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Innovation in Tow: R&D FDI and investment incentives

Abstract: Multinational corporations (MNCs) increasingly internationalize research and development (R&D), but the distribution of foreign direct investment (FDI) in R&D differs from that of general FDI. I use data on US MNC affiliates' investments abroad (2001–2008) to demonstrate that increasing value added predicts more future R&D FDI, as R&D FDI is an upgrade decision. I then use data on R&D investment incentives to show that, while governments spend resources on R&D incentives, these can be negative predictors of R&D FDI. The findings imply that government efforts are best directed at incremental encouragement of value-added activities, as efforts to jump to R&D FDI are misguided.

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1 Investing in R&D

As highly capable people reside in all countries, and multinational corporations (MNCs) have footholds around the world, locating research and development (R&D) abroad has become a growing trend in international business. Foreign R&D expenditures by MNC affiliates more than doubled from 1993 to 2002, growing from 10% to 16% of MNCs' R&D budgets (UNCTAD 2005). Among US affiliates, foreign R&D expenditures reached US$104 billion in 2008 (BEA).

For a country that is host to foreign direct investment (FDI), R&D FDI carries with it the potential for technology transfer, jobs for highly skilled local workers, and spillovers to other domestic enterprises – the sorts of characteristics that make FDI attractive to capital-seeking economies. Governments have thus sought to capitalize on the internationalization of R&D. In a survey of 84 national agencies tasked with FDI promotion, 55% claimed to actively promote R&D FDI, including 46% of the agencies in developing countries (UNCTAD 2005: p. 213). The investment incentives offered around R&D FDI cover the full suite of tax reductions or exemptions, trade benefits, subsidized loans and grants, and allowances for capital and training (Johnson 2011). Indeed, some scholars and practitioners presume that that the operative question is not whether but how to promote R&D FDI (Archibugi and Iammarino 1999; OECD 2002b; OECD 2003; Rama 2008).

Yet behind this “sense of policy urgency” around R&D FDI stands a “lack of knowledge on process and effects” (Edler and Polt 2008). How do MNCs make decisions as to where to site R&D FDI? To what extent can government investment incentives influence that siting? Without answers to these questions, the buzz of R&D FDI promotion activity may be misguided.

This paper documents variation in the distribution of R&D FDI relative to the distribution of general FDI across host countries. To explain this variation, I argue that the international distribution of R&D FDI depends on the quality of the FDI that has gone before. In particular, firms “upgrade” to R&D in locations where FDI has proved valuable, because the track record of previous FDI mitigates uncertainty around the success of future R&D investments. To demonstrate this upgrading path, I show a robust and positive association between the previous value-added activities of US affiliates and US firms’ future investments in R&D abroad (2001–2008), holding constant industry, returns from sales, returns from exports, and economy-wide determinants of FDI. Next, I test the effects of government incentive programs on the siting of R&D FDI, demonstrating that the presence of R&D FDI incentives has no positive and possibly even a negative association with the distribution of R&D FDI from US affiliates.

In a world where policymakers choose to expend resources to attract R&D FDI, this paper’s findings about firms’ decision-making processes and the unhelpful impact of investment incentives have real implications for public policy. In short, government R&D attraction policies assume that R&D FDI can be attracted, but the empirical evidence is not compelling. While this paper provides evidence that efforts to entice new investors into R&D FDI may be ill-advised, efforts to facilitate upgrading of current FDI in order to attract R&D investments may be more successful.

The paper is organized as follows. The first section defines R&D FDI and describes variation in its distribution across countries. I go on to argue that R&D FDI is best understood as the result of an upgrade decision, predicated on the success of existing FDI in a country and industry. The argument draws on 22 semi-structured interviews undertaken in 2007–2009 with top MNC executives in France and the heads of MNC affiliates at R&D labs in China, as well as follow-up interviews in the US in 2011.[1] The next section provides quantitative evidence that the success of foreign affiliates in a country, measured by value-added contributions and not by market- or export platform-seeking factors, is positively associated with future R&D FDI flows. I then consider the impact of R&D FDI investment incentives on US-origin R&D FDI, using data assembled by Johnson (2011, 2013).

1 This research was undertaken together with Suzanne Berger, Edward Steinfeld, and Yasheng Huang of the MIT Political Science Department and the Sloan School of Management.

I conclude by examining implications for public policy. R&D FDI may indeed be one of the most valuable forms of FDI, and governments around the world recognize this and want it to be a lynchpin of their economic development. But investment promotion policies can be misguided if they focus on attracting R&D FDI to locations where other forms of FDI have not yet proven valuable. Instead, policymakers need to understand that innovation comes in tow.

2 Distribution of R&D FDI

R&D FDI covers MNC expenditures on R&D that overlap with expenditure abroad in entities affiliated with the MNC. The OECD Frascati Manual (2002a) provides the definition of R&D commonly used in international statistics:[2]

> *Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. (2.1.63)*

By focusing on "experimental development," Frascati attempts to limit the scope of R&D to inputs that provide the solutions to problems with scientific or technical aspects (2.3.1.84). Additionally, Frascati's expansive inclusion of R&D as that which contributes to "knowledge" helps to make measures of R&D expenditures more comprehensive, including types of innovation not necessarily covered in the development of products and processes. As investments in R&D include the acquisition of physical and human capital to aid in the firm's scientific and technical innovative capacity, it is not surprising that foreign R&D – an archetypal strategic investment – is often absorbed into the firm through FDI rather than undertaken at arms-length (Dunning 1980). Further, traditional FDI is often used as an export platform or to access local markets. Analogously, R&D FDI can be intended for exploitation beyond local markets or to generate adaptations for those markets, improving a firm's competitiveness (Ghoshal and Bartlett 1990; Pearce 1999).

From 1997 to 2002, R&D FDI grew 1.7 times, reaching US$60.5 billion. R&D FDI originating from the US has constituted the lion's share, though contributions from the rest of the word grew considerably (see Table 1).[3] At first glance, trends in

2 The United Nations System of National Accounts (SNA) also provides a (somewhat different) definition of R&D; however, the OECD definition has become the international standard and sits behind R&D FDI data used here.

3 The considerable amount of R&D FDI that enters the US is not under consideration in this article (Serapio and Dalton 1999).

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Table 1 US-origin R&D FDI vs. Other R&D FDI (US$ millions).

