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Do Multinational Enterprises Contribute to Convergence or Divergence? A Disaggregated Analysis of US FDI

by

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Abstract

It is a widely held belief that foreign direct investment (FDI) has a positive effect on economic growth. We test this hypothesis by performing convergence regressions derived from a model of endogenous technological change. We estimate the rate of growth in per-capita income, relative to the per-capita income of the United States, in terms of US FDI, human development, financial development, and trade. We apply a panel approach, instrumenting for explanatory variables and correcting for correlated errors by clustering by countries. The heterogeneity of FDI is taken into account by considering various FDI-related activities – in addition to the conventionally used FDI stocks and flows. Furthermore, we draw on industry-specific FDI data, rather than exclusively on aggregated data. Our empirical analysis puts into question the currently prevailing euphoria about FDI as a means to induce economic catching-up processes of developing countries. We conclude that the central challenge facing policymakers is not to attract FDI, but to improve the local conditions required to benefit from the widely perceived unique advantages of FDI. In addition, our findings support the proposition that FDI stocks do not adequately reflect FDI-related economic activities.

Keywords: foreign direct investment, heterogeneity of FDI, growth effects, convergence regressions

JEL classification: F23, O40

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I. INTRODUCTION

Governments around the world take part in fierce international competition for foreign direct investment (FDI), not least by offering subsidies to multinational companies. Developing and newly industrializing countries are strongly advised, even by former critics of multinational companies such as the United Nations, to draw on FDI in order to supplement domestic savings and induce catching-up processes. This reflects the widely held belief, particularly among policymakers, that FDI has positive effects on economic growth that are supposed to result at least partly from technological spillovers. According to UN (2002: 5), the Conference on Financing for Development in Monterrey, Mexico, in March 2002 has shown that “foreign direct investment contributes toward financing sustained economic growth over the long term. It is especially important for its potential to transfer knowledge and technology, create jobs, boost overall productivity, enhance competitiveness and entrepreneurship, and ultimately eradicate poverty through economic growth and development."

The underlying argument is that FDI inflows amount to more than just capital imports. FDI is often thought of as "a composite bundle of capital stocks, know-how, and technology, and hence its impact on growth is expected to be manifold" (De Mello 1997: 1). JBIC Institute (2002: 1) posits that FDI is the dominant channel of international transfers of technology: "Multinational enterprises … are powerful and effective vehicles for disseminating technology from developed to developing countries and are often the only source of new and innovative technologies, which are usually not available in the arm's-length market."[1]

Yet, it is surprisingly hard to come by conclusive evidence supporting this predominant view. Previous empirical studies have resulted in highly ambiguous findings on the growth impact of FDI. A short review of the relevant literature reveals that the unique advantages of FDI over domestic investment as well as other forms of capital imports may be compromised in various ways (Section II). Several studies point to the relevance of supportive host-country conditions, which are often lacking in developing countries. The growth impact of FDI may also depend on investors' motivations and the type of FDI. The heterogeneity of FDI is largely ignored in the literature.

It is in two ways that we attempt to overcome this limitation (Section III). First, we consider various dimensions of FDI such as FDI-related R&D activities, technology imports, export operations and intra-firm trade - in addition to the conventionally used FDI stocks and flows. Second, we apply disaggregated FDI data for specific industries, in contrast to the aggregate stock or flow data typically used in previous studies. We draw on the detailed online data base provided for US FDI by the US Department of Commerce, Bureau of Economic Analysis (BEA).

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1 Likewise, Borensztein et al. (1998) and UNCTAD (1999: 207) consider FDI to be a major channel for developing countries to access advanced technologies.

We perform convergence regressions estimating the cross-country contribution of different dimensions of US FDI in different industries to convergence and growth. The form of these estimates is derived from a model of endogenous technological change similar to the one used by Aghion, Howitt and Mayer-Foulkes (2005) to explain the impact of financial development on convergence (Section IV). The convergence regressions estimate the rate of growth in per-capita income of host countries, relative to the per-capita income of the United States, in terms of US FDI, human development, financial development, and trade. The distinctive feature feature of convergence regressions is that the independent variables are also interacted with relative per-capita income, to obtain a measure of their impact on *convergence*. Thus for each of the independent variables we obtain two coefficients estimating their impact on growth as a function of relative per-capita income. We apply a panel approach, instrumenting for explanatory variables and correcting for correlated errors by clustering by countries. We also use a robust estimate to control for heteroskedasticity.

We find that FDI dimensions for which the results are significant have a positive effect on the growth of relative income of fairly advanced host countries (Section V). However, the effect on relative growth diminishes for lower-income countries FDI contributes to convergence only for countries classified by the World Bank as high-income countries, and could contribute negatively for middle and low-income countries. This finding has important policy implications, as we conclude in Section VI.

II. WHERE DO WE STAND?

Based on a review of the literature, the OECD (2002: 13) concludes that FDI contributes to factor productivity and income growth in host countries. Some recent studies do support such an optimistic assessment. Using FDI stock and/or flow data and applying OLS estimates, Ram and Zhang (2002) as well as Khawar (2005) find the nexus between FDI and the host countries' economic growth to be positive. Blonigen and Wang (2004) present Seemingly Unrelated Regression (SUR) estimates of the determinants of per-capita growth across countries, including decade-averages of FDI inflows, for the 1970s and 1980s. Their estimates based on the full sample, comprising both developing and developed host countries, do not reveal a significant effect of FDI on growth. However, when including the interaction of explanatory variables with a dummy variable indicating developing host countries, the growth impact of FDI turns positive for almost all developing countries, except for some countries with particularly low levels of education.

Yet it remains debatable if, and under which conditions, FDI leads to convergence. Several studies suggest that the growth impact of FDI depends on whether or not certain pre-conditions are met in the host countries. Balasubramanyam et al. (1996) stress that openness to trade is essential for reaping positive growth effects of FDI. According to De Mello (1997), the larger the technological gap between the host and the home country of FDI, the smaller the impact FDI will have in the former. Alfaro et al. (2001) conclude that, below a threshold level of financial market development in the host country, FDI will not exert beneficial effects on growth. Borensztein et al. (1998) show that FDI raises growth only in countries with a sufficiently qualified labor force.[2] In one way or another, these studies echo an earlier finding of Blomström et al. (1994), namely that developing countries must have reached a minimum level of economic development before they can capture the growth-enhancing effects of FDI.

Most of the earlier studies have some limitations in common, which may have as a consequence that the growth effects of FDI are overstated. First of all, the endogeneity of the FDI variable is often ignored. According to Carcovic and Levine (2002), the exogenous component of FDI flows does not exert a significant independent influence on per-capita income growth even if non-linearities caused by host-country characteristics are taken into account.[3]

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2 While Ram and Zhang (2002) as well as Khawar (2005) do not find any evidence supporting the complementarity between FDI and the host country's level of education, Blonigen and Wang (2004) report a similar pattern as in Borensztein et al. (1998), even though the turning point is shown to be at a lower level of education.

3 Blonigen and Wang (2004) argue, however, that this result is due to "inappropriate pooling of wealthy and poor countries."

Second, most studies consider only FDI flows, even though Blonigen and Wang (2004) point out that theory would suggest that FDI stocks are the appropriate measure to be used in growth regressions. It is, thus, interesting to note that Caves (1996: 237) reckons that "the relationship between a LDC's stock of foreign investment and its subsequent growth is a matter on which we totally lack trustworthy conclusions." Dutt (1997), who uses stock data, even finds a significantly negative growth impact of FDI.

Third, FDI dimensions other than stocks and flows are hardly considered in the literature on the FDI-growth nexus, even though they can reasonably be expected to play a role:

- The reasoning of Balasubramanyam et al. (1996) implies that world-market oriented FDI is superior to purely local-market oriented FDI because the former is more in line with comparative cost advantages of host countries.[4] This suggests to consider FDI-related exports as an important dimension of FDI, as we do in the subsequent analysis.
- UNCTAD (1998: 111-116) argues that multinational companies are increasingly pursuing complex integration strategies. Hence, the convergence effects of FDI may depend on the extent to which developing host countries

4 Nunnenkamp and Spatz (2004) argue that so-called efficiency-seeking FDI is more likely to bring in technology and know-how that is compatible with the host country's level of development, and to enable local suppliers and competitors to benefit from spillovers through adaptation and imitation. Moreover, this type of FDI is supposed to generate growth-enhancing export earnings.

are part of the sourcing and marketing networks of multinational companies. This can be checked by looking at another FDI dimension, namely the degree of vertical integration of foreign affiliates (proxied by imports from, and exports to the parent company).

- It is widely agreed in the literature that technology transfers and economic spillovers are crucially important for FDI to promote growth (OECD 2002**:** 95). Spillovers are notoriously difficult to measure.[5] Their significance is likely to depend on (i) the supply of superior technology and know-how by multinational companies, and (ii) the capacity of host countries to absorb superior technology and know-how. Hence, FDI may induce divergence, rather than convergence, not only because host countries lack absorptive capacity (Görg and Greenaway 2002; Xu 2000), but also because multinational companies supply less technology to developing countries. The latter proposition can be checked by considering FDI dimensions such as R&D activities of foreign affiliates and technology transfers by parent companies.

Fourth, the literature largely ignores another aspect of the heterogeneity of FDI by using aggregate stock or flow data. Nunnenkamp and Spatz (2004) argue that

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5 For a detailed review, see Blomström et al. (2000). Görg and Greenaway (2002) point out that studies reporting positive spillovers may provide a biased picture when cross-sectional data are used. This is because higher productivity in a particular sector may not only be the result of more FDI, but also be the reason for more FDI to flow into this sector.

the motivations underlying FDI differ across sectors and manufacturing industries. It cannot be ruled out that this translates into varying growth effects of FDI in particular industries. For example, the growth effects tend to be compromised if FDI crowds out local investment. Fears of crowding-out, which were widespread in developing countries in the past, may have receded since several cross-country studies have found no evidence to this effect (Lipsey 2000). However, Agosin and Mayer (2000) show that crowding-out has been the norm in Latin America. Crowding-out may also depend on the sectoral structure of FDI. FDI in the services sector, often related to privatization programs, is an obvious case in point, but local investment may also be replaced in manufacturing industries in which local producers lack competitiveness.[6] At the same time, FDI-related spillovers tend to be industry-specific (Kokko 2002). For instance, resource seeking FDI in the primary sector often takes place in economic enclaves with weak linkages to the local economy.

