0.016**
	(0.053)	(0.051)	(0.041)	(0.033)	(0.011)
$POPG_{it}$	-0.033	-0.031	-0.020	-0.018	-0.020
	(0.172)	(0.204)	(0.456)	(0.548)	(0.491)
Observations	168	168	168	168	168
F test (p-value)	0.000	0.000	0.000	0.000	0.003
Hansen p-value	0.351	0.337	0.328	0.230	0.410
AR(1) p-value	0.026	0.014	0.012	0.013	0.029
AR(2) p-value	0.712	0.728	0.560	0.778	0.936

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2nd lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

Table 1.5. TFP growth regression with nine-year averaged data

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.127*	0.009	-0.000		
	(0.080)	(0.927)	(0.996)		
FDI_{it}	0.033*	0.012		0.008	0.025
	(0.089)	(0.587)		(0.686)	(0.307)
$FDI_{it}*lnDTF_{i,t-1}$		0.025*	0.028**	0.020**	
		(0.086)	(0.041)	(0.049)	
$lnRY_{it}$	0.022	0.036	0.045	0.031	-0.018
	(0.494)	(0.277)	(0.172)	(0.415)	(0.626)
$lnHK_{it}$	-0.206	-0.194	-0.202	-0.270*	-0.270
	(0.128)	(0.144)	(0.127)	(0.080)	(0.105)
$lnTO_{it}$	0.172	-0.018	-0.004	0.052	0.093
	(0.266)	(0.906)	(0.979)	(0.818)	(0.718)
INF_{it}	-0.040*	-0.045	-0.044	-0.040	-0.042
	(0.059)	(0.103)	(0.104)	(0.230)	(0.134)
$POPG_{it}$	-0.127*	-0.145*	-0.130*	-0.138	-0.133
	(0.053)	(0.086)	(0.075)	(0.113)	(0.115)
Observations	184	184	184	184	184
F test (p-value)	0.001	0.001	0.001	0.005	0.004
Hansen p-value	0.755	0.296	0.192	0.204	0.642
AR(1) p-value	0.010	0.014	0.021	0.024	0.006
AR(2) p-value	0.568	0.524	0.502	0.528	0.657

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the nine-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in nine-year averages.

(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2nd lag of the right hand-side variables are used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

So far we have run regressions with a dependent variable as TFP growth. TFP in turn was calculated from the Cobb-Douglas production function discussed in Section 1.4. But some may argue that this is not the best way of measuring TFP, especially for developing countries where the share of capital can be different from 0.3. To address such criticisms, we work with the same Cobb-Douglas production function: $Y=A*K^{\alpha}L^{1-\alpha}$. After taking logs from both sides and differencing out the production function, we have income growth as the function of TFP growth, growth rate of capital and labor. Replacing TFP growth with income growth in equation (3), we have the regression model with a dependent variable of income growth, as well as all the regressors we have had so far, plus capital and labor growth. We show the results of the model we use for this estimation in Table 1.6. The only differences from the previous analysis are that the dependent variable is income growth with two extra independent variables of capital growth and labor growth. The growth rates of income, capital and labor are calculated as the differences in log values over five years. We still estimate the static model with a one-step system GMM. FDI is instrumented with only external IV and other regressors with their lags.

For the direct effect of FDI the coefficient is 0.148, which is quite close to the initial estimate with TFP growth as the dependent variable, where the value is 0.167. The significance level increases from 5% to 1%.The size of the coefficient of autonomous technological transfer (DTF) also does not change much. In model (2) the interaction term is statistically significant at the 5% level and the significance of DTF disappears (as well as FDI, which is similar to the previous results). This hints that when income growth is used as the dependent variable, the catching up only takes place from the adoption of MNC technology. (An alternative explanation for this is that FDI technology can be transferred through larger distances to the technology leader and no autonomous transfer occurs). In models (3) and (4) the significance of the interaction term increases to 1% when we exclude one of the variables from which the interaction term is created. FDI still remains significant in model (5) when we drop DTF from the first model and we observe the coefficient increase in the marginal effect of FDI.

Among control variables only R&D intensity remains significant and similar to the results in Table 1.2. Inflation becomes significant in models (4) and (5) only. As expected, the signs for both capital and labor growth rates are positive. Capital growth is statistically significant in all sub-models but labor growth insignificantly affects income growth in model (5). Another thing to notice here is about the coefficients for capital and labor, which seem to show increasing returns to scale.