Year	US-origin	Rest of world-origin	%
1997	14,593	21,229	69
1998	14,664	22,343	66
1999	18,144	29,214	62
2000	20,457	32,945	62
2001	19,702	37,760	52
2002	21,063	39,425	53

Source: US Bureau of Economic Analysis (BEA) (2012), UNCTAD.

R&D FDI favor industrial countries, fitting broadly with trends in FDI in general. R&D FDI between the US and Europe is an order of magnitude higher than the rest of the world. In 2000, for example, R&D FDI into Europe accounted for 60% of US outflows (US$18.6 billion); European flows accounted for 65% (US$12.9 billion) of R&D FDI into the US (NSF 2004). China, too, receives significant amounts of R&D FDI: cumulative US-origin R&D investments in the country jumped from US$7 million in 1994 to US$506 million in 2000, topping US$4 trillion in 2008.

However, the distribution of R&D FDI stock across countries suggests that the determinants behind R&D FDI differ systematically from that of FDI in general. Figure 1 summarizes variation in the international distribution of R&D FDI, reporting US-origin R&D FDI as a percent of total US-origin FDI, averaged by country (1999–2008).[4] If R&D FDI followed trends in FDI more broadly, these percentages would be consistent across destination countries. Instead, we see that Israel, Sweden, and India receive disproportionately high amounts of R&D FDI, while countries like the Netherlands, the UAE, and Nigeria receive very low amounts of R&D FDI proportional to their US-origin FDI. When comparing US-origin R&D FDI to each country's total FDI intake, the correlation coefficient is only 0.14 in this period (WDI). This paper addresses why this distribution varies and whether government-provided R&D FDI investment incentives have explanatory power.

Figure 2 provides evidence on why understanding the process behind R&D FDI decision-making is important. This figure draws on UNESCO data collected for stocks of R&D FDI by host country (1997–2010). In absolute terms, R&D FDI varies considerably across world regions. Natural resource-related R&D FDI accounts for very high levels in the Middle East and North Africa, while Europe and the Americas have received more R&D FDI than Asia and Africa. However, as a percentage

4 I rely on US-origin data from the Bureau of Economic Analysis (BEA) for its comprehensiveness and as US firms account for the lion's share of international R&D flows.

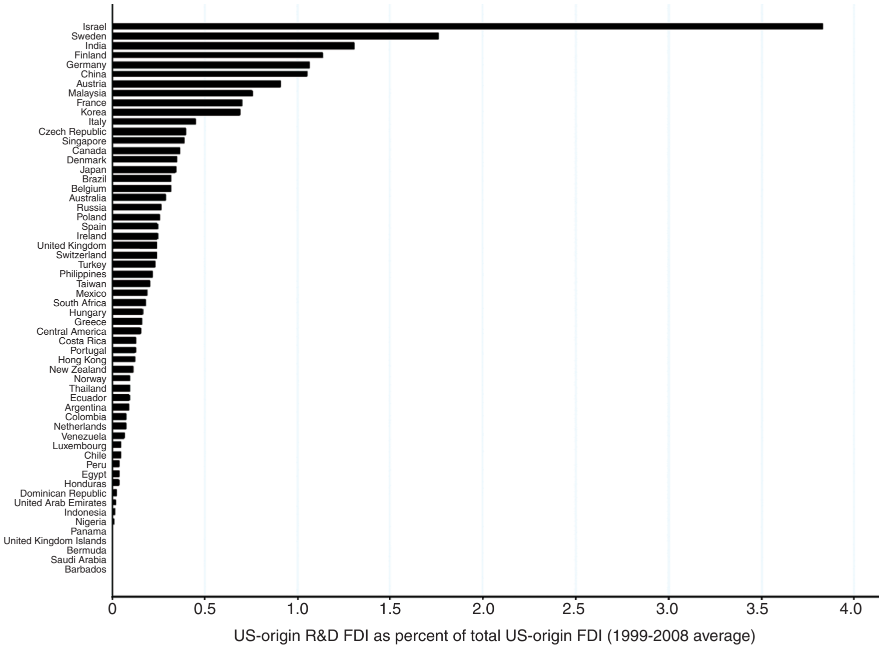

Figure 1 Variation in R&D FDI as a percentage of overall FDI, (US-origin, 1999–2008).
Source: US Bureau of Economic Analysis (BEA) (2012).

of total spending on R&D, foreign R&D plays an enormous role in Africa, followed by the Middle East, Americas, Europe, and Asia. Indeed, local innovation environments in both developed and developing countries have relied on R&D FDI. In Canada and the UK, for example, foreign investors have recently accounted for over 7 and 12% of R&D, respectively. Even in countries with effectively 0.000% R&D FDI as a component of total FDI stock, like Uganda and Mozambique, foreign investors dominate local research activities. In Uganda, foreign investors' small absolute values of R&D FDI nevertheless recently accounted for up to 74% of total R&D spending that occurs in the country.[5] Uganda and countries like it have a concerted interest in understanding how the productive resources of R&D FDI might come to their country as, in the lottery of FDI projects, R&D FDI is widely expected to more predictably support development goals. Understanding what

5 Although in 2009 total FDI in China was one thousand times greater than that in Uganda, foreign-sourced R&D in China has accounted for a maximum of 2.7% of R&D spending. Government-sponsored R&D accounts for between 23 and 33% of R&D spending in China over this period (UNESCO).

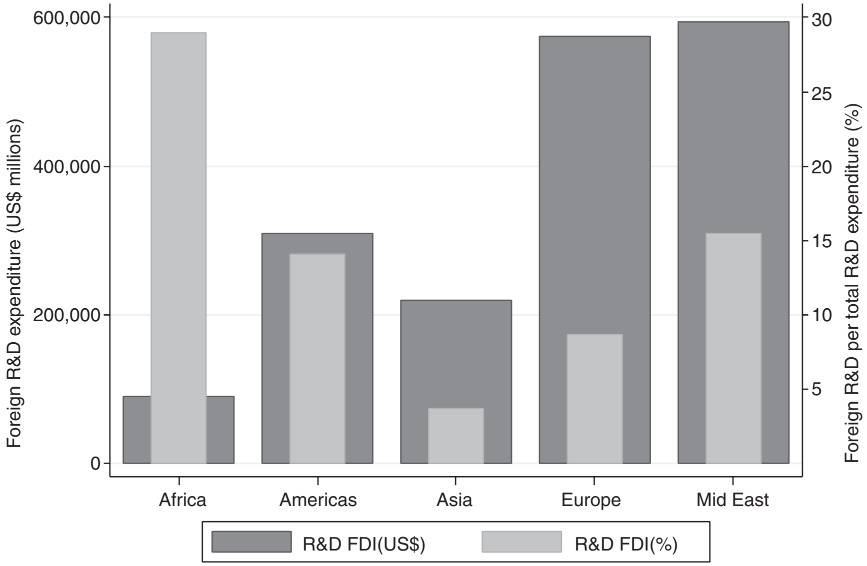

Figure 2 R&D FDI, by world region.
Source: UNESCO Institute for Statistics, Science and Technology, Table 28 (2012).

it is that brings firms to invest in R&D abroad, and how that differs from FDI in general, has major implications for innovation and growth.