All this suggests that favorable growth effects of FDI cannot be taken for granted. Poor countries may find themselves in a trap which is difficult to escape: FDI-related technology transfers and spillovers to the local economy would be required most urgently in poor countries to narrow particularly wide productivity gaps. However, the supply of superior technology by multinational

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6 This is not to ignore that "crowding out of domestic investment through FDI may not necessarily be a problem" (OECD 2002: 26), if the released domestic resources are used for more productive purposes.

companies to poor countries could be constrained by the type of FDI these host countries tend to attract. Furthermore, local firms may be too far behind in terms of technological and managerial development to benefit from imitating technologies applied by foreign investors and to become involved in corporate networks.

III. US FDI IN DEVELOPED AND DEVELOPING COUNTRIES: STYLIZED FACTS

It is in two respects that detailed FDI data are required for a large number of host countries to perform a cross-country analysis that accounts for the heterogeneity of FDI. First, in addition to conventionally used FDI dimensions such as FDI stocks and flows, other dimensions that may be relevant for the economic growth effects of FDI have to be covered. These include: R&D activities of foreign affiliates, technology transfers from parent companies to affiliates, the export orientation of affiliates, and the integration of affiliates into parent companies' sourcing and marketing networks. Second, sectorally disaggregated data are needed to assess the relevance of industry characteristics in shaping the growth impact of FDI. To the best of our knowledge, there is only one data source that meets both requirements: the online data base provided by the US Department of Commerce, Bureau of Economic Analysis (BEA), for US FDI abroad as well as the activities (so-called operational data) of majority owned non-bank affiliates of US parent companies.

Comparable data are not available for other home countries. Hence, the subsequent analysis is restricted to the economic growth effects of US FDI. While it cannot be ruled out that the growth impact of FDI from other home countries differs from that of US FDI,[7] it should be noted that the United States represents by far the most important home country of FDI; in 2003 the United States accounted for slightly more than a quarter of worldwide outward FDI stocks (UNCTAD 2004: Annex table B.4).[8]

We apply BEA data on the following FDI dimensions for the period 1980-2000:

- US direct investment position abroad on a historical cost basis,
- US direct investment abroad, capital outflows,
- US direct investment abroad, income,
- Royalties and license fees, US parents' receipts,
- Research and development performed by affiliates,
- US exports of goods shipped to affiliates by US parents,
- US imports of goods shipped by affiliates to US parents,
- Employment of affiliates,
- Employee compensation of affiliates,
- Gross product of affiliates,

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7 This may be because the structure of outward FDI stocks differs between major home countries. For instance, more than 90 percent of Germany's FDI stocks are located in major industrialized countries, compared to less than 70 percent of US FDI stocks; the manufacturing sector accounts for less than 20 percent of Germany's FDI stocks, but for almost one third of UK FDI stocks (OECD 2004).

8 The United Kingdom ranked second with a share of less than 14 percent.

- Sales by affiliates to foreign countries other than the host country,
- Sales by affiliates to the United States,
- Total sales by affiliates.

Information on some of these FDI dimensions is also used to compare different sectors and industries according to factor intensities and other characteristics such as export orientation and the degree of vertical integration. We draw on industry-specific BEA data for petroleum,[9] manufacturing, wholesale trade, finance (except depository institutions)[10], services,[11] and other industries.[12] The manufacturing sector is broken down further into food and kindred products, chemicals and allied products, primary and fabricated metals, industrial machinery and equipment, electronic and other electric equipment, transportation equipment, and other manufacturing.

A comparison of different FDI dimensions and major characteristics of FDI in specific industries provides tentative insights as to why positive growth and

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[9] Petroleum, which comprises oil and gas extraction as well as petroleum and coal products, is used as a proxy for the primary sector that receives resource seeking FDI. The primary sector as a whole cannot be singled out from BEA data as agriculture and mining were included in "other industries" in the period of observation.

[10] Real estate and holding companies are subsumed under "finance" in the BEA source.

[11] "Services" according to BEA statistics comprise, inter alia, business services, hotels, health services, motion pictures, as well as engineering, architectural and surveying services.

[12] Some services items such as transportation and communication are included in "other industries."

convergence effects of FDI cannot be taken for granted. A simple inspection of the data indicates that for developing countries, and especially the poorest among them, it may be more difficult to derive economic benefits from FDI than to attract FDI. All developing countries[13] hosted 30 percent of total US FDI stocks in 2000. Taking this share as a yardstick, Figure 1 portrays the relative importance of other FDI dimensions in developing countries. In other words, bars exceeding a ratio of "one" (the horizontal line in Figure 1) indicate that the share of developing countries with regard to this particular FDI dimension is higher than their share in US FDI stocks. For example, this is the case for employment of US affiliates as FDI in developing countries tends to be more labor intensive than FDI in developed countries.

More surprisingly perhaps, the export share of US affiliates in developing countries slightly exceeds the share of developing countries in US FDI stocks, and intra-firm trade of affiliates in developing countries with US parent companies is by far more important than FDI stocks would suggest.[14] However, the strong vertical integration is exclusively due to US affiliates in Mexico. If

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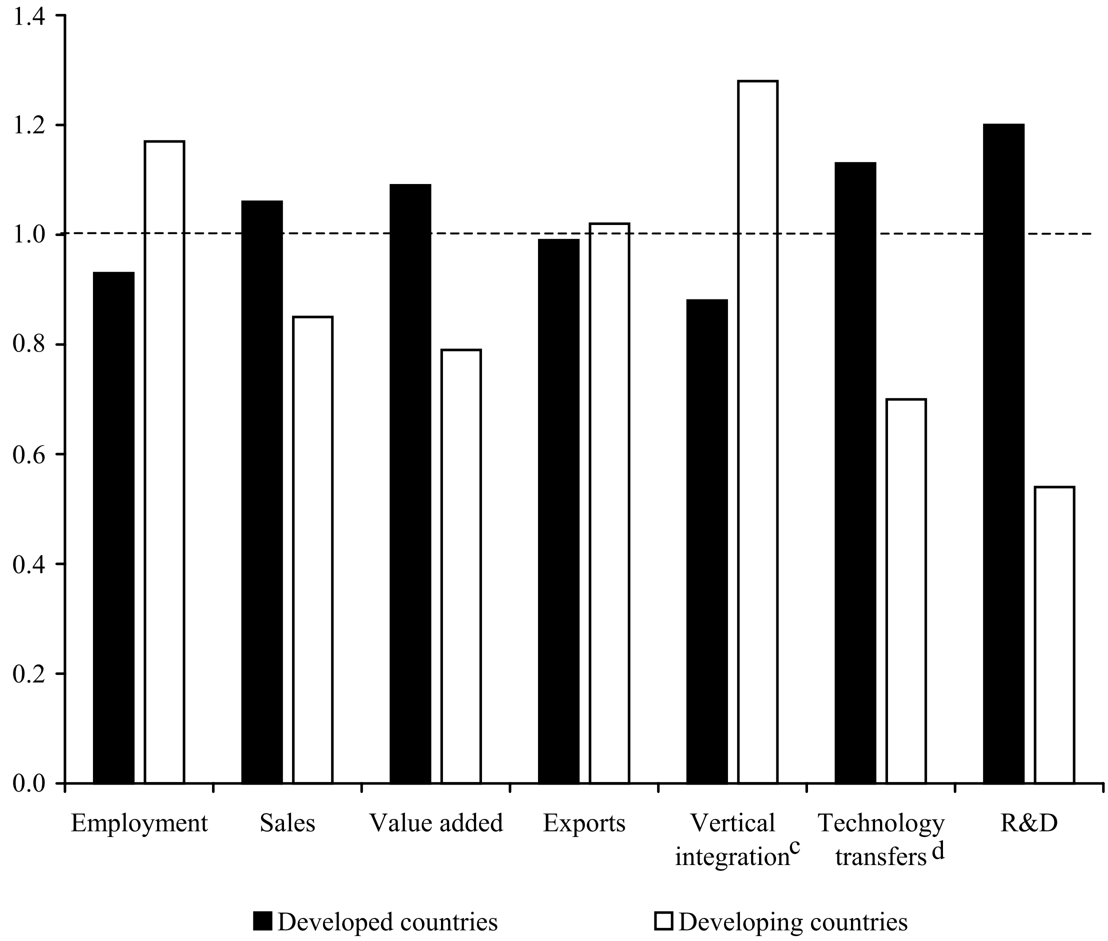
[13] All hosts of US FDI except Canada, European countries, Australia, New Zealand and Japan are regarded as developing countries in the following.

[14] The latter observation may indicate that vertical FDI, which aims at making use of international cost differentials, figures more prominently in developing countries than in developed countries, where horizontal FDI dominates because of factor endowments that are similar to those in the United States. For the motivations underlying vertical and horizontal FDI, see, e.g., Carr et al. (2001).

Figure 1 — Relative Importance of Selected Dimensions of FDI[a]: Developed and Developing Host Countries of US FDI Compared[b], 2000



[a]All dimensions refer to data for US majority owned non-bank affiliates in all industries. Calculated as the share of the respective country group with regard to the specific FDI dimension, relative to its share in US FDI stocks (historical cost basis); i.e., bars above (below) 1 indicate that the specific FDI dimension figures more (less) prominently than FDI stocks for the respective country group.— [b] Developed countries comprise Canada, Europe, Japan, Australia and New Zealand.— [c] Based on the sum of exports to, and imports from US parent companies.— [d]Measured by royalties and license fees paid by foreign affiliates to US parent companies.

Source: BEA.