Our model successfully passes various diagnostics tests. F-test p-values are significant at the 1% level. The Hansen test shows that our instruments are valid with the p-values over 10%. Expected first-order autocorrelation is detected, but we do not find second-order autocorrelation which justifies the usage of second lags of other variables as instruments for the differenced formation of the level equation.

So far we have used the ratio of US labor productivity to the labor productivity of the country under consideration for DTF. It may be possible that the labor productivity ratios are not reliable determinants of the technological distances to leaders. To address this problem we replace DTF with a different measure and run the same regression in Table 1.5. This time, the DTF is measured as the ratio of US TFP to the TFP of the country under consideration. Including the DTF measure based on TFP, when the dependent variable is TFP growth, will significantly bias the results. The estimations with the new measure of DTF are reported in Table 1.7. One notable difference in this table is that the direct significant effect of FDI decreases both economically and statistically.

The size of the coefficient is 1.5 times smaller than in Table 1.2 and it is only significant at the 10% level. Autonomous convergence, on the other hand, becomes highly significant with a coefficient that is twice as high. When we test the advantage of relative backwardness to benefit from multinationals in model (2) we obtain a significant effect for both DTF and its interaction, which was not the case for the former in Table 1.6. The sign of FDI becomes negative and insignificant, but the FDI-based absorptive capacity has a greater effect at the 5% level of significance. This is not due to the multicollinearity in the model, which is further supported by (3) and (4). Performance of other variables is similar to the case in Table 1.6 and the diagnostic checks point towards the acceptability of the results. Robustness tests carried out so far confirm our main findings although with varying levels of statistical and economic significance.

In Table 1.8, we run the estimations of income growth with DTF based on a pool of 'technology leaders'. Because setting only one technology leader may not be reasonable, here we specify the leaders as the G7 countries and DTF is constructed as explained in Section 1.4. Overall, the results are very similar to the ones in Table 1.7. As the last point of robustness we estimate the model in equation (3) with alternative panel-data estimators. These are fixed and random-effects estimators, the tables for which are reported in Appendix C.

Table 1.6. GDP growth regression

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.147***	0.044	0.049		
	(0.000)	(0.412)	(0.238)		
FDI_{it}	0.148***	-0.003		0.037	0.176***
	(0.007)	(0.977)		(0.649)	(0.004)
$FDI_{it}*lnDTF_{i,t-1}$		0.165**	0.160***	0.193***	
		(0.046)	(0.004)	(0.000)	
$lnRY_{it}$	0.039**	0.047***	0.047***	0.030*	-0.013
	(0.013)	(0.003)	(0.004)	(0.080)	(0.182)
$lnHK_{it}$	-0.022	-0.068	-0.068	-0.084	-0.080
	(0.776)	(0.234)	(0.242)	(0.189)	(0.192)
$lnTO_{it}$	0.077	0.006	0.013	-0.026	-0.020
	(0.371)	(0.944)	(0.872)	(0.651)	(0.709)
INF_{it}	0.003	0.002	0.002	-0.011***	-0.011***
	(0.815)	(0.860)	(0.865)	(0.007)	(0.001)
$POPG_{it}$	-0.051	-0.046	-0.045	-0.051*	-0.040
	(0.160)	(0.170)	(0.227)	(0.051)	(0.101)
ΔlnK_{it}	0.476***	0.508***	0.505***	0.419***	0.402***
	(0.009)	(0.003)	(0.001)	(0.001)	(0.001)
ΔlnL_{it}	0.495**	0.590**	0.583**	0.431*	0.185
	(0.039)	(0.043)	(0.047)	(0.051)	(0.373)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.964	0.975	0.949	0.986	0.979
AR(1) p-value	0.006	0.004	0.004	0.003	0.006
AR(2) p-value	0.859	0.919	0.917	0.559	0.235

Notes: (i) Variable specification: Dependant variable ΔlnY= GDP growth calculated as the five-year difference of log real GDP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; ΔlnK_{it}= growth rate of capital stock; ΔlnL_{it}= growth rate of labor. All regressors are in five-year averages except for capital and labor which are calculated as five-year differences.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 3rd lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 2nd lag of the corresponding differences are used as instruments.