3 Existing explanations

Governments around the world have been acting on one set of hypotheses for what brings R&D FDI to one country over another. By implementing investment incentives around R&D FDI, governments assume that the marginal cost of building infrastructure for and running R&D FDI is key to a siting decision. The investment could be here or there, but the lower tax rates, subsidies, or trade benefits offered here make one country the winner and the other the loser. What is important to note about these approaches are the assumptions: if all countries are inherently competitive destinations for R&D FDI, then the right kinds of incentives can bid a country up to be a competitive destination. The focus of this explanation is on the host country and not the firm.

Recent scholarship offers another explanation for the international distribution of R&D FDI: a large number of R&D internationalization decisions are hypothesized to be "accidental" – the "unintended by-product" of mergers and

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acquisitions by firms that prefer to do their R&D at home (Gulbrandsen and Godoe 2008; see also Casson and Singh 1993, Niosi and Godin 1999). The contingencies of mergers and acquisitions may lead some R&D FDI investments to sprout in what seem to be unexpected locations. Nevertheless, the evidence here demonstrates that long-term investment and reinvestment in R&D in a particular country is far from the result of an (ongoing) accident.

I seek to understand the distribution of R&D FDI by starting from the firm. One branch of the firm-level literature on international R&D emphasizes that firms engage in it because of market-seeking incentives, positing that internationally situated R&D facilitates product adaptation for new markets in ways home-market R&D facilities cannot (Ronstadt 1977; De Meyer 1993; Cantwell and Janne 1999; Gerybadze and Reger 1999; Kumar 2001). Authors of technology-seeking explanations, on the other hand, argue that internationalized R&D is a product of firms' desire for access to new and/or augmented technologies, implying that human capital and physical infrastructure – at the right price – are key locational determinants (Florida 1997; Niosi and Godin 1999; Zander 1999; Griffith, Harrison, and Van Reenen 2006; Ito and Wakasugi 2007). One way to operationalize technology-seeking explanations is to look for evidence that R&D FDI takes place in countries that serve as export platforms to third countries. Kuemmerle (1999) combines explanations and finds possible synergies when firms internationalize R&D for both market- and technology-seeking reasons. These market- and export platform-seeking hypotheses for R&D FDI better account for what we know about multinational corporations' decision-making than what might look like wishful thinking on the part of governments or the unsatisfactory answer that R&D FDI distribution is mere accident.

4 Upgrading to R&D FDI

Nevertheless, what market- and export platform-seeking explanations miss in explaining the distribution of R&D FDI is the role of the history of FDI in a given location. I argue that a firm uses information derived from its and/or other firms' previous investments in a country to update beliefs about a location's suitability for R&D investments. Because R&D FDI is a particularly costly and uncertain endeavor, information on the success of previous investments is valuable to what we can think of as an R&D FDI upgrade decision.

Locating R&D at home allows for economies of scale, lower cultural or lingual barriers between researchers, and the political benefit of employing highly skilled workers in the firm's home country. R&D investments are expensive

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in both resources and time: they require high-salaried researchers, close management to integrate outputs into the firm's strategic plans, and strict intellectual property and knowledge diffusion regulations. If R&D projects require quick iteration, integrating work across long distances requires planning and forethought (Locke and Wellhausen 2014). R&D is strategic and uncertain, especially when compounded with the uncertainty of locating investment abroad in a new political and economic environment. For these reasons, firms are necessarily cautious in extending their R&D networks. We can thus presume that firms are interested in new information that might relieve uncertainty over the success to be had by locating R&D FDI in a given country. Putting R&D facilities in countries where existing FDI has proven valuable is a way to use prior experience to mitigate the uncertainty around long-distance R&D.

In 22 interviews with R&D executives at firms in telecommunications, nuclear technology, sports equipment, pharmaceuticals, automotive, defense, and biotechnology, top R&D executives in France, the US, and at multinational subsidiaries in China discussed the process of locating R&D FDI abroad.[6] Indeed, executives shared the notion that moving or extending R&D facilities abroad is a process.[7] For example, respondents at French and American affiliates in China cited between 3–19 year incubation periods as they moved from traditional FDI to R&D FDI in the country.[8]

Several respondents acknowledged that the process of growing R&D centers internationally may not have been planned *ex ante*. One respondent noted the particularly high bar his firm placed on R&D centers, indicating that his firm did not have a strategy to nurture other types of FDI into internationally integrated R&D facilities. Rather, the firm watched for locations that proved successful in other pursuits. For example, it was not planned but rather came as a pleasant surprise to the firm when an Australian team proved itself in routine "pre-R&D" activities; this began a snowballing process after which the team was rewarded with full status as an R&D center. A Chinese team in the firm has followed the same path.[9]

6 This research, undertaken in 2007–2009, was funded and assisted by the Essonne Development Agency, from Essonne, France. The first purpose of the interviews was to explore the distribution of R&D between French and French-invested multinational corporations and their Chinese subsidiaries. Respondents were R&D managers or managing directors in business units associated with innovation and strategy. Interviews were conducted at 22 organizations (9 in China, 13 in France, 1 in US).

7 Gersbach and Schmutzler (2011) argue that intrafirm communication between home and destination is key to the R&D FDI upgrading process.