Mexico is excluded from the group of developing host countries, the ratio of 1.28 reported in Figure 1 drops to 0.75. This means that intra-firm trade with US parents is *less* advanced than FDI stocks would suggest for affiliates in developing countries other than Mexico. This is especially so for particularly poor developing host countries. The sum of affiliate exports to, and affiliate imports from US parent companies amounted to less than 4 percent of total sales by US affiliates operating in African countries, compared to more than 11 percent of total sales by US affiliates operating in developed countries (data for 2000 from BEA). At the same time, 82 percent of total sales by US affiliates in the manufacturing sector of African host countries were destined to local markets, while the corresponding share was 59 percent in developed host countries.

FDI-induced convergence of poor developing countries also appears to have been hindered by relatively weak R&D activities of US affiliates in these host countries. Even though Africa's share in total US FDI stocks just slightly exceeded one percent in 2000, its share in R&D expenditures of all US affiliates was still much lower (0.14 percent). It is also for all developing countries that the share in FDI-related R&D activities falls considerably short of the share in FDI stocks (Figure 1).[15] The concentration of R&D activities in developed host countries is not unexpected, considering relative factor endowments in

15 In this regard, excluding Mexico does not change the picture.

developed and developing countries. However, developing countries also received considerably less technology transfers, measured by royalties and license fees paid by US affiliates to their parent companies, than the share of developing countries in US FDI stocks would have suggested.[16] Hence, the limited supply of advanced technologies by US direct investors to developing host countries may have constrained the potential of growth-enhancing spillovers to the local economy.

The sectoral structure of US FDI in developed and developing host countries offers further insights to this effect. Resource seeking FDI in the primary sector plays a marginal role in developed countries, but figures prominently in poor developing countries. US FDI in the petroleum industry, which we consider a proxy of this type of FDI, accounted for more than 60 percent of total US FDI stocks in Africa in 2000 (compared to 7 percent in developed countries). FDI in the petroleum industry is exceptional in various respects: It is extremely capital intensive, technology transfers and R&D activities by US affiliates are negligible, and the degree of vertical integration is very low (Table 1). In addition, resource seeking FDI in this industry is often in economic enclaves with few linkages to the local product and labor markets. Rather than enhancing economic development of poor host countries, it tends to induce rent-seeking and might cause "Dutch disease" effects. According to Nunnenkamp and Spatz

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16 The ratio of 0.7 shown in Figure 1 declines further to 0.64 if Mexico is excluded.

(2004), resource seeking FDI in the petroleum industry may be detrimental to growth in developing countries with weak institutions.

The structure of FDI in the manufacturing sector, too, differs significantly between developed and developing host countries. The share of developing countries in industry-specific FDI stocks held by the United States in all host countries ranges from 19 percent in chemicals and metals to 50 percent in electronic equipment (Figure 2). At the same time, manufacturing industries differ significantly with regard to factor intensities, technology transfers, export orientation and vertical integration (Table 1). For example, US FDI in the labor intensive electronic equipment industry of developing countries is in accordance with factor endowments typically prevailing in these host countries. Positive growth effects may have been supported by the strong export orientation and the high degree of vertical integration in this industry. On the other hand, technology transfers to affiliates operating in the electronic equipment industry are clearly below the manufacturing average. By contrast, machinery stands out in terms of high technology transfers, and transport equipment in terms of high R&D activities undertaken by US affiliates. Mainly developed host countries of US FDI may have benefited from the application of recent technologies in these industries, considering that about three quarters of US FDI stocks were located in developed countries. This applies even more so to the chemical industry, which ranks second (behind machinery) when local R&D and technology transfers are taken together.

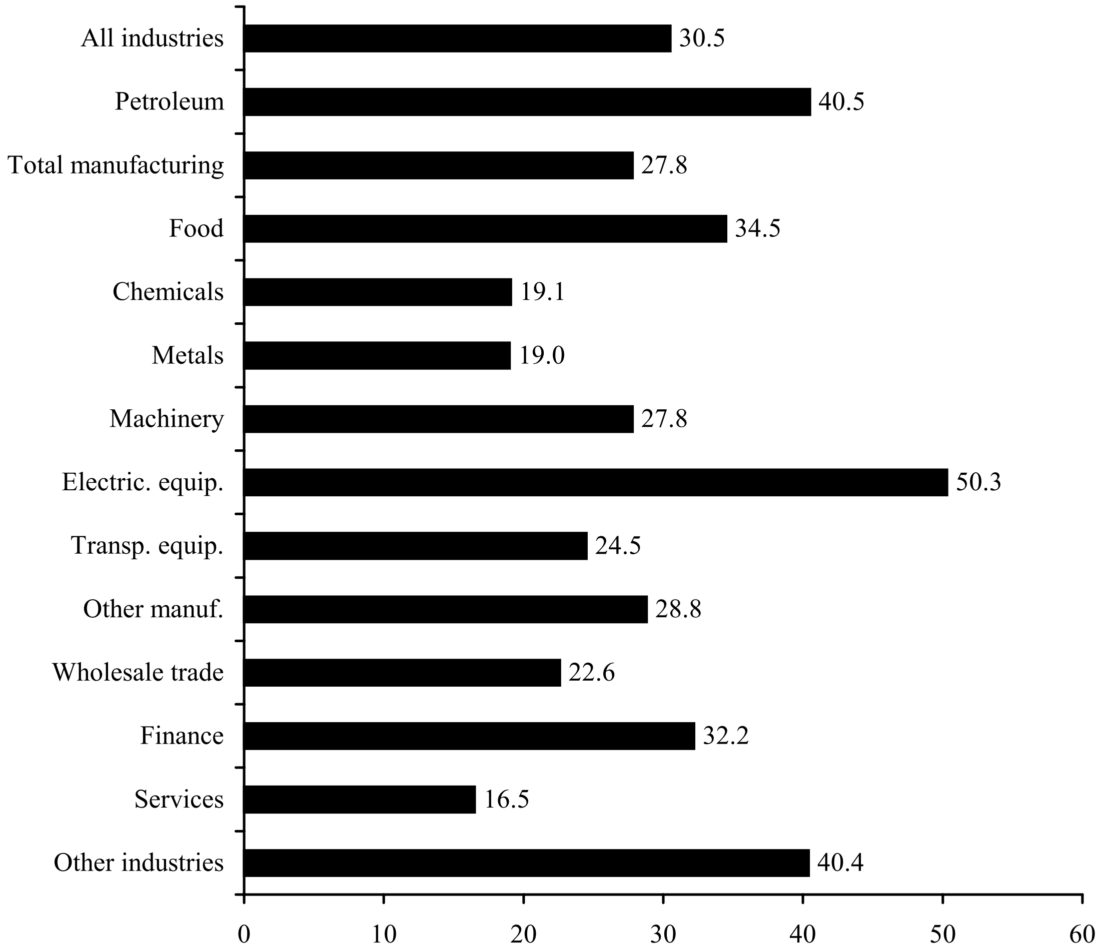
Table 1 — Characteristics of Industries: Selected Indicators for All Host Countries of US FDI (majority owned non-bank affiliates) in 1998

	Labor intensity[a]	Human capital intensity[b]	R&D intensity[c]	Technology transfers[d]	Export orien-tation[e]	Vertical integration[f]
All industries	13.4	33.2	2.90	4.57	35.3	16.4
Petroleum	1.8	49.9	0.13	0.02	22.5	4.3
Total manufacturing	15.9	31.5	5.19	4.85	44.5	25.5
Food	16.5	26.2	1.36	5.37	26.1	5.1
Chemicals	10.2	41.0	7.78	6.12	35.2	12.6
Metals	17.3	33.5	1.59	1.99	33.5	11.4
Machinery	15.7	36.2	3.12	11.33	60.7	28.9
Electr. equip.	31.7	19.0	5.68	3.68	57.2	41.1
Transp. equip.	15.4	37.5	10.78	0.20	52.4	46.9
Other man.	14.7	30.8	2.37	3.84	34.2	14.7
Wholesale trade	9.5	48.7	1.16	6.76	35.4	16.5
Finance	10.0	60.4	0.25	3.50	33.9	0.02
Services	18.5	37.2	1.95	10.97	18.3	2.0
Other industries	28.0	18.4	0.09	2.87	9.5	3.2

[a]Number of employees of US affiliates per million $ of value added. — [b]Compensation of employees ($ 1000) per employee of US affiliates. — [c]R&D expenditures of US affiliates in percent of value added. — [d]Royalties and license fees paid by US affiliates to their parent companies in percent of value added. — [e]Total exports of US affiliates in percent of total sales. — [f]Sum of exports of US affiliates to, and imports of US affiliates from their parent companies in percent of total sales of US affiliates.

Quelle: BEA.

Figure 2 — Share of Developing Countries[a] in Industry-specific US FDI Stocks, 1998 (percent)



[a]Proxied by all countries except Canada, European countries, Japan, Australia and New Zealand; New Zealand included in food, other manufacturing, services, and other industries (due to undisclosed data).

Source: BEA.

Likewise, mainly developed countries appear to have benefited from high technology transfers in services industries (as defined by BEA). As shown in Figure 2, the share of developing countries in industry-specific FDI stocks was particularly low (16.5 percent) in "services." Considering the group of five industries in which technology transfers exceeded the average of 4.57 percent of US affiliates' value added (food, chemicals, machinery, wholesale trade, and services), 78 percent of US FDI stocks were located in developed host countries. By contrast, the share of developing countries in US FDI stocks was relatively high (34 percent) for the group of seven industries in which technology transfers remained below the average. This pattern underscores our proposition that FDI may lead to divergence, rather than convergence.

IV. MODEL AND ESTIMATION APPROACH

While most current theories of cross-country differences in per-capita income imply that all countries share the same long-run growth rate (of TFP or per-capita GDP), a recent strand of literature in endogenous technological change has expanded the scope of both theoretical and empirical studies to include the possibility of long-term differences in growth rates. The historical record shows that growth rates indeed differ substantially across countries over long periods of time. Pritchett (1997) estimates that the proportional gap in per-capita GDP between the richest and poorest countries grew more than five-fold from 1870 to

1990. According to Maddison (2001), the proportional gap between the richest group of countries and the poorest grew from 3 in 1820 to 19 in 1998.