Table 1.7. GDP growth regression with alternative DTF (DTF based on the US TFP)

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.258***	0.128*	0.124*		
	(0.000)	(0.056)	(0.053)		
FDI_{it}	0.113*	-0.027		-0.080	0.144**
	(0.092)	(0.720)		(0.290)	(0.012)
$FDI_{it}*lnDTF_{i,t-1}$		0.248**	0.238**	0.345***	
		(0.023)	(0.013)	(0.000)	
$lnRY_{it}$	0.064***	0.074***	0.072***	0.065**	0.009
	(0.009)	(0.007)	(0.005)	(0.016)	(0.595)
$lnHK_{it}$	-0.023	0.002	-0.004	-0.020	-0.119
	(0.754)	(0.983)	(0.961)	(0.821)	(0.102)
$lnTO_{it}$	0.180*	0.085	0.079	-0.046	-0.045
	(0.069)	(0.348)	(0.358)	(0.518)	(0.537)
INF_{it}	0.004	0.012	0.011	0.018	0.006
	(0.829)	(0.617)	(0.645)	(0.597)	(0.811)
$POPG_{it}$	-0.020	-0.024	-0.027	-0.034	-0.041
	(0.452)	(0.452)	(0.376)	(0.320)	(0.150)
ΔlnK_{it}	0.368*	0.421**	0.419**	0.459***	0.379***
	(0.052)	(0.026)	(0.022)	(0.003)	(0.002)
ΔlnL_{it}	0.665**	0.890***	0.875***	0.827**	0.355
	(0.027)	(0.006)	(0.005)	(0.015)	(0.261)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.934	0.950	0.940	0.811	0.651
AR(1) p-value	0.007	0.005	0.004	0.004	0.009
AR(2) p-value	0.513	0.401	0.443	0.536	0.563

Notes: (i) Variable specification: Dependant variable ΔlnY= GDP growth calculated as the five-year difference of log real GDP; DTF= Distance to the Technological Frontier calculated as TFP of the US (A^{max}) divided by the TFP of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; ΔlnK_{it}= growth rate of capital stock; ΔlnL_{it}= growth rate of labor. All regressors are in five-year averages except for capital and labor which are calculated as five-year differences.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 4th to 5^{th} lags of the right hand-side variables are used as instruments for the differenced formation. In the level equation, 3^{rd} lag of the corresponding differences are used as instruments.

Table 1.8. GDP growth regression with alternative DTF (DTF based on G7 TFP)

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.179***	0.145**	0.130**		
	(0.000)	(0.018)	(0.037)		
FDI_{it}	0.129*	-0.006		-0.024	0.144**
	(0.062)	(0.929)		(0.731)	(0.012)
$FDI_{it}*lnDTF_{i,t-1}$		0.160**	0.172**	0.277***	
		(0.043)	(0.019)	(0.000)	
$lnRY_{it}$	0.034**	0.077***	0.077***	0.063***	0.009
	(0.012)	(0.002)	(0.001)	(0.008)	(0.595)
$lnHK_{it}$	-0.066	-0.025	-0.025	-0.041	-0.119
	(0.281)	(0.750)	(0.747)	(0.633)	(0.102)
$lnTO_{it}$	0.139**	0.121	0.107	-0.062	-0.045
	(0.014)	(0.157)	(0.210)	(0.374)	(0.537)
INF_{it}	-0.010**	0.010	0.011	0.015	0.006
	(0.018)	(0.694)	(0.669)	(0.632)	(0.811)
$POPG_{it}$	-0.052*	-0.041	-0.042	-0.039	-0.041
	(0.055)	(0.191)	(0.159)	(0.259)	(0.150)
ΔlnK_{it}	0.470***	0.610***	0.618***	0.515***	0.379***
	(0.001)	(0.000)	(0.000)	(0.002)	(0.002)
ΔlnL_{it}	0.399*	1.067***	1.083***	0.797**	0.355
	(0.064)	(0.001)	(0.001)	(0.018)	(0.261)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.992	0.902	0.978	0.876	0.651
AR(1) p-value	0.003	0.003	0.003	0.004	0.009
AR(2) p-value	0.849	0.429	0.433	0.644	0.563

Notes: (i) Variable specification: Dependant variable ΔlnY= GDP growth calculated as the five-year difference of log real GDP; DTF= Distance to the Technological Frontier calculated as weighted average TFP of G7 (A^{max}) divided by the TFP of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; ΔlnK_{it}= growth rate of capital stock; ΔlnL_{it}= growth rate of labor. All regressors are in five-year averages except for capital and labor which are calculated as five-year differences.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 4th to 5th lags of the right hand-side variables are used as instruments for the differenced formation. In the level equation, 3rd lag of the corresponding differences are used as instruments.