8 Interviews, R&D executives at telecommunications firm and pharmaceutical firm, Shanghai, China (2007).

9 Interview, R&D executive at pharmaceutical firm, France (2007).

Several respondents described "pre-R&D" experiments designed to test a location's R&D FDI capacity. What respondents termed pre-R&D are projects requiring particular scientific and/or technical expertise but which do not fit the Frascati definition of R&D. These projects might involve instances of technology transfer or exploiting overflow technical capacity rather than original scientific and technical problem solving. It is important to note that the choice to engage in pre-R&D may be a public relations endeavor. Respondents at multinational affiliates in China, for example, readily acknowledged that such PR activities were different from a purer form of R&D. Nevertheless, the willingness for the multinational parent to commit resources to such PR demonstrates that locations are proving valuable and, by implication, are more likely to become valuable for higher-skilled activities like R&D than locations without such PR efforts.[10]

Sometimes, pre-R&D experiments occur outside the firm, when executives take signals from R&D (whether pre- or full-fledged) in other firms. For example, a respondent representing a multinational subsidiary in Brazil described how his firm "missed the ball" in accessing a new mining innovation that had been acquired by a multinational competitor. The respondent explained that his firm has started to extend its existing R&D to Brazil and to search for Brazilian R&D talent partly in response to this oversight.[11] In China, the timing of several electronics firms' R&D lab openings converged on the period 2001 to 2006, suggesting that industry trends provide signals that influence intra-firm upgrading decisions.[12] Information that mitigates uncertainty about the success of potential R&D FDI can emerge from within the firm or from observations of competitors' investments in a given country.

Interview evidence thus suggests that R&D FDI is likely to emerge as part of long-term processes in places that prove themselves to a firm itself or to others in its industry. The choice to engage in R&D abroad is about much more than affiliate sales or exports. Investors are looking for signals that R&D FDI might be successful, and evidence of successful, value-adding FDI provides information that can relieve uncertainty over the prospects of R&D FDI in that location.

Hypothesis 1. R&D FDI is more likely to take place in a location with a history of providing value to foreign investors than otherwise.

10 This PR stage corresponds with the argument by Gassmann and Von Zedtwitz (1999) that behavioral organization constrains the speed with which R&D structures can adapt, making "quantum leaps" in R&D FDI unlikely.

11 Interview, strategy executive at natural resource firm, Cambridge, MA (2008).

12 Interviews, R&D executives at four electronics firms, Shanghai, China and France (2007).

While this process of building on previous success may seem almost intuitive, it implies that government efforts worldwide to target R&D FDI are misplaced. Firms taking signals from other firms as to the probability of successful R&D FDI are unlikely to change their behavior in response to government incentives to invest in R&D FDI.

Hypothesis 2. R&D FDI incentive policies are unlikely to have an independent causal effect on firm siting of R&D FDI.

5 Estimating the effect of value added

In this section, I test H1: evidence of previously valuable FDI, whether in a firm or in an industry in a given destination country, increases the likelihood of future flows of R&D FDI. The identification strategy is off of year-on-year changes in US-origin R&D FDI by destination country-industry. This conservative approach accounts for trends over time and across countries and industries while avoiding modeling issues associated with a lagged dependent variable. The estimation equation is as follows:

$$(R\&D\ FDI)_{i,j,t}=\beta_1(Value\ added)_{i,j,t-1}+\beta_2\mathbf{X}_{i,t-1}+\gamma_{ij}+\tau_t+\varepsilon_{ijt} \quad (1)$$

where β_1 is the coefficient of interest, measuring the effect that (lagged) levels of value added by country-industry have on the outcome of interest. $\mathbf{X}_{i,t-1}$ consists of (lagged) time-varying country-level controls, γ_{ij} are fixed effects by country-industry, and τ_t are yearly fixed effects. Robust standard errors are clustered by country-industry to account for serial correlation (Zeger and Liang 1986).

5.1 Dependent variable: US-origin R&D FDI by country-industry

To capture variation in R&D FDI, I use data from the US Bureau of Economic Analysis (BEA) on non-bank US multinational affiliates abroad, from 1999 to 2008, in logged US$ millions.[13] The BEA data is based on the Frascati definition of R&D, which attempts to separate pre-R&D investments from full R&D investments; this allows us some confidence that R&D FDI measures are measuring R&D proper. Importantly, the BEA data on R&D expenditure abroad is disaggregated by both

13 The BEA changed relevant data definitions in 2009, accounting for the end of the series.

country and industry. As the role of R&D varies by industry, incorporating industry variation into the structure of the analysis provides an optimal solution to control for industry effects on R&D FDI upgrading. The thirteen BEA industry categories allow the analysis to account for differences in R&D propensity across chemicals manufacturing and wholesale trade, for example.[14] It is important to note that constraining data to US-origin R&D FDI will not allow us to separate out how much R&D FDI is due to intra-firm effects and how much is due to cross-firm effects. Tracking US firms investing over time in the same industry in the same country will, necessarily, include data on many of the same firms. However, by focusing on flows to a particular industry-country, the data also includes effects at the industry level and thus across firms.

The data covers R&D FDI flows into a maximum of 43 countries, which include developed, middle income, and developing economies (see Appendix Table 1 for full country list). Given the variation present in Table 1, in which countries at diverse levels of development nevertheless receive similar proportions of R&D FDI, including all possible destination countries is the most appropriate means of testing the hypotheses presented here. Indeed, value added can emerge from operations in low- or high-cost environments; multinationals would, broadly speaking, be less likely to invest across countries at different development levels if value added were so easily parsed.

5.2 Variable of interest: value added

What is it about traditional forms of FDI, in activities like production, marketing, or extraction, that can provide information relevant to pre-R&D and R&D proper? The upgrading argument spelled out here relies not on affiliate success in terms of, say, profitability. Rather, the more relevant metric that can provide information on the likely success of R&D FDI are affiliate contributions to value added. Indeed, in a world of modularized production, the value added activity of foreign affiliates are a key measure of the significance of foreign affiliates to the multinational parent (Sturgeon 2002; Steinfeld 2004). *Value added* (in loged US$ millions), as defined by the BEA, refers to “the portion of the goods and services ...

14 Industry categories are as follows: Finance and insurance; information; manufacturing: chemicals; manufacturing: computers and electronics; manufacturing: electrical equipment; manufacturing: food; manufacturing: machinery; manufacturing: primary and fabricated metals; manufacturing: transportation equipment; mining; professional, scientific, and technical services; utilities; wholesale trade. “Other industries” are dropped from the analysis.

that reflects the production of the firm itself."[15] The expectation here is that the more value investments in a given country-industry are adding to that country-industry's outputs, the more likely it is that investment in R&D FDI in that location will prove valuable.

5.3 Alternative explanations: total sales

Total sales (logged US$ millions) captures the value of goods and services sold including those produced in the host country and elsewhere (BEA). Testing the effect of total sales on future R&D FDI allows us to control for market-seeking explanations for R&D FDI, which would predict that higher sales should lead to more R&D FDI. As market-seeking arguments do not distinguish whether the market is supplied locally or internationally, *Total sales* is an appropriate measure. The correlation with *Value added* in the sample is 0.14.