The divergence between rich and poor countries continued through the end of the twentieth century. Although studies such as Barro and Sala-i-Martin (1992), Mankiw, Romer and Weil (1992) and Evans (1996) show that a substantial group of rich and middle-income countries have been converging to parallel growth paths over the past 50 years or so, the gap between these countries as a whole and the poorest countries as a whole has continued to widen. For example, the proportional gap in per-capita GDP between Mayer-Foulkes' (2002) richest and poorest convergence groups grew by a factor of 2.6 between 1960 and 1995, the period usually studied in cross-country regressions, and the proportional gap between Maddison's richest and poorest groups grew by a factor of 1.75 between 1950 and 1998.

In the last decade, the empirical growth literature has arrived at the consensus that technological differences are a central factor underlying divergence. Easterly and Levine (2001) estimate that about 60 percent of the cross-country variation in growth rates of per-capita GDP is attributable to differences in productivity growth. Klenow and Rodríguez-Clare (1997) estimate that in their sample about 90 percent of the variation is attributable to differences in productivity growth. Thus divergence reflects long-lasting cross-country differences in rates of technological progress.

In two recent papers, Howitt and Mayer-Foulkes (2005) and Aghion, Howitt and Mayer-Foulkes (2005) develop models extending the theory of endogenous technological change so that it can account for underdevelopment. In these models, technological leaders and some groups of following countries grow at the growth rate of the leading technological edge, while other followers further behind may grow at a lower rate. Essentially, what defines underdevelopment are economic phenomena that impede technological change, for example, threshold requirements in human capital accumulation to attain R&D rather than being restricted to technological implementation, and institutional development necessary for credit markets to fuel desired levels of technological change. When these failures are not too strong, countries will lag in levels but not in growth, while for stronger failures countries will also attain lower growth rates.

Both papers introduce models for closed economies in which growth occurs through technological transfers (exchange of ideas) whose rate is governed by local characteristics of the economy. These local characteristics determine the rate of absorption of innovations occurring worldwide or, for simplicity, in leading economies. A convergence effect exists because the farther behind an economy lags, the more technologies can be tapped from world knowledge. However, divergence is possible because local conditions may make the rate of absorption too low. Thus, the extent to which follower economies will convergence in growth rates or levels to the leading economies is endogenously determined. Essentially, the model for small countries[17] is of the form:

$$a_{t+1} = \mu(X(a_t)) + \frac{1-\mu(X(a_t))}{1+g_t} a_t, \qquad (1)$$

where $a_t = A_t / \overline{A}_t$ represents the technological level A_t of a small country with respect to the leading technological edge $\overline{A}_t$, μ represents the probability of innovation in each intermediate sector, itself a function of variables $\mathbf{X}_t$ (such as financial development or a threshold effect for the possibility of R&D) which might in turn depend on a_t. Finally, g_t represents the growth rate of the technological frontier.

As mentioned in Section I, it is widely believed that FDI works like financial development. If this is true, the above model can be considered an adequate point of departure for the econometric estimates. We assume in the following that there is a set of variables $\mathbf{X}_t$ influencing the probability of innovation and, therefore, determining the magnitude (and sign) of convergence. These variables include FDI and variables that are essential to control for if the impact of FDI is to be ascertained, namely financial development, trade, as well as human and physical capital.

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[17] Countries are regarded as small if they have an insignificant effect on the rate of growth of the leading technological edge.

We follow Aghion, Howitt and Mayer-Foulkes (2005), who evaluate the effects of financial development on convergence, and use worker productivity as a proxy for technological levels, because these cannot be measured directly.[18] Hence, the relative technological level a_t is represented by *relative* per-capita income to the United States, which proxies for the leading technological edge. The estimate has the form of a standard growth regression in the relative income variable, except for the inclusion of an interaction term between financial development ("credit") – the variable influencing convergence – and the initial relative income term.[19] Here we perform a similar estimate, except that we expand the variables influencing convergence to include credit, US FDI, openness to trade, capital and human capital. Also, we consider a panel rather than just a cross-section, and instrument all stock variables.

Let i index countries and t time, and let $\mathbf{X}_{i,t}$ stand for the variables influencing convergence, $y_{i,t}$ represents the log of per-capita income of country i. Define the relative per-capita income to the United States, a deflated variable that proxies for a_t, by:

$$\hat{y}_{i,t} = y_{i,t} - y_{US,t}\,. \qquad (2)$$

We estimate the following equation, which we call a *convergence regression*:

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[18] The estimates of technological levels depend on assumptions on the production function and on measurements of human and physical capital which are not very precise and, in any case, are scarce for low-income countries.

[19] It is shown under some assumptions that this regression model can be derived from a log-linear approximation to (1).

$$\Delta\hat{y}_{i,t+5} = \beta_0 + \beta_y \hat{y}_{i,t} + \beta_X \overline{X}_{i,t} + \beta_{Xy} \overline{X}_{i,t} \bar{\hat{y}}_{i,t} + \beta_Z Z_{i,t} + \varepsilon_t + \eta_{i,t}. \quad (3)$$

Here Δ is the forward difference operator, so that the dependent variable is the growth rate of relative per-capita income. $\mathbf{X}_{i,t}$ are variables influencing convergence, stated in a bounded form consistent with a steady-state analysis. In our case, these variables characterizing the economy are the ratios of private credit, US FDI, imports plus exports, and physical capital to GDP, and the absolute variable, log life expectancy (which proxies human capital). Averages of $\mathbf{X}_{i,t}$ and $\hat{y}_{i,t}$ over the five-year period t to t + 5 are used because the convergence effect that is modeled occurs continuously over this period. Finally, $\mathbf{Z}_{i,t}$ are other variables and their coefficients. In particular, we use for $\mathbf{Z}_{i,t}$ the change in the ratio of physical capital to GDP and the change in life expectancy, thus controlling for the effects of physical and human capital accumulation on growth. We also include a fixed time effect ε_t in some of the regressions. All variables in the regression are stationary variables.

Thus, our estimates control for the most important variables that could have an impact on economic growth, and also for the most important variables which could be related to FDI, namely physical and human capital accumulation, institutional arrangements affecting the economy (represented by the amount of private credit as a ratio to GDP), and openness to trade.

Physical and human capital accumulation are considered in two ways. First, we enter capital stocks which may themselves determine growth and convergence rates. In the case of physical capital, we use the ratio to GDP, which is a stationary variable and less subject to endogenous variation (Klenow and Rodríguez-Clare 1997). Second, we control for changes in the physical capital ratio and for changes in life expectancy within each period (our flow variables), that is, for changes in inputs which may give rise to growth independently of any FDI effects.

As shown in Aghion, Howitt and Mayer-Foulkes (2005), the rate of convergence estimated for each country is $\beta_y + \boldsymbol{\beta}_{\mathbf{X}y}\overline{\mathbf{X}}_{i,t}$. Convergence occurs if this is negative. If a variable in $\mathbf{X}_{i,t}$ promotes convergence it will have a negative coefficient in $\beta_{i\mathbf{X}y}$. Also, relative income levels depend positively on the non-interacted coefficient $\beta_{i\mathbf{X}}$. As reported in detail below, we find that US FDI consistently obtains positive signs for both coefficients. The positive sign for the non-interacted coefficient $\beta_{i\mathbf{X}}$ (the intercept) means that US FDI contributes positively to the growth of per-capita income relative to the United States for countries with an income at the US level. A positive sign for the interacted coefficient $\beta_{i\mathbf{X}y}$ (the slope) means that this effect diminishes for lower-income countries. An estimate is made of the relative income level at which the effect becomes zero. This usually occurs at higher income levels as defined in the World Bank classification.

The sample is defined by those countries for which the private credit variable, per-capita income, and life expectancy are available over the quinquenia 1980-

1985 to 1995-2000, amounting to 313 observations.[20] For part of this sample, trade and physical capital variables are unavailable. So as not to reduce the sample, we made the observation for these variables "zero" and included a dummy for "Not available (NA)".

In convergence regression (3), the error term may be correlated with the variables $\mathbf{X}_{i,t}$ influencing convergence (due to endogeneity), and with the mean relative income level $\bar{y}_{i,t}$ occurring through the period *t* to *t* + 5. In addition, the errors may be correlated across time periods for each country. This second problem is corrected using clustering and a robust estimate of the errors. To correct for the first problem, all of the variables $\overline{\mathrm{X}}_{i,t}$ and their interactions with $\bar{y}_{i,t}$ are instrumented . Table 2 lists the set of instruments we use.

Table 2 – Instruments Used for the Convergence Determinants

Convergence determinant	Instruments
Private credit	Legal origin dummies
US FDI	Log distance to US, log area, tropical, latitude, landlocked
Openness to trade	Exports and imports in 1958
Life expectancy	Life expectancy in 1962.

Legal origin dummies for English, French, German and Scandinavian legal systems are exogenous variables mostly determined long before our estimation

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20 Including life expectancy only eliminates four observations.

period 1980-2000. These variables are intimately associated with the property rights regime that makes private credit possible and instrument for the institutional structure of countries. They are used by Levine, Loayza and Beck (2000) and later Aghion, Howitt and Mayer-Foulkes (2005) to study the impact of financial development on economic growth. The four dummies were supplemented by a "Legal origin not available" dummy so as not to reduce the sample.

In the case of US FDI, the distance to the United States is a natural instrument. The remaining variables log area, tropical, latitude, and landlocked may also have a bearing on the incentives for FDI, and are found to be statistically relevant. Moreover, since instruments are in fact used jointly, the presence of these geographical instruments strengthens the instrument set as a whole. The instruments are fairly effective, as can be seen from the OLS regressions for US FDI stocks (historical cost basis) and R&D expenditures of US affiliates, taken over the regression sample (Table 3). For openness to trade and life expectancy, we simply use the corresponding variables for 1958 and 1962, respectively.