The results shown in Table C4 come from fixed-effects regression. The values in parentheses are the T-test p-values based on robust standard errors. When we examine the direct effect of FDI in (1) we obtain a very similar result to Table 1.2. But the effect of FDI-based absorptive capacity is now 1.5 times larger than in Table 1.2 and significant at the 1% level. Models (3) to (5) confirm this finding. Of course, endogeneity is ignored in fixed effects as well as in random effects. Under the random-effects specification in Table C5, the size of the direct effect of FDI reduces. For the interaction term both the size and significance go down. But the random-effects estimator assumes that country-specific effects are uncorrelated with the error term, which is a weaker assumption than in the fixed-effects models. The weaker result on FDI-based absorptive capacity may be related to this.

1.6 Conclusion

Technological spillovers from FDI have been thought to be an important source of technological progress for countries hosting multinationals (Das, 1987; Findlay, 1978; Fosfuri *et al.*, 2001). Yet the empirical studies have found contradictory results on the proposed effect of technological diffusion at the micro as well as the macro levels (Aitken & Harrison, 1999; Alfaro *et al.*, 2004; Keller, 2004; Keller & Yeaple, 2009; Woo, 2009). This study argues that the differences in the macro-level studies are due to econometric estimation problems. In an attempt to resolve those problems, we analyse panel data for 49 countries over the period 1974-2008. In our analysis, we employ the system GMM estimation method with new external instruments to account for the issues of endogeneity and fixed effects.

By analysing the impact of real FDI stock in real GDP on TFP growth we find support that FDI is an important factor of technological transfer, as evidenced by positive significant effect on TFP growth. Our positive results of FDI are in line with the empirical findings of Li and Liu (2005) and Woo (2009), which also discover positive effects from FDI on economic growth in cross-country studies. We have also tested whether the distance to the technology frontier, which has received less attention in the literature, can enhance the positive role of FDI on TFP growth. We also find evidence for this, which is indicated by statistically significant positive effects from the interaction of the FDI variable with the distance to the technological frontier. This result demonstrates that countries that are farther from the technological leaders will have a greater potential to benefit from FDI than those who are closer. With this finding, we confirm the theoretical proposals of Findlay (1978) and Wang and Blomstrom (1992). On the one hand, this result supports the findings of Blalock and

Gertler (2009); on the other, it contradicts the empirical results of Li and Liu (2005), who report that a larger technology gap decreases a country's ability to learn the technology of multinationals.

But our results, as well as Li and Liu's, should be interpreted with caution. These two different findings might very likely be due to different measures of dependent variable, estimation methods, sample of countries as well as the measure of FDI. For example, results might differ whether FDI stock or flow is used. While Li and Liu (2005) use FDI flows in GDP, our positive results come from the measure of FDI stock in GDP. FDI flows are the new foreign firms coming into country. It is quite possible that initial competition from the multinationals would see some domestic firms lose market share and efficiency. Some inefficient firms might even be forced out of the market or have to invest in learning and new technologies to compete with FDI firms, which would result in some decline in output (Liu, 2008). Hence, we would expect FDI flow to reduce the output growth in the backward country. On the other hand, FDI stock is a measure of all the inflows accumulated over time and, though it increases when new firms arrive, a large amount of stock will be already established firms. So the domestic companies which lag behind the multinationals would be able to learn a great deal from them. There could also be further enhancement in TFP through vertical linkages, as suggested by recent studies (Alfaro *et al.*, 2009; Wang, 2010). This might explain the two different results of the role of the technology gap in the technological diffusion from FDI.

Our findings remain robust to alternative estimation methods (fixed effects and random effects), the shortening of the sample period and different averaging of the time period. The alternative measures of TFP growth and the distance to technology frontier still validate our findings. The policy implication of our analysis is straightforward: multinational firms should be welcomed as they do not cause negative externalities in the form of productivity reduction in the economy. They can in fact improve the countries' technology adoption through this channel and technologically backward countries are likely to benefit more.