5.4 Exports

The value of *Exports* (logged US$ millions) from US affiliates in a given country-industry allows for a test of the proposition that R&D FDI location is determined by the country's potential as an export platform. One set of factors that contribute to export potential are the technical resources available in a country; export potential is correlated with the ability of these resources to facilitate production and, perhaps, innovation. The argument advanced here, however, is that success as an export platform is not in itself evidence that a location would be likely to be a good host to R&D FDI. Multinationals, with dense intra-firm networks, have the ability to perform R&D elsewhere and transfer the knowledge gained to export-heavy locations; co-location is not integral to export success.

5.5 Additional covariates[16]

If host government attraction efforts have an effect on firms' choices in locating R&D FDI, one likely channel would be through the government's own efforts to

15 Value added also captures the contribution an investment makes to a host country's GDP, because it is calculated based on the value of outputs produced by labor and property in that country. (BEA).

16 Data are from the World Bank World Development Indicators unless otherwise noted.

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foster domestic investment in R&D. The hope would be that domestic efforts to grow human capital could persuade multinationals to take advantage of local resources and engage in their own R&D. A measure of the local allocation of resources to R&D – or *Domestic expenditure on R&D as a percentage of GDP* – is an important means to account for direct links between local capacity and foreign efforts. That this measure focuses on resource allocation rather than government policy initiatives is important. Again, most governments in the world have made at least nominal policy commitments to promoting R&D FDI (NSF 2004). If indeed there is a positive relationship between *Domestic R&D per GDP* and foreign R&D, more research into variation in government policy along these lines is warranted. In the absence of a robust relationship, however, widespread government commitments to boosting R&D capacity and using such resources to attempt to entice R&D FDI is called into question. Additionally, this measure accounts for an alternative logic whereby domestic R&D might crowd out foreign R&D.

I control for several economic and political variables that have been found significant in extensive literature on the determinants of FDI as a whole. *Total FDI flows* (logged) is an important control for the investment behavior of firms from all other source countries. *Trade*, measured as exports and imports as a percentage of GDP, is a common measure of openness to international commerce that is generally positively associated with FDI flows. *Capital account openness* similarly controls for the international financial integration of the host country with the broader world (Chinn and Ito 2008). As the analysis includes both developed and developing destination countries, *GDP per capita* (logged) is of particular importance in separating out what might be characteristics that make R&D FDI more or less attractive in countries with different infrastructure levels and different prices attached to human capital and other R&D inputs. *GDP per capita* also helps to control for market size, which again can provide evidence on the hypothesis that R&D FDI is market-seeking.

A robust literature in political science looks at the effects of democracy in general (Jensen 2003, 2006) and of the protection of property rights in particular (Li and Resnick 2003) on FDI. In the main analyses I therefore include both a measure for *Polity score*, from autocracy (–10) to democracy (10), well known in the literature (PolityIV). As a whole, country-level political and economic covariates account for determinants of FDI in general, relevant in a study of a specific subset of FDI flows. See Appendix Table 2 for summary statistics.

6 Results: effects of value added

The regression results in Table 2 provide strong evidence for H1. Model (0) reports the equation's reduced form. Consistent with the hypotheses advanced

Table 2 Determinants of (logged) US-origin R&D FDI expenditure, by country-industry (2001–2008).

	Model (0)	Model (1)	Model (2)	Model (3)	Model (4)
Value added (Logged)		0.129***			0.148***
		(0.023)			(0.031)
Sales (Logged)			−0.001		−0.000
			(0.004)		(0.005)
Exports (Logged)				−0.000	0.003
				(0.005)	(0.005)
R&D expenditures per GDP	0.159	0.262*	0.155	0.229*	0.283
	(0.118)	(0.141)	(0.137)	(0.137)	(0.173)
Total FDI (Logged)	0.006	0.015	0.014	−0.010	0.006
	(0.011)	(0.012)	(0.012)	(0.012)	(0.015)
Trade (per GDP)	−0.002	−0.003*	−0.002	−0.002	−0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Capital account openness	−0.013	−0.017	−0.016	−0.013	−0.011
	(0.025)	(0.027)	(0.026)	(0.028)	(0.031)
GDP per capita (Logged)	1.393***	1.228***	1.484***	1.325***	1.165***
	(0.392)	(0.418)	(0.423)	(0.415)	(0.434)
Polity score	−0.019**	−0.016*	−0.018*	−0.021**	−0.018
	(0.008)	(0.009)	(0.010)	(0.009)	(0.012)
Constant	−10.622***	−10.090***	−11.666***	−9.901***	−9.464***
	(3.364)	(3.508)	(3.535)	(3.474)	(3.631)
Observations	3112	2729	2642	2467	1860
Country-Industry groups	680	658	661	668	617
R^2 (within)	0.16	0.22	0.18	0.17	0.24

All independent variables are lagged. Year and country-industry fixed effects.
Robust standard errors clustered by country-industry, *p<0.10, **p<0.05, ***p<0.01.

here, Model (1) reports that a 1% increase in value added in a particular country-industry in the previous year is associated with a 13% increase in R&D FDI in the following year. The effect size remains large, at 15%, in the full Model (4). The magnitude and stability of this relationship suggest that prior firm performance in terms of generating value added is a significant and important predictor of future R&D FDI in a particular country-industry. As mentioned above, this effect may be the result of intra-firm upgrading and/or firm responses to signals of others' successful value added in a particular country-industry. Indeed, in interviews top executives at multinational parent companies and at their foreign subsidiaries mentioned both processes at work. While we cannot conclude from these results why foreign affiliates in a given country were generating more value added, we do have strong evidence that countries with affiliates increasingly important to parent multinationals' creation of value are much more likely to be host to R&D FDI.

In contrast, *Sales* in the previous year do not have a statistically significant association with future R&D FDI flows, as demonstrated in Models (2) and (4). The non-significance of sales contrasts with the large magnitude and significant coefficient on *GDP per capita* across models. This variable, which captures development level and availability of infrastructure as well as market size, suggests that a variety of aspects of the domestic economy may help to shape multinational parents' decisions to invest in R&D FDI abroad. However, *GDP per capita* does not capture market success – in the firm or in the industry – in the way that previous sales do. Controlling for whether or not the potential market is large, the non-significance of sales provides evidence that, all else equal, successful exploitation of local markets is insufficient to incentivize multinational parents to expand R&D FDI efforts.