Table 3 – Selected Dimensions of US FDI Regressed on Instruments[a]

	US FDI stocks (historical cost basis)	R&D by US affiliates
Log distance to US	-0.046	-0.019
	[1.73]	[2.01]*
Log area	-0.044	-0.017
	[3.53]**	[5.14]**
Latitude	-0.002	0
	[1.78]	[0.87]
Landlocked	0.298	-0.028
	[4.29]**	[1.35]
Tropical	0.19	0.001
	[3.22]**	[0.11]
Constant	1.347	0.362
	[5.16]**	[4.27]**
Observations	317	129
R-squared	0.17	0.24

[a]Robust t statistics in square brackets;
* significant at 5 percent; ** significant at 1 percent

Source: Own calculations based on BEA

V. EMPIRICAL RESULTS

We use convergence regression (3) to estimate the effect of US FDI on the growth of income relative to the United States, according to the relative income of each country. Estimates are run for each of the 13 FDI dimensions listed in Section III. At the same time, we make use of the industrial classification of the BEA data. In addition to applying aggregate FDI data for all industries and total manufacturing, we run the estimates on the basis of industry-specific data for 12 industries (petroleum, wholesale trade, finance, services, other industries, food and kindred products, chemicals and allied products, primary and fabricated metals, industrial machinery and equipment, electronic and other electric equipment, transportation equipment, and other manufacturing).[21] In principle, this results in 13*14 regressions. For 54 regressions there were more than 50 US FDI data points (in the 1980-1995 sample, which has 313 observations).

The availability of data for physical capital, which ends in 1992, was another limiting factor in running the regressions. Extrapolation was used to generate the 1990-1995 average of the level and the rate of change of physical capital. However, it was impossible to include physical capital in the 1995-2000 period.

The change in physical capital is clearly endogenous with economic growth errors, but this variable need not necessarily be instrumented since we are not interested in an estimate of its coefficient. Moreover, we do not have any specific instruments for it. Nevertheless, since our set of instruments is relatively large, it is possible to run the estimates instrumenting for all variables. Note also that the inclusion of time dummies, a somewhat non-economic variable, could reduce the significance of results. Finally, excluding the physical capital variable allows considering a larger sample. According to these considerations, the regressions were run in five different ways (Table 4).

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21 See Section III for detailed description.

Table 4 – Description of Estimates

Estimate	Sample	Instrumented variables
1	1980-1995	All stock variables and also physical and human capital change
2	1980-1995	All stock variables
3	1980-1995	All stock variables; no time dummies used
4	1980-2000	All stock variables; NA dummy for physical capital included
5	1980-2000	All stock variables; all physical capital variables excluded

Overall, the findings are similar across regression sets. Table 5 presents a comparison of estimates 1 to 5 when applied to US FDI stocks on historical cost basis, for both the instrumented and non-instrumented versions.[22] Most of the results achieved for controlling variables are plausible. Initial relative income is always significantly negative with little variation in coefficient values. Likewise, life expectancy, which proxies for human capital, obtains fairly robust results. Both, the level of life expectancy and its interaction with initial relative income are significantly positive. Physical capital, trade and private credit lose significance after instrumentation. By contrast, the instrumentation increases the coefficient obtained for US FDI, as is to be expected for a variable that is positively correlated with shocks to economic growth. The coefficients of US FDI and its interaction with initial relative income are hardly affected when

22 The complete regression results for other FDI dimensions and particular industries are not reported here, but are available from the authors upon request.

varying the sample and instrumentation according to estimates 1 to 5. Both coefficients turn out to be significantly positive. The positive sign of the interaction term means that US FDI leads to divergence rather than convergence for host countries below a certain threshold of relative income (see below for details).

The finding that the non-interacted as well as the interacted coefficients of US FDI are positive also applies to other FDI dimensions and particular industries. This can be seen in Figure 3 which portrays the histograms of all these coefficients as well as the corresponding t-statistics. Almost all non-interacted coefficients are significant at the 5 percent level; the same is true for roughly half of the interacted coefficients. The results achieved from a regression across the total set of FDI coefficients underscore that the choice between estimates 1 to 5 has little effect. The underlying regression equation is as follows:

$$c_i = \sum_{Industries\ j} \alpha_i I_{ij} + \sum_{FDIdimensions\ j} \beta_i F_{ij} + \sum_{Estimate\ j} \eta_{ij} \qquad \textbf{(4)}$$

This regression reveals the effect on US FDI coefficients of belonging to a specific industry or FDI dimension. I_{ij} is "one" if coefficient i belongs to industry j and "zero" otherwise, and similarly in the case of F_{ij} for FDI dimensions. Fixed effects η_{ij} for each estimate j = 1 to 5 are also included.

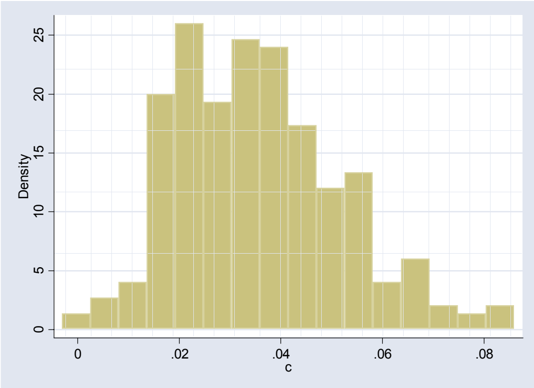
Table 5 — Comparison between Convergence Regressions for Per-capita Income Relative to US[a] (Instrumented Variables[b], Clustered by Countries, Robust Estimates)

	1	2	3	4	5	1(OLS)	2(OLS)	3(OLS)	4(OLS)	5(OLS)
Initial relative income y	-0.31 (7.52)**	-0.316 (7.46)**	-0.336 (6.67)**	-0.301 (6.15)**	-0.293 (6.81)**	-0.327 (17.62)**	-0.328 (16.97)**	-0.328 (16.97)**	-0.34 (19.40)**	-0.342 (19.61)**
US FDI(stocks at hist. cost)	0.022 (3.15)**	0.023 (3.11)**	0.022 (2.44)*	0.02 (2.34)*	0.02 (2.79)**	0.015 (3.49)**	0.014 (3.11)**	0.014 (3.11)**	0.014 (3.37)**	0.013 (2.84)**
US FDI × Average y	0.02 (2.31)*	0.021 (2.41)*	0.021 (1.97)	0.018 (1.97)	0.02 (2.63)**	0.008 (2.95)**	0.007 (2.86)**	0.007 (2.86)**	0.007 (2.98)**	0.008 (3.00)**
Life expectancy	0.207 (6.53)**	0.21 (6.44)**	0.233 (6.15)**	0.208 (6.28)**	0.19 (6.14)**	0.228 (10.17)**	0.224 (9.14)**	0.224 (9.14)**	0.223 (10.02)**	0.223 (10.51)**
Life expect × Average y	0.069 (6.69)**	0.071 (6.66)**	0.077 (6.24)**	0.066 (5.59)**	0.066 (6.26)**	0.069 (13.16)**	0.07 (12.89)**	0.07 (12.89)**	0.071 (14.62)**	0.071 (15.02)**
Private credit	-0.014 (1.29)	-0.013 (1.13)	-0.009 (0.73)	-0.013 (1.03)	-0.005 (0.55)	-0.018 (2.87)**	-0.018 (2.90)**	-0.018 (2.90)**	-0.021 (3.69)**	-0.012 (2.97)**
Private credit × Average y	-0.025 (1.38)	-0.022 (1.18)	-0.005 (0.19)	-0.015 (0.53)	-0.034 (1.76)	-0.016 (2.93)**	-0.017 (3.02)**	-0.017 (3.02)**	-0.018 (3.65)**	-0.015 (3.87)**
Trade	0.01 (1.54)	0.009 (1.43)	0.008 (1.17)	0.01 (1.60)	0.008 (1.38)	0.012 (2.99)**	0.011 (2.88)**	0.011 (2.88)**	0.013 (3.30)**	0.013 (3.47)**
Trade × Average y	0.002 (0.27)	0.001 (0.20)	-0.001 (0.19)	0.001 (0.21)	0.001 (0.17)	0.006 (2.53)*	0.006 (2.47)*	0.006 (2.47)*	0.009 (3.27)**	0.009 (3.71)**
NA Trade	0.04 (1.51)	0.037 (1.40)	0.029 (1.05)	0.031 (1.22)	0.032 (1.36)	0.052 (2.94)**	0.049 (2.83)**	0.049 (2.83)**	0.054 (3.21)**	0.057 (3.75)**
NA Trade × Average y	0.005 (0.19)	0.003 (0.11)	-0.01 (0.34)	-0.001 (0.04)	0.001 (0.05)	0.027 (2.47)*	0.026 (2.41)*	0.026 (2.41)*	0.034 (3.18)**	0.038 (3.85)**
Capital	0.012 (1.01)	0.012 (0.95)	0.021 (0.88)	0.022 (1.36)		0.012 (2.35)*	0.011 (2.21)*	0.011 (2.21)*	0.011 (2.50)*	
Capital × Average y	-0.012 (0.57)	-0.016 (0.71)	-0.022 (0.68)	-0.008 (0.32)		0.006 (1.15)	0.005 (1.05)	0.005 (1.05)	0.008 (2.00)*	
NA Capital	0 (0.03)	0.003 (0.25)	0.014 (0.80)	0.016 (0.93)		-0.001 (0.20)	0.001 (0.11)	0.001 (0.11)	0.002 (0.34)	
NA Capital × Average y	-0.002 (0.45)	-0.002 (0.37)	0.004 (0.34)	0.007 (0.69)		0.002 (0.68)	0.003 (0.86)	0.003 (0.86)	0.004 (1.35)	
dCapital	0.006 (1.50)	0.007 (1.70)	-0.009 (0.25)	-0.015 (0.36)		0.007 (2.10)*	0.007 (2.34)*	0.007 (2.34)*	0.007 (2.32)*	
dLife Expectancy	-0.144 (0.89)	-0.06 (0.38)	0.595 (1.11)	0.007 (0.02)	-0.425 (1.37)	-0.02 (0.14)	0.048 (0.33)	0.048 (0.33)	-0.128 (1.50)	-0.144 (1.78)
Dummy 1980-1985		-0.003 (1.05)	-0.004 (1.16)	0.001 (0.09)	0.007 (1.68)		-0.003 (1.11)	-0.003 (1.11)	0.001 (0.27)	0.003 (1.28)
Dummy 1985-1990		0.004 (1.72)	0.004 (1.15)	0.007 (1.21)	0.015 (3.73)**		0.004 (1.91)	0.004 (1.91)	0.008 (1.98)*	0.01 (4.29)**
Dummy 1990-1995				0.004 (0.83)	0.012 (3.07)**				0.004 (1.07)	0.006 (3.42)**
Dummy NA Capital				-0.011 (1.30)					-0.004 (1.02)	
Constant	-0.942 (7.41)**	-0.953 (7.29)**	-1.053 (6.58)**	-0.949 (6.81)**	-0.871 (6.83)**	-1.031 (11.50)**	-1.011 (10.14)**	-1.011 (10.14)**	-1.014 (11.12)**	-1.017 (11.70)**
Observations	313	313	313	391	391	313	313	313	391	391
R-squared	0.7	0.7	0.61	0.62	0.66	0.76	0.77	0.77	0.77	0.76