Another major contribution of this work is that we develop a new external instrument (IV) for the share of FDI stock in GDP based on the data on the existence of IPAs. Our constructed IV for FDI exhibit high levels of correlation with the share of FDI in GDP. This IV can be used in future work in cases where FDI is very likely to suffer from reverse causality.

Although we report a positive effect from FDI, some future work may be necessary to advance the FDI growth literature to the next level. In particular, the analysis could include more countries once data become available. At the micro level, the hypothesis of the advantage of the technology gap can be tested under a consistent framework. Studies carried out so far use the share of FDI firm sales in total sales, or FDI employment share as the level of foreign penetration in the industry, neither of which take into account how long the FDI firm has been operating in the industry. But to benefit from the multinationals in the same industry, domestic laggard firms may need some time, and the longer the period of existence of MNCs, the more they may benefit from them. Thus, firm-level studies should incorporate the length of FDI existence into FDI penetration measures.

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Appendices

A. System GMM estimator

A system GMM estimation method has been employed throughout this chapter. In equation (3), by replacing the dependent variable ΔlnA_{it} (TFP growth) with y_{it} , and all other observed explanatory variables with X_{it} we obtain:

$$y_{it} = \alpha_0 + X_{it}B' + T_t + v_{it} \ , \qquad (A1)$$

where $$v_{it} = \mu_i + \varepsilon_{it}$$

$$X_{it} = (lnDTF_{i,t-1} \ \ FDI_{it} \ \ FDI_{it} * lnDTF_{i,t-1} \ \ lnRY_{it} \ \ lnHK_{it} \ lnTO_{it} \ \ INF_{it} \ \ POPG_{it})$$

$$B' = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_9 \end{pmatrix}$$

Several estimation problems arise: First, pooled OLS does not account for the error-component nature of disturbances, hence the estimated coefficients can be biased. Moreover, if some or all of the predictors are correlated with the time-invariant country effect (μ_i), then this raises the problem of endogeneity. Next, the fixed-effects model can eliminate this time-invariant effect. But this does not completely remove the possibility of the correlation of explanatory variables with the idiosyncratic error term (ε_{it}). As has been shown in the case between FDI and growth (Choe, 2003; Li & Liu, 2005), the transformed $\Delta\varepsilon_{it}$ will still be correlated with ΔFDI_{it} in the fixed-effects estimation.

Arellano and Bond (1991) suggest using the following differenced equation:

$$\Delta y_{it} = \Delta X_{it}B' + \Delta T_t + \Delta\varepsilon_{it} \qquad (A2)$$

Under the assumptions of no-serial correlation in ε_{it} and non-strict exogeneity of predictors (Arellano & Bover, 1995), Arellano-Bond difference GMM estimators can be obtained from the following moment conditions:

$$E\left(X_{i,t-\tau}\Delta\varepsilon_{it}\right) = 0, \tau = 2, \dots, T; \ t \geq 3 \qquad (A3)$$

where the second and further lags of X_i's are used as instruments for the differenced transformations in (A2). Since the second and further lags of x_{it} are good instruments for

Δx_{it} $(x_{it} - x_{i,t-1})$ and $x_{i,t-2}$ is uncorrelated with $\Delta\varepsilon_{it}$ $(\varepsilon_{it} - \varepsilon_{i,t-1})$ they become valid instruments for Δx_{it} and solve the problem of endogeneity.

However, there are several weaknesses with this first-difference transformation. First, in unbalanced panels, first differencing creates gaps for missing observations. Second, as Blundell and Bond show (1998), untransformed lags are weak instruments for the differenced predictors.

Hence, Blundell and Bond (1998) propose an approach outlined in Arellano and Bover (1995). Along with the first-differenced transformation they suggest including an additional equation of the level. After including the level equation, X_i's in the level will be instrumented by the first lag of the differenced X_i's (since Δx_{it}'s are not correlated with μ_i they become valid instruments). So, in addition to (A3) we have the following moment conditions:

$$E\left(\Delta X_{i,t-\tau} v_{it}\right) = 0, \qquad \tau = 1 \qquad\qquad (A4)$$

where $v_{it} = \mu_i + \varepsilon_{it}$

Moment conditions (A3) and (A4) are used for the system GMM estimator. Along with internal instruments, system GMM also allows us to include external instruments. When we instrument FDI with an external instrument, in moment conditions (A3) and (A4) the internal instruments for FDI are dropped and FDI will be instrumented by CumDIPA.