Similarly, *Exports* in the previous year do not have a significant association with future R&D FDI flows in Models (3) or (4). Success as an export platform does not indicate that multinational parents are moving or expanding R&D FDI efforts in a given country. In the sense that export platforms provide technology that is unavailable in other locations, these findings are a strike against technology-seeking explanations as first-order determinants of R&D FDI. In the sense of reducing uncertainty around R&D FDI, evidence of value added – exactly that outcome expected from R&D investments – plays a much stronger and more consistent role.

Controls are generally signed as expected. The host country's aggregate R&D expenditures as a percentage of GDP is a positive albeit not wholly robust predictor of US R&D FDI flows parsed by country-industry. The negative sign on trade suggests that R&D FDI likely takes place under conditions where trade relationships are insufficient to bring to the multinational affiliate the gains expected from local R&D. Interestingly, more democratic countries are, all else equal, less likely to receive R&D FDI.

As the theory laid out here implies that a change in value added should result in a change in R&D FDI expenditure, Table 3 presents estimations based on a difference-in-difference specification. In Models (5) and (8), the independent effect of value added is again positive and significant, with a year-on-year change in value added associated with a 4 to 9% increase in R&D FDI. In Model (6), a positive year-on-year change in affiliate sales is in fact associated with a decline in R&D FDI, providing further evidence that market-seeking explanations as operationalized by sales do not account for R&D FDI outcomes. Exports are again insignificant in both the reduced and full models.

Table 3 Difference-in-difference specification, determinants of (logged) US-origin R&D FDI expenditure, by country-industry (2001–2008).

	Model (5)	Model (6)	Model (7)	Model (8)
Value added (Logged)	0.040***			0.091**
	(0.014)			(0.039)
Sales (Logged)		−0.005*		−0.008
		(0.003)		(0.005)
Exports (Logged)			−0.001	0.002
			(0.004)	(0.005)
Constant	0.073**	0.061	0.109***	0.161**
	(0.032)	(0.043)	(0.041)	(0.071)
Observations	1719	1486	1301	781
Country-industry groups	470	467	447	339
R^2 (within)	0.02	0.02	0.02	0.05

All independent variables are lagged. Year and country-industry fixed effects.
Robust standard errors clustered by country-industry, *p<0.10, **p<0.05, ***p<0.01.
Not reported: R&D expenditures per GDP, total FDI (logged), trade (per GDP), capital account openness, GDP per capita, Polity score.

6.1 Robustness: education

To what extent might education levels in the host economy account for changes in R&D FDI? While the above analyses have taken R&D expenditure in the host economy into account, it could be that measures of human capital more accurately reflect the kinds of resources attractive to multinational affiliates considering R&D FDI. As the literature on industrial clusters demonstrates, R&D centers can benefit from access to local resources like local universities (Saxenian 1994). In interviews conducted for this study, executives occasionally mentioning such local resources. However, in telling the story of moving from FDI to R&D FDI, respondents focused much more on firms' experiences in foreign locations than the availability of external resources. Quantitatively, I examine the effects of local human capital resources on R&D FDI with three measures, although data availability restricts the sample considerably. Results are reported in Table 4. First, in Model (9), I include a measure of the percentage of the host country labor force that has secondary education, which in fact has a negative and significant relationship to R&D FDI levels. Model (10) replaces this variable with the percent of the workforce with university (tertiary) education. In the highly technical and scientific pursuit of R&D, these are the workers that are most likely to make direct contributions to multinational affiliates engaging in R&D. The coefficient is positive as expected but it is outside standard levels of significance. The relation-

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Table 4 Educational determinants of (logged) US-origin R&D FDI expenditure, by country-industry (2001–2008).

	Model (9)	Model (10)	Model (11)
Value added (Logged)	0.148***	0.147***	0.155***
	(0.025)	(0.025)	(0.029)
Secondary education (pct workforce)	−0.008**		
	(0.004)		
Tertiary education (pct workforce)		0.005	
		(0.004)	
University spending on R&D (US$ thou)			0.000
			(0.000)
Constant	1.682	2.838	−2.206
	(4.750)	(4.619)	(4.240)
Observations	1750	1750	1714
Country-industry groups	492	492	461
R^2 (within)	0.22	0.22	0.21

All independent variables are lagged. Year and country-industry fixed effects.
Robust standard errors clustered by country-industry, *p<0.10, **p<0.05, ***p<0.01.
Not reported: R&D expenditures per GDP, Total FDI (logged), Trade (per GDP), capital account openness, GDP per capita, Polity score.

ship between university-educated workers and US-origin R&D FDI thus appears weak. Third, in Model (11), I include a measure of R&D spending by universities (UNESCO). If the activities of local universities are attractive to potential foreign R&D investors, then a measure of R&D spending should be a compelling way to account for those attractive characteristics. However, the coefficient is very small and well outside standard levels of significance. To the extent that R&D spending by universities can proxy for the kinds of local networks thought conducive to developing R&D clusters, the link between local university resources and multinational decision-making appears far less important than the prior history of firms in the country-industry. Indeed, the effects of value added in the previous year are, again, significant and large in all Models. In these estimations, increased value added in the previous year is associated with 15 to 16% increases in future R&D flows.

7 What role incentives?

I now move on to test whether R&D FDI investment incentives have an effect on R&D FDI siting beyond that explained by the previous value added of local

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FDI. To do this, I employ a dataset collected by Johnson (2011) on R&D FDI incentives in a set of twelve important developing economies. From 1985 to 2005, countries as diverse as Brazil, Chile, China, Colombia, Korea, Malaysia, Mexico, Singapore, Uruguay, Venezuela, and Vietnam have used R&D FDI incentives extensively. These incentives take a variety of forms, including reduced or exempt taxes (federal, excise, sales, VAT, additional deductions); trade benefits (import duties, tariffs); and subsidies (for capital, buildings, training, investment; subsidized loans and grants). Conditions for receiving incentives include initial investments or increased investments in R&D activities (Johnson 2011, 2013). However, these countries do not employ R&D FDI incentives in every year. Therefore, I compare country-years with R&D FDI incentives in place to those without in order to isolate any independent effect of the incentives. For robustness, I estimate models that count whether R&D FDI incentives were present in the previous 1, 2, or 3 years. If R&D FDI incentives have an independent effect on R&D FDI siting, we would expect to see a positive and significant coefficient on any or all of these covariates.