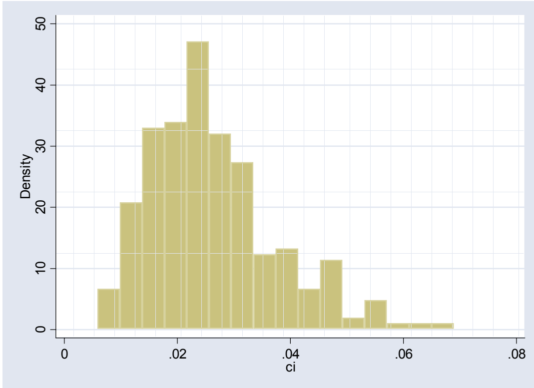
[a] All regressions use FDI stock data in all industries. Robust t-statistics in parentheses; *,** significant at 5 percent and 1 percent, respectively. — [b] Instruments: legal origin, tropical, distance to US, area, latitude, landlocked, exports and imports in 1958, life expectancy in 1962.

Source: Own calculations based on BEA.

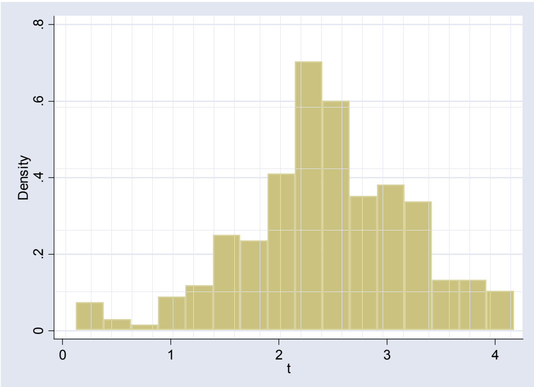
Figure 3 — Histograms for US FDI Coefficients and their t-Statistics (from 5 sets of regressions)



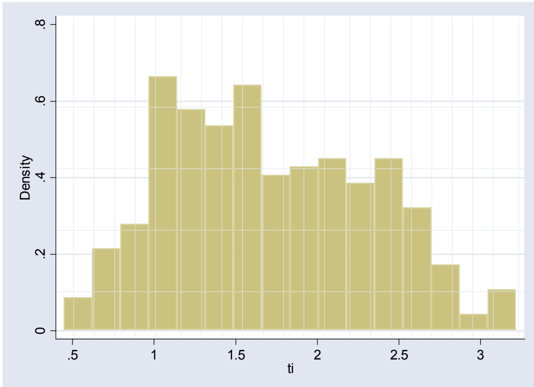
3.1 Non-interacted Coefficients



3.2 Interacted Coefficients



3.3 Non-interacted t-Statistics



3.4 Interacted t-Statistics

The regression effects show that the three estimates for the 1980-1995 sample are essentially the same (Table 6, lower panel). The results obtained for the 1980-2000 sample including physical capital give slightly higher non-interacted coefficients which are slightly less significant. By contrast, the exclusion of the physical capital variable has the effect that all coefficients are higher and more significant.

Table 6 — Comparison of Coefficients across Regression Sets

	Industries, FDI dimensions and regression effect	**Non-interacted coefficient**	**Interacted coefficient**	**Non-interacted t-statistic**	**Interacted t-statistic**
Industries[a] (all industries as reference)	Petroleum	0.008	0.006	-0.232	0.11
		(2.78)**	(2.05)*	(1.47)	(0.73)
	Total manufacturing	-0.004	0.001	-0.12	-0.149
		(2.00)*	(0.51)	(1.02)	(1.33)
	Food and kindred products	-0.025	-0.001	-1.261	-0.186
		(10.26)**	(0.34)	(9.51)**	(1.48)
	Chemicals and allied products	-0.009	0.001	-0.415	-0.118
		(4.18)**	(0.61)	(3.52)**	(1.05)
	Primary and fabricated metals	-0.011	0.015	-0.754	0.122
		(3.32)**	(4.72)**	(4.09)**	(0.70)
	Electronic and other electric equipment	-0.009	0.013	-0.233	0.336
		(3.18)**	(4.83)**	(1.47)	(2.23)*
	Other manufacturing	-0.01	-0.001	-1.144	-0.648
		(3.02)**	(0.23)	(6.20)**	(3.69)**
	Wholesale trade	0.008	0.012	-0.047	0.083
		(3.32)**	(5.15)**	(0.36)	(0.66)
	Finance	-0.009	0.02	-0.919	0.097
		(2.79)**	(6.35)**	(4.98)**	(0.55)
	Services	0.005	0.019	0.16	0.564
		(2.22)*	(8.32)**	(1.20)	(4.46)**
	Other industries	0.01	0.013	0.476	0.328
		(2.95)**	(4.13)**	(2.58)*	(1.86)
FDI dimensions[b] (stocks at historical cost as reference)	Capital outflows	0.005	0.006	-0.434	-0.282
		(1.10)	(1.45)	(1.76)	(1.20)
	Income	0.006	0.004	0.074	-0.197
		(3.22)**	(2.39)*	(0.70)	(1.97)
	Royalties and license fees	0.004	0.007	0.659	0.637
		(1.58)	(2.78)**	(4.31)**	(4.38)**
	Total sales by affiliates	0.012	0.004	-0.268	-0.305
		(5.77)**	(1.80)	(2.29)*	(2.74)**
	Sales by aff. to the United States	0.019	0.026	0.015	0.031
		(4.12)**	(6.10)**	(0.06)	(0.13)
	Sales by aff. to foreign countries	0.024	0.023	0.413	0.769
	(except host country)	(5.32)**	(5.38)**	(1.68)	(3.29)**
	Employment of affiliates	0.02	0.004	-0.397	-0.538
		(10.72)**	(2.44)*	(3.94)**	(5.62)**
	Employee compensation of affiliates	0.024	0.009	-0.213	-0.45
		(13.20)**	(4.98)**	(2.11)*	(4.70)**
	US imports shipped by aff. to US parents	-0.005	0.003	-1.363	-0.763
		(1.10)	(0.69)	(5.55)**	(3.26)**
	US exports shipped to aff. by US parents	0.02	0.016	0.003	-0.053
		(7.18)**	(6.06)**	(0.02)	(0.36)
Regression effect (1980-1995 sample, capital changes not instrumented, as reference)	1980-1995 sample, all variables instrumented	-0.001	0	-0.254	-0.06
		(0.46)	(0.22)	(2.68)**	(0.66)
	1980-1995 sample, capital changes not instrumented, no time dummies	0.002	-0.002	0.174	-0.069
		(1.16)	(1.12)	(1.84)	(0.77)
	1980-2000 sample, capital changes not instrumented	0.007	0.002	-0.198	-0.129
		(4.26)**	(1.42)	(2.09)*	(1.43)
	1980-2000 sample, capital excluded (see text)	0.005	0.005	0.447	0.417
		(2.95)**	(3.28)**	(4.71)**	(4.62)**
	Constant	0.025	0.013	2.804	1.855
		(10.78)**	(6.38)**	(22.61)**	(15.71)**
	Observations	270	270	270	270
	R-squared	0.72	0.52	0.63	0.48

[a]Industrial machinery and transportation equipment not significantly different from the reference.— [b]R&D by affiliates not significantly different from the reference.

Source: own calculations based on BEA.

The findings reported so far strongly suggest that US FDI, in general, contributes to convergence only in host countries that have achieved a relatively high per-capita income already. Yet, the estimates run for different dimensions of FDI and for FDI in particular industries support the proposition that FDI is a heterogeneous phenomenon. In Table 7, we consider various FDI dimensions, in addition to the conventionally used FDI stocks and flows, and report the coefficients of the non-interacted and interacted FDI terms for US FDI in all industries and total manufacturing:

- Using aggregated data for all industries, it turns out that both coefficients of US FDI *outflows* are considerably higher than those of US FDI *stocks* on historical cost basis. This is consistent with previous studies which typically show weaker growth effects when relying on stock data.[23]
- Compared to FDI stocks, almost all other FDI dimensions obtain a higher coefficient of the *non-interacted* FDI term. In particular when using aggregated data for all industries, as most previous studies do, the effects of FDI appear to be understated by measuring FDI on the basis of stock data. This is probably because FDI stocks do not adequately reflect FDI-related activities of foreign affiliates. The strongest effects are shown if FDI is measured by R&D activities undertaken by US affiliates in host countries.

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23 See Section II as well as Nunnenkamp and Spatz (2004).

- The *interacted* FDI term remains insignificant for several FDI dimensions. For example, there is no evidence of divergence effects with regard to the employment of affiliates, their sales to the United States and shipments to parent companies. By contrast, the coefficient and significance of the interacted term is particularly high for R&D by affiliates.