We report errors which are robust to heteroscedasticity and within sample serial correlation. We also test the model specification by the Hansen test of over-identifying restrictions, and we apply Arellano-Bond test to detect any serial correlation.

B. Data source and correlation matrix

Table B1. Data sources and definitions

Variable	Definition	Source
ΔlnA	Total factor productivity growth calculated as the five-year difference of log TFP. TFP was constructed from Penn World Tables Version 6.3	Penn World Tables Version 6.3 http://pwt.econ.upenn.edu/php_site/pwt_index.php
DTF	Distance to the technological frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration.	Penn World Tables Version 6.3 http://pwt.econ.upenn.edu/php_site/pwt_index.php
FDI	Share of the real FDI stock in real GDP.	Lane & Milesi-Ferretti (2007) http://www.philiplane.org/EWN.html
RY	R&D intensity (R&D expenditure/GDP). Data comes from UNESCO Statistical Yearbook (various issues)	http://data.un.org/Data.aspx?d=UNESCO&f=series:ST_20600
HK	Human capital measured as the average years of schooling of the population aged over 25	Barro and Lee (2010) http://www.barrolee.com/
TO	Trade openness measured as the value of restrictions on trade in economic globalization component of Globalization index	Dreher (2006) http://globalization.kof.ethz.ch/
INF	Inflation measured as an annual change in GDP deflator	Penn World Tables Version 6.3 http://pwt.econ.upenn.edu/php_site/pwt_index.php
POPG	Annual rate of population growth	World Development Indicators http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
FSY* lnDTF	FDI-based absorptive capacity. Measured as the interaction of FDI and the log of the distance to the technology frontier	
CumDIPA	Cumulative years of existence of IPA adjusted for the importance of recent years and the efficiency of the government. IPA existence data were obtained from Harding and Javorcik (2011).	Harding and Javorcik (2011) and WGI (Worldbank) http://info.worldbank.org/governance/wgi/index.asp
CumDIPA* lnDTF	Instrument for FDI-based absorptive capacity. The interaction of CumDIPA and the log of the distance to the frontier	

Table B2. Correlation Matrix: 1974-2008

	ΔlnA	*lnDTF*	*FDI*	*lnRY*	*lnHK*	*lnTO*	*INF*	*POPG*	*FDI* lnDTF*	*CumDIPA*	*Cum DIPA *lnDTF*
ΔlnA	1										
lnDTF	0.129*	1									
FDI	0.181*	0.002	1								
lnRY	0.064	-0.710*	0.015	1							
lnHK	0.080	-0.565*	0.239*	0.479*	1						
lnTO	0.092	-0.721*	0.304*	0.505*	0.654*	1					
INF	-0.136*	0.066	-0.100	-0.098	-0.169*	-0.140*	1				
POPG	-0.191*	0.415*	0.077	-0.384*	-0.521*	-0.538*	0.094	1			
FDI*lnDTF	0.264*	0.595*	0.500*	-0.502*	-0.118	-0.152*	-0.028	0.220*	1		
CumDIPA	0.09	-0.117	0.460*	0.220*	0.292*	0.285*	-0.095	-0.102	0.065	1	
CumDIPA*lnDTF	0.156*	0.348*	0.208*	-0.190*	0.011	-0.045	-0.063	-0.013	0.347*	0.586*	1

Notes: (i) Variable specification: ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP; RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; CumDIPA=the length of the existence of IPA in the middle of averaged five years which is adjusted for recent years and government efficiency.
(ii) All variables are calculated in five-year averages unless otherwise specified. (iii) Asterisk (*) indicates 5% level of significance.