8 Results: investment incentives

Table 5 reports regression results, in which R&D FDI incentive variables are added to the reduced form model (Model 1) and the sample is reduced to country-industry-year observations for the twelve countries on which R&D FDI incentive information is available. Far from seeing a positive relationship between R&D FDI incentives and US-origin R&D FDI siting, the relationship is consistently negative. In Models (12) and (13), R&D FDI incentives have no independent effect. When R&D FDI incentives were present in the previous 1, 2, or 3 years, the relationship is negative and significant – with R&D FDI incentives in fact associated with 8% lower levels of R&D FDI (Model 14). This relationship supports the logic not that R&D FDI incentives are signals of attractiveness, but rather that R&D FDI incentives may be signals of underlying reasons not to site R&D FDI in a given country. In other words, a government might be implementing incentives in order to compensate for unattractive aspects of the local economy. Much more important, and consistently positive and significant, is the presence of value added in the country-industry in previous years.

Do R&D FDI incentives have an effect on R&D FDI siting via effects on value added? Figure 3 provides graphical evidence that no, this channel is not present. The data points in light gray reflect industry-country-years in which R&D FDI incentives are in place, plotted by R&D FDI expenditure and value added in that

Table 5 Role of R&D investment incentives in US-origin R&D FDI expenditure, by country-industry (2001–2008).

	Model (12)	Model (13)	Model (14)
Value added (Logged)	0.067***	0.066**	0.082***
	(0.024)	(0.026)	(0.029)
R&D FDI Incentive, last year	−0.037		
	(0.064)		
R&D FDI Incentive, last 2 years		−0.041	
		(0.043)	
R&D FDI Incentive, last 3 years			−0.078**
			(0.035)
R&D Expenditures per GDP	0.320	0.190	−0.135
	(0.308)	(0.340)	(0.359)
Total FDI (Logged)	−0.037**	−0.030	−0.018
	(0.018)	(0.019)	(0.018)
Trade (per GDP)	−0.001	−0.001	−0.001
	(0.002)	(0.002)	(0.002)
Capital account openness	−0.005	0.007	0.044
	(0.021)	(0.021)	(0.035)
GDP per capita (Logged)	1.264**	1.539**	2.189***
	(0.632)	(0.672)	(0.775)
Polity score	−0.020**	−0.041***	−0.105**
	(0.009)	(0.015)	(0.053)
Constant	−9.006*	−11.086**	−16.102***
	(4.953)	(5.285)	(6.075)
Observations	798	727	621
Country-Industry groups	162	160	157
R^2 (within)	0.18	0.16	0.15

All independent variables are lagged. Year and country-industry fixed effects.
Robust standard errors clustered by country-industry, *p<0.10, **p<0.05, ***p<0.01.
Countries: Argentina, Brazil, Chile, China, Colombia, Ecuador, Korea, Mexico, Malaysia, Peru, Philippines, Singapore.

industry-country-year. In contrast, points in dark gray are industry-country-years in which no R&D FDI incentives are available. With a simple visual inspection, we see considerable overlap in the levels of value added accruing in these different moments. Thus we have further confidence that it is the experience of firms and industries, rather than the independent effect of particular government incentive policies, that are moving results on R&D FDI outcomes. By starting from the point of view of the firm, the theory and evidence laid out here demonstrates that R&D FDI decisions are responsive to firm experiences. Specific R&D FDI attraction policies can even be counterproductive.

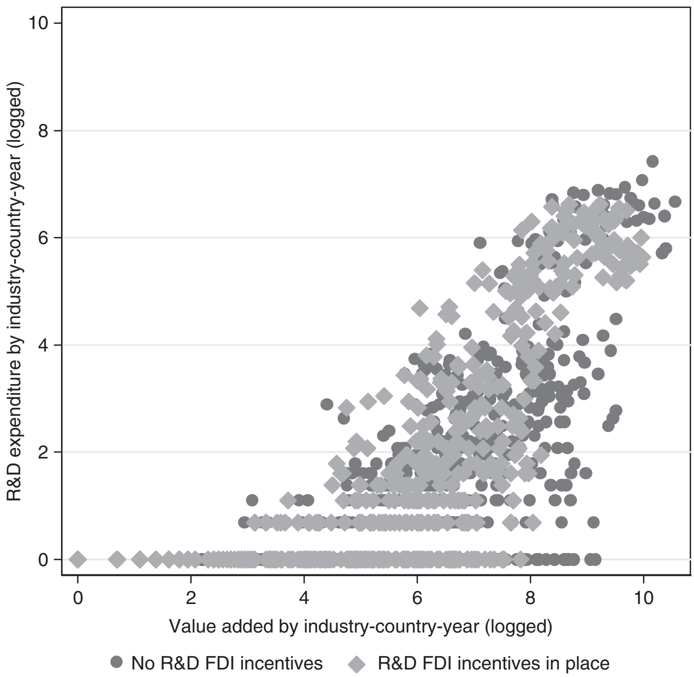

Figure 3 Comparison of value-added activity, by presence of R&D FDI incentives. Source: US Bureau of Economic Analysis (BEA) (2012), Johnson (2011).

9 Innovation in tow

Economic globalization offers firms new creative, technical, and innovative resources upon which to draw: the striking growth in R&D FDI is not surprising. Yet why R&D FDI occurs and accumulates in some places more than others, in a way different from general FDI patterns, is puzzling. By drawing on interviews with firm-level decision-makers and quantitative evidence, this paper has argued that the previous value of FDI is key to understanding both the incidence and distribution of R&D FDI across countries. In the process, this paper has disaggregated the concept of FDI in ways that suggest further research into other types of FDI, whether their distributions differ from FDI in general, and why.

Why do firms innovate where they do? The upgrading story presented here argues that locations with existing FDI that provides increasing value added are the locations likely to receive R&D FDI. This process is at least tacitly understood by firm-level decision-makers, but it has clear and underemphasized policy

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implications for national governments. The data here do not allow us to distinguish between R&D FDI as an upgrading process internal to the firm or present across an industry. Nonetheless, policies that spur current investors to increase value added activities would be useful in promoting R&D FDI (cf. Guimon 2009). As reinvestment is an increasingly common component of FDI around the world, the potential for governments to nurture long-term, upgrading processes within firms may indeed exist. Or, governments can focus on promoting the development of value added activities in an industry, as one firm's success may inspire new R&D FDI by competitors. R&D FDI-specific incentives, however, do not speak directly to the process of upgrading embedded in either mechanism. By addressing the R&D internationalization process from the firm's perspective, this paper highlights how the mitigation of uncertainty over R&D FDI potential ultimately leads firms to take advantage of the scientific and technical resources other countries have to offer.