Table 7 — Selected FDI Dimensions: Coefficient and Significance of Non-Interacted and Interacted Terms[a]

	All industries		Total manufacturing	
	non-interacted term	interacted term	non-interacted term	interacted term
FDI stocks on historical cost basis	0.023**	0.021*	0.024*	0.013
	(3.11)	(2.41)	(2.25)	(1.30)
FDI outflows	_0.049**_	_0.052*_	0.026*	0.019
	_(2.81)_	_(2.13)_	(2.28)	(1.19)
Employment of affiliates	0.042*	0.017	0.037*	0.014
	(2.28)	(1.12)	(2.18)	(1.01)
Total sales by affiliates	0.042**	0.026*	0.025	0.008
	(2.77)	(2.24)	(1.89)	(0.70)
Sales by aff. to foreign countries (except host country)	0.048**	0.037**	_0.031*_	_0.039_
	(3.16)	(2.84)	_(2.33)_	_(1.65)_
Sales by aff. to United States	0.040**	0.037	_0.021_	_0.042_
	(2.82)	(1.91)	_(1.40)_	_(1.33)_
US exports shipped to aff. by US parents	0.043*	0.015	0.046**	0.047*
	(2.46)	(1.13)	(2.90)	(2.44)
US imports shipped by aff. to US parents	0.018	0.015	_0.030*_	_0.044_
	(1.23)	(0.93)	_(2.01)_	_(1.50)_
Royalties and license fees	0.036**	0.03**	0.029**	0.024*
	(3.78)	(2.87)	(3.68)	(2.19)
R&D by affiliates	_0.099**_	_0.102**_	_0.059*_	_0.082**_
	_(3.41)_	_(3.21)_	_(2.58)_	_(3.48)_

[a]t-statistics in parentheses; *, ** significant at 5 percent and 1 percent, respectively; in italics for estimates based on less than 50 observations for the particular FDI dimension.

Source: own calculations based on BEA.

The second panel of Table 6 compares the coefficients of the non-interacted and interacted FDI terms between FDI dimensions by running regression (4) across the total set of FDI coefficients. The results underscore that higher coefficient values, though often associated with lower significance, are achieved when considering FDI dimensions other than FDI stocks on historical cost basis. In most instances, both the non-interacted and the interacted terms turn out to be higher compared to the reference of FDI stocks. However, making full use of the coefficients achieved in industry-specific estimates results in two important deviations from the findings reported in Table 7 on the basis of aggregated FDI data for all industries. First, the effects of FDI outflows are no longer stronger than the effects of FDI stocks. Second, royalties and license fees, which proxy technology transfers from US parents to their foreign affiliates, still obtain a higher coefficient of the interaction term, but the non-interaction term turns insignificant when compared to that of FDI stocks.[24]

The regression results in Table 6 can be used to estimate the impact of different FDI dimensions, as well as FDI in different industries, on economic growth and convergence in the host countries of US FDI. Figure 4 presents the calculations for selected FDI dimensions. It turns out that the threshold of relative per-capita

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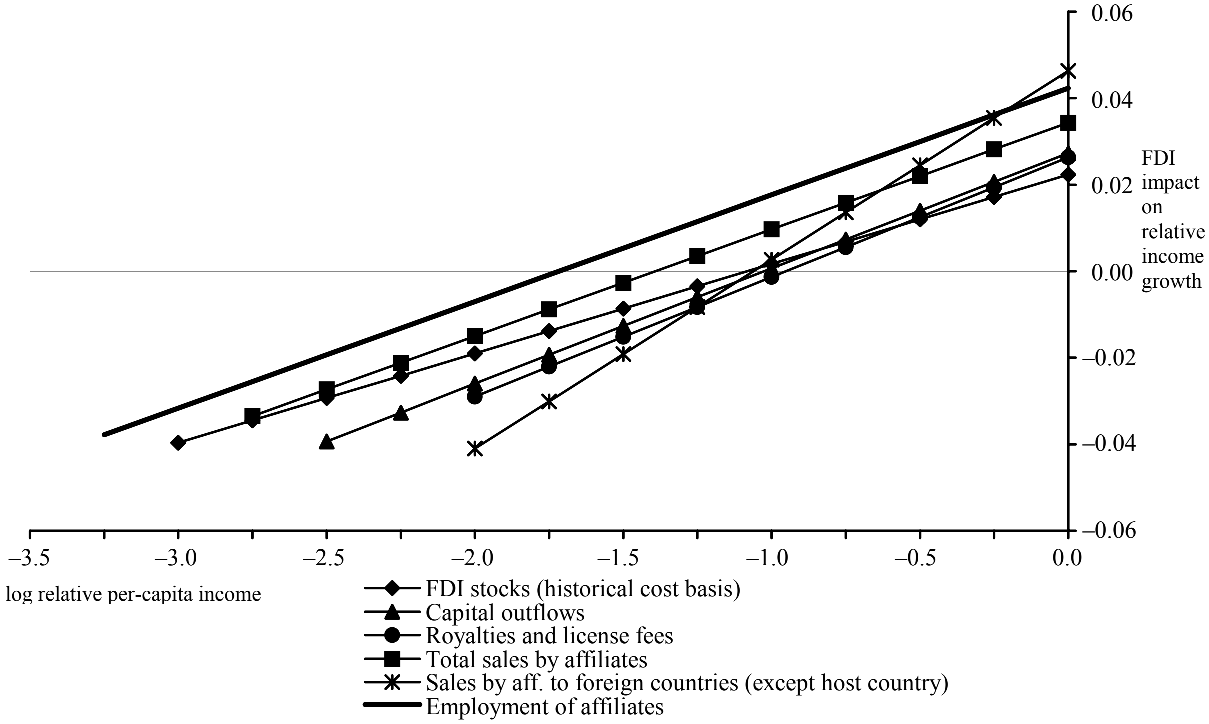
[24] R&D performed by US affiliates is not listed in Table 6 as industry-specific data are largely lacking for this FDI dimension.

Figure 4 — Estimated Impact of US FDI: Selected FDI Dimensions[a]



[a]Individual graph lengths adapted to reflect average sample range for each FDI dimension. Source: own calculations based on BEA.

income beyond which convergence occurs depends on which FDI-related activity is considered. Most notably, only high-income host countries (according to World Bank classification) are likely to benefit from technology transfers from US parent companies.[25] This supports the reasoning in Sections II and IV that many developing countries lack absorptive capacity and are plagued by local conditions impeding technological spillovers. Even when considering employment or total sales of US affiliates, however, convergence effects appear

25 Note that high-income countries have a log relative per-capita income of –1.4 or higher.

to be restricted to fairly advanced host countries in the upper middle or higher income groups.

Turning to industry-specific estimates, it has to be recalled that the number of FDI-related observations is often below 50. Estimates are based on a larger number of observations for almost all particular industries (except industrial machinery and transportation equipment) only if FDI stocks on historical cost basis are used. Hence, we start with this FDI dimension to estimate the industry-specific coefficients of the non-interacted and interacted terms (Table 8, first two columns). Both coefficients remain insignificant for three industries: In the case of “finance”, this may be due to the inclusion of FDI in real estate and holding companies. Likewise, “other manufacturing” represents a fairly heterogeneous set of industries. More surprisingly perhaps, it is also for chemicals that both FDI coefficients are insignificant. A possible explanation is that US FDI in this industry is extremely concentrated in industrialized host countries (Figure 2 above). Note that the results based on FDI stocks are relatively weak for the metal industry, too, which represents another manufacturing industry with an extremely strong concentration of US FDI in industrialized countries. However, the estimates based on some other FDI dimensions (e.g., sales to foreign countries as well as royalties and license fees in Table 8) suggest another explanation, namely that stock data do not adequately reflect FDI-related activities, especially so in the chemical industry.

Table 8 — Selected Industries: Coefficient and Significance of Non-Interacted and Interacted Terms[a]

Industries	FDI dimensions:					
	FDI stocks on historical cost basis		Sales by aff. to foreign countries (except host country)		Royalties and license fees	
	non-interacted term	interacted term	non-interacted term	interacted term	non-interacted term	interacted term
Petroleum	0.038** (4.18)	0.034** (3.12)	– –	– –	– –	– –
Food and kindred products	0.021* (2.43)	0.026* (2.16)	*0.031 (1.31)*	*0.069 (1.98)*	*0.049 (1.91)*	*0.099 (1.64)*
Chemicals and allied products	0.015 (1.88)	0.012 (1.11)	*0.025* (2.43)*	*0.034* (2.49)*	0.024** (2.97)	0.022** (2.65)
Primary and fabricated metals	0.017* (1.99)	0.028 (1.64)	*0.141** (3.89)*	*0.374** (4.86)*	*0.042* (2.19)*	*0.105 (1.78)*
Industrial machinery and equipment	*0.022** (2.71)*	*0.016 (1.19)*	*0.086** (3.35)*	*0.171** (3.18)*	*0.059 (1.51)*	*0.063 (1.83)*
Electronic and other electric equipment	0.021** (2.79)	0.028* (2.27)	*0.050** (2.67)*	*0.118** (2.82)*	*0.035** (2.85)*	*0.069** (2.67)*
Transportation equipment	*0.026* (2.60)*	*0.048** (2.79)*	*0.082** (2.69)*	*0.275** (3.28)*	*0.047* (2.62)*	*0.092 (1.84)*
Other manufacturing	0.016 (1.68)	0.011 (0.80)	– –	– –	*0.055* (2.47)*	*0.079 (1.57)*
Wholesale trade	0.038** (3.24)	0.024* (2.47)	*0.079** (2.84)*	*0.141* (2.40)*	*0.027** (2.85)*	*0.020 (1.13)*
Finance	0.014 (1.42)	0.024 (1.57)	– –	– –	– –	– –
Services	0.032** (3.17)	0.037* (2.51)	*0.033 (1.32)*	*0.011 (0.32)*	*0.133** (3.11)*	*0.437** (5.73)*
Other industries	0.036** (3.23)	0.024* (2.38)	– –	– –	*0.091** (3.02)*	*0.183* (2.55)*

[a]t-statistics in parentheses; *, ** significant at 5 percent and 1 percent, respectively; in italics for estimates based on less than 50 observations for the particular FDI dimension and industry.