C. Other robustness tables

Table C1. TFP growth regression with 2-step system GMM

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.128***	0.008	0.069		
	(0.001)	(0.870)	(0.144)		
FDI_{it}	0.159*	-0.310		0.047	0.187**
	(0.050)	(0.309)		(0.622)	(0.049)
$FDI_{it}*lnDTF_{i,t-1}$		0.280***	0.140**	0.192***	
		(0.001)	(0.015)	(0.002)	
$lnRY_{it}$	0.026*	0.097**	0.037**	0.009	-0.028*
	(0.075)	(0.013)	(0.029)	(0.562)	(0.089)
$lnHK_{it}$	-0.016	-0.064	-0.033	-0.045	-0.052
	(0.851)	(0.554)	(0.674)	(0.590)	(0.488)
$lnTO_{it}$	0.132**	-0.113	0.087	0.054	0.053
	(0.040)	(0.362)	(0.306)	(0.458)	(0.448)
INF_{it}	-0.014**	-0.002	-0.014**	-0.014*	-0.015**
	(0.048)	(0.766)	(0.046)	(0.076)	(0.044)
$POPG_{it}$	-0.049**	-0.073**	-0.041	-0.037	-0.045*
	(0.026)	(0.028)	(0.107)	(0.118)	(0.083)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.002
Hansen p-value	0.847	0.784	0.808	0.674	0.680
AR(1) p-value	0.010	0.002	0.007	0.009	0.017
AR(2) p-value	0.855	0.284	0.997	0.486	0.305

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the 5-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2^{nd} lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

Table C2. TFP growth regression with lagged dependent variable

	(1)	(2)	(3)	(4)	(5)
$\Delta lnA_{i,t-1}$	-0.138	-0.119	-0.069	-0.141	-0.175
	(0.209)	(0.276)	(0.436)	(0.181)	(0.108)
$lnDTF_{i,t-1}$	0.115***	0.073*	0.057		
	(0.000)	(0.063)	(0.122)		
FDI_{it}	0.182***	0.134*		0.106	0.197***
	(0.009)	(0.090)		(0.134)	(0.009)
$FDI_{it}*lnDTF_{i,t-1}$		0.087*	0.135***	0.149***	
		(0.083)	(0.001)	(0.000)	
$lnRY_{it}$	0.024*	0.029*	0.034**	0.013	-0.021
	(0.097)	(0.066)	(0.027)	(0.451)	(0.119)
$lnHK_{it}$	-0.037	-0.057	-0.060	-0.080	-0.081
	(0.573)	(0.416)	(0.352)	(0.276)	(0.273)
$lnTO_{it}$	0.119*	0.071	0.087	0.024	0.039
	(0.072)	(0.308)	(0.256)	(0.635)	(0.504)
INF_{it}	-0.014**	-0.014**	-0.014**	-0.014**	-0.015***
	(0.019)	(0.022)	(0.022)	(0.019)	(0.006)
$POPG_{it}$	-0.057**	-0.061**	-0.047*	-0.057**	-0.058**
	(0.020)	(0.016)	(0.081)	(0.030)	(0.042)
Observations	228	228	228	228	228
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Hansen p-value	0.971	0.965	0.980	0.913	0.927
AR(1) p-value	0.002	0.001	0.002	0.001	0.002
AR(2) p-value	0.383	0.392	0.641	0.190	0.059

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 2nd lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 1st lag of the corresponding differences are used as instruments.

Table C3.TFP growth regression excluding RY

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.044**	-0.018	-0.045		
	(0.048)	(0.652)	(0.207)		
FDI_{it}	0.188**	0.129*		0.138**	0.183*
	(0.020)	(0.067)		(0.034)	(0.054)
FDI_{it}*$lnDTF_{i,t-1}$		0.120*	0.163***	0.142***	
		(0.061)	(0.007)	(0.002)	
$lnRY_{it}$	…	…	…	…	…
$lnHK_{it}$	-0.061	-0.056	-0.055	0.002	-0.076
	(0.209)	(0.239)	(0.218)	(0.975)	(0.218)
$lnTO_{it}$	-0.012	-0.083	-0.071	-0.064	-0.065
	(0.854)	(0.256)	(0.417)	(0.337)	(0.386)
INF_{it}	-0.008	-0.007	-0.007	-0.006	-0.007
	(0.237)	(0.250)	(0.251)	(0.282)	(0.281)
$POPG_{it}$	-0.075**	-0.080**	-0.060*	-0.056	-0.063
$lnDTF_{i,t-1}$	(0.031)	(0.019)	(0.088)	(0.113)	(0.100)
Observations	336	336	336	336	336
F test (p-value)	0.000	0.000	0.000	0.000	0.001
Hansen p-value	0.748	0.688	0.664	0.402	0.347
AR(1) p-value	0.000	0.000	0.000	0.000	0.000
AR(2) p-value	0.265	0.217	0.199	0.181	0.236

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.