Source: own calculations based on BEA.

In addition to the aforementioned industries, the interaction term remains insignificant for FDI stocks in industrial machinery and equipment. Divergence effects of FDI in this industry may have been contained by particularly high technology transfers to US affiliates and their particularly strong export orientation (Table 1 above). However, the number of FDI-related observations in machinery is too small to draw strong conclusions. Moreover, similar to chemicals, the results for machinery vary considerably across FDI dimensions: Considering royalties and license fees, instead of FDI stocks, both the non-interaction and the interaction terms turn out to be insignificant, whereas both terms are significantly positive when considering the sales of US affiliates to foreign countries other than the host country.

Different industry characteristics notwithstanding, the results are fairly similar for FDI stocks in the remaining industries. Yet, it is also for these industries that relying exclusively on stock data may provide a misleading picture on the effects of FDI on growth and convergence. As before with regard to FDI dimensions, the first panel of Table 6 compares the coefficients of the non-interacted and interacted FDI terms between industries, based on the total set of FDI coefficients with all industries serving as the reference.[26] There are three categories of industries:

(i) Relatively high coefficients for both the non-interaction and interaction terms are shown for petroleum, wholesale trade, services, and other industries.

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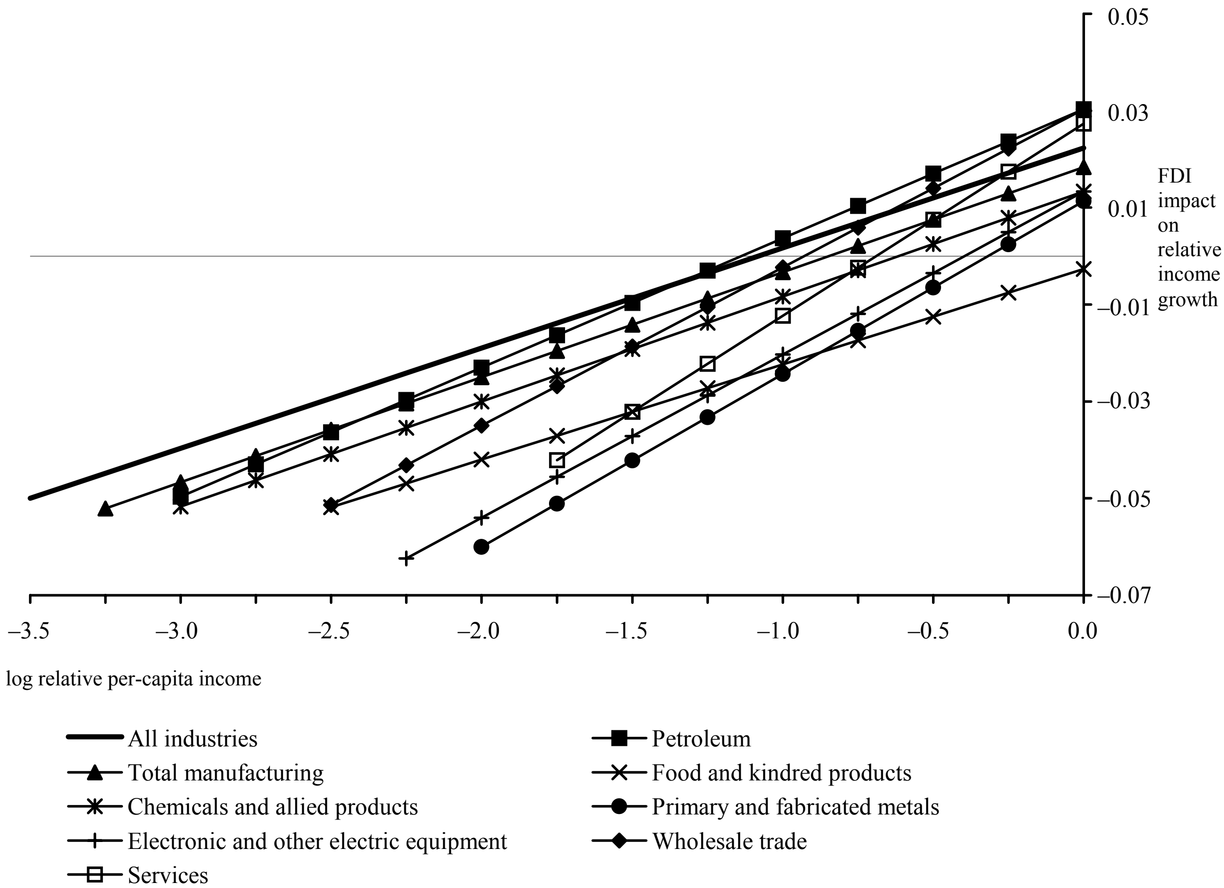
[26] There are no entries for industrial machinery and transportation equipment as the regression underlying Table 6 is restricted to coefficients based on at least 50 observations.

(ii) Manufacturing as a whole as well as food, chemicals, and other manufacturing obtain a lower coefficient of the non-interaction term, while the interaction term reveals little difference compared to the reference of all industries.

(iii) Divergence effects appear most likely in the metal industry, in electronic and electric equipment, and in finance. It may be surprising that electronic and electric equipment belongs to this category. US FDI in this relatively labor intensive industry tends to be in accordance with factor endowments prevailing in developing host countries. As noted in Section III, however, convergence induced by FDI in electronic and electric equipment may have been hindered by minor technology transfers.

The estimated impact of US FDI on convergence, portrayed in Figure 5 for selected industries, underscores the differences across industries outlined above. For host countries close to US income levels, we observe relatively strong convergence effects if US FDI takes place in the services sector (wholesale trade and "services" as defined by BEA) and in the petroleum industry. By contrast, convergence effects are marginal at best, even in most advanced host countries, for FDI in some industries, including food, metals, and electronic and electric equipment. All industries have in common, however, that the threshold of relative per-capita income beyond which US FDI leads to convergence is fairly high, i.e., in the range of high-income countries as defined by the World Bank.

Figure 5 — Estimated Impact of US FDI: Selected Industries[a]



[a]Individual graph lengths adapted to reflect average sample range for each industry.
Source: own calculations based on BEA.

VI. SUMMARY AND CONCLUSIONS

In this paper, we perform convergence regressions that estimate the rate of growth in per-capita income, relative to the per-capita income of the United States, in terms of US FDI, human development, financial development, and trade. The distinctive feature of convergence regressions is that the independent variables are also interacted with relative per-capita income, to obtain a measure of their impact on convergence. Thus for each of the independent variables we obtain two coefficients estimating their impact on growth as a function of relative per-capita income. We apply a panel approach, instrumenting for explanatory variables and correcting for correlated errors by clustering by countries. We also use a robust estimate to control for heteroskedasticity.

At the same time, we account for the heterogeneity of FDI that is largely ignored in previous empirical studies on the growth impact of FDI. We consider various US FDI-related activities such as R&D undertaken by foreign affiliates, technology imports from parent companies, export operations of affiliates and intra-firm trade – in addition to the conventionally used FDI stocks and flows. Furthermore, we draw on industry-specific FDI data provided by the US Department of Commerce, Bureau of Economic Analysis, rather than exclusively relying on highly aggregated data as typically done in previous studies.

Our findings support the proposition that the widely used measure of FDI stocks does not adequately reflect FDI-related economic activities of foreign affiliates of US based multinational companies. Both the non-interacted and the interacted terms of FDI vary across FDI-related activities. FDI dimensions such as the employment of US affiliates and their total sales are more likely to contribute to convergence than the mere presence of US affiliates, as reflected in FDI stocks. By contrast, convergence effects are less likely to result from technology transfers by US parent companies, as indicated by technology transfer payments of US affiliates in the form of royalties and license fees. This supports the view that many developing countries lack absorptive capacity and are plagued by local conditions impeding technological spillovers.

Differences in growth and convergence effects are less pronounced when comparing US FDI across industries rather than across economic dimensions of FDI. This may be due, at least partly, to data limitations. Various industry-specific estimates of convergence equations suffer from an insufficient number of observations. Based on FDI stocks (more observations are available for this inferior measure), we found similar results for industries revealing different characteristics in terms of factor intensities and export orientation. Yet, divergence effects appear to be more likely in some industries, including the electronic and electric equipment industry. Convergence effects in this relatively labor intensive industry, in which US FDI tends to be in accordance with factor endowments prevailing in developing countries, may have been hindered by weak technological spillovers.

These differences across FDI dimensions and industries notwithstanding, the convergence regressions have one important thing in common. While economic activities related to US FDI have a positive effect on the growth of relative income in fairly advanced host countries, therefore contributing to their convergence to US income levels, this effect diminishes for lower-income host countries. In most host countries classified by the World Bank as low- or middle-income countries, US FDI tends to widen income differentials.

Hence, our analysis puts into question the currently prevailing euphoria about FDI as a means to induce or strengthen economic catching-up processes of developing countries. Hopes raised by international organizations, notably the United Nations, that FDI could help eradicate poverty appear to be highly unreasonable. The central challenge facing policymakers in developing countries is *not* to attract FDI, but to improve the local conditions required to benefit from the widely perceived unique advantages of FDI. The absorptive capacity of host countries in making use of superior technologies applied by foreign direct investors appears to be crucially important in this regard. Local firms are often too far behind the technological frontier to grasp opportunities for technological and managerial imitation.

This leads to the conclusion that policymakers in developing countries should focus their attention on local economic phenomena that impede technological progress. Human capital formation, institution building and local enterprise development may help raise the rate of absorption of technological and managerial innovations available worldwide. Unless the technological gap is narrowed in this way, it makes little sense to enter into the fierce international competition for FDI by offering fiscal incentives and outright subsidies, in order to attract FDI in technologically advanced operations. Developing countries should use scarce public resources more productively.

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