(ii) F test tests the joint significance of estimated coefficients. Hansen test checks the validity of instruments where the null hypothesis is instruments are not correlated with the residuals. Arellano-Bond AR test measures the first (AR (1)) and second order (AR (2)) autocorrelation. T test p values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space. In most cases, 3^{rd} lag of the right hand-side variables is used as instruments for the differenced formation. In the level equation, 2^{nd} lag of the corresponding differences are used as instruments.

Table C4. TFP growth regression (Fixed Effects)

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.250***	0.183***	0.175***		
	(0.000)	(0.000)	(0.000)		
FDI_{it}	0.161**	0.060		-0.004	0.160
	(0.035)	(0.379)		(0.953)	(0.149)
$FDI_{it}*lnDTF_{i,t-1}$		0.159***	0.179***	0.257***	
		(0.009)	(0.002)	(0.000)	
$lnRY_{it}$	0.016	0.030	0.031	0.027	-0.004
	(0.170)	(0.140)	(0.131)	(0.215)	(0.804)
$lnHK_{it}$	-0.099	-0.096	-0.097	-0.106*	-0.119**
	(0.159)	(0.184)	(0.193)	(0.098)	(0.039)
$lnTO_{it}$	0.147**	0.068	0.049	-0.009	0.096
	(0.047)	(0.234)	(0.317)	(0.860)	(0.241)
INF_{it}	-0.005**	-0.004*	-0.004	-0.007***	-0.012***
	(0.012)	(0.098)	(0.118)	(0.004)	(0.000)
$POPG_{it}$	-0.030	-0.027	-0.025	-0.041	-0.059*
	(0.260)	(0.285)	(0.304)	(0.143)	(0.065)
Observations	248	248	248	248	248
F test (p-value)	0.000	0.000	0.000	0.000	0.000
Adjusted R^2	0.355	0.386	0.386	0.332	0.223

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.
(ii) F test tests the joint significance of estimated coefficients. T statistics p-values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space

Table C5. TFP growth regression (Random Effects)

	(1)	(2)	(3)	(4)	(5)
$lnDTF_{i,t-1}$	0.090***	0.066***	0.062***		
	(0.000)	(0.005)	(0.005)		
FDI_{it}	0.087***	0.049		0.029	0.113***
	(0.001)	(0.250)		(0.523)	(0.000)
$FDI_{it}*lnDTF_{i,t-1}$		0.065*	0.085***	0.121***	
		(0.071)	(0.001)	(0.000)	
$lnRY_{it}$	0.022***	0.025***	0.027***	0.017**	0.001
	(0.005)	(0.001)	(0.001)	(0.043)	(0.922)
$lnHK_{it}$	0.006	-0.004	-0.003	-0.031	-0.030
	(0.829)	(0.906)	(0.920)	(0.320)	(0.303)
$lnTO_{it}$	0.084***	0.062*	0.067*	-0.017	-0.033
	(0.007)	(0.063)	(0.083)	(0.540)	(0.273)
INF_{it}	-0.009***	-0.010***	-0.010***	-0.011***	-0.013***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$POPG_{it}$	-0.027***	-0.028***	-0.025*	-0.034***	-0.036***
	(0.004)	(0.006)	(0.052)	(0.003)	(0.002)
Observations	248	248	248	248	248
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000
Overall R^2	0.309	0.322	0.317	0.289	0.224

Notes: (i) Variable specification: Dependant variable ΔlnA= Total factor productivity growth calculated as the five-year difference of log TFP; DTF= Distance to the Technological Frontier calculated as labor productivity of the US (A^{max}) divided by the labor productivity of the country (A_i) under consideration; FDI= share of real FDI stock in real GDP which is instrumented with CumDIPA (without internal instruments); RY= R&D intensity (R&D expenditure/GDP); HK= Human Capital measured as the average years of schooling of the population aged over 25; TO= Trade Openness measured as the value of restrictions on trade in economic globalization component of Globalization index (Dreher 2006); INF= inflation measured as an annual change in GDP deflator (in ratio); POPG= annual rate of population growth; All regressors are in five-year averages.

(ii) F test tests the joint significance of estimated coefficients. T statistics p-values (based on robust standard errors) are in parenthesis. *, **, *** indicate significance at 10%, 5% and 1% levels, respectively. All regressions have been run by including time dummies, which, along with the constant are not reported to save space