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Appendix

Appendix Table 1 Maximum destination countries in Tables (2), (3), and (4).

Australia	Israel
Argentina	Italy
Austria	Korea
Belgium	Malaysia
Brazil	Mexico
Canada	Netherlands
Chile	New Zealand
China	Nigeria
Colombia	Panama
Costa Rica	Peru
Czech Republic	Philippines
Denmark	Poland
Ecuador	Portugal
Egypt	Russia
Finland	Saudi Arabia
Germany	Singapore
Greece	South Africa
Honduras	Spain
Hungary	Sweden
India	Thailand
Ireland	Turkey
	UK

Appendix Table 2 Summary statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum	Source
R&D (Logged)	3112	1.340	1.935	0	8.700	BEA
Value added (Logged)	2734	5.101	2.637	0	12.037	BEA
Sales (Logged)	2616	6.442	2.883	0	13.362	BEA
Exports (Logged)	2467	2.619	2.806	0	11.235	BEA
R&D per GDP	2711	1.089	1.033	0.038	4.665	World Bank WDI
Total FDI (Logged)	2569	22.020	1.434	18.407	25.658	World Bank WDI
Trade	3112	91.679	70.067	21.739	460.471	World Bank WDI
Capital account openness	3112	1.019	1.414	-1.159	2.456	Chinn and Ito (2008 [2012])
GDP per capita (Logged)	3112	8.681	1.082	6.110	10.556	World Bank WDI
Polity score	3112	7.109	4.677	-10	10	PolityIV
Secondary labor (pct workforce)	1677	43.640	17.167	13.3	79.2	World Bank WDI
College labor (pct workforce)	1677	25.283	10.181	5.2	54	World Bank WDI
University R&D spending (US$ thou.)	1091	199774	340132	113	1577669	World Bank WDI
R&D FDI Incentive, 1 year	2060	0.334466	0.471918	0	1	Johnson (2011)
R&D FDI Incentive, 2 years	1608	0.766791	0.9358871	0	2	Johnson (2011)
R&D FDI Incentive, 3 years	1396	1.204155	1.356999	0	3	Johnson (2011)

References

Archibugi, Daniele and Simona Iammarino. 1999. “The Policy Implications of the Globalisation of Innovation.” *Research Policy* 28: 317–336.

Cantwell, John and Odile Janne. 1999. “Technological Globalization and Innovative Centres: The role of corporate technological leadership and locational hierarchy.” *Research Policy* 28 (2): 119–144.

Casson, Mark and Satwinder Singh. 1993. “Corporate Research and Development Strategies: The influence of firm, industry, and country factors on the decentralization of R&D.” *R&D Management* 23 (2): 91–108.

Chinn, Menzie and Hiro Ito. 2008. “A New Measure of Financial Openness.” *Journal of Comparative Policy Analysis* 10 (3): 309–322.

De Meyer, Arnoud. 1993. “Management of an International Network of Industrial R&D Laboratories.” *R&D Management* 23 (2): 109–120.

Dunning, John. 1980. “Toward an Eclectic Theory of International Production: Some Empirical Tests.” *Journal of International Business Studies* 11: 9–31.

Edler, Jakob and Wolfgang Polt. 2008. “International Industrial R&D – Policy Challenges: Introduction to the Special Issue.” *The Journal of Technology Transfer* 33 (4): 331–336.

Florida, Richard. 1997. The Globalization of R&D: Results of a Survey of Foreign-Affiliated R&D Laboratories in the USA.” Research Policy 26 (1): 85–103.

Gassmann, Oliver and Maximilian Von Zedtwitz. 1999. “New Concepts and Trends in International R&D Organization.” *Research Policy* 28 (2): 231–250.

Gersbach, Hans and Armin Schmutzler. 2011. “Foreign Direct Investment and R&D-offshoring.” *Oxford Economic Papers* 63 (1): 134–157.

Gerybadze, Alexander and Guido Reger. 1999. “Globalization of R&D: Recent changes in the management of innovation in transnational corporations.” *Research Policy* 28 (2): 251–274.

Ghoshal, Sumantra and Christopher Bartlett. 1990. “The Multinational Corporation as an Interorganizational Network.” *Academy of Management Review* 15 (4): 603–626.

Griffith, Rachel, Rupert Harrison, and John Van Reenen. 2006. “How Special is the Special Relationship? Using the Impact of US R&D Spillovers on UK Firms as a Test of Technology Sourcing.” *American Economic Review* 96: 1859–1875.

Guimon, Jose. 2009. “Government Strategies to Attract R&D-intensive FDI.” *The Journal of Technology Transfer* 34 (4): 364–379.

Gulbrandsen, Magnus and Helge Godoe. 2008. “ ‘We Really don’t Want to Move, but…’: Identity and Strategy in the Internationalization of Industrial R&D.” *The Journal of Technology Transfer* 33 (4): 379–392.

Ito, Banri and Ryuhei Wakasugi. 2007. “What Factors Determine the Mode of Overseas R&D by Multinationals? Empirical evidence.” *Research Policy* 36 (8): 1275–1287.

Jensen, Nathan. 2003. “Democratic Governance and Multinational Corporations: Political Regimes and Inflows of Foreign Direct Investment.” *International Organization* 57 (3): 587–616.

Jensen, Nathan. 2006. *Nation-States and the Multinational Corporation*. Princeton, NJ: Princeton University Press.

Johnson, Kristina. 2011. “Advancing the Agenda on Investment Incentives: A New Dataset.” Paper presented at the Annual Meeting of the American Political Science Association, Seattle, WA.

Johnson, Kristina. 2013. “Investment Incentives: A New Dataset.” Paper presented at the Annual Meeting of the International Studies Association, San Francisco, CA.
Kuemmerle, Walter. 1999. “ The Drivers of Foreign Direct Investment into Research and Development: An Empirical Investigation.” *Journal of International Business Studies* 30 (1): 1–24.
Kumar, Nagesh. 2001. “Determinants of Location of Overseas R&D Activity of Multinational Enterprises: The case of US and Japanese corporations.” *Research Policy* 20 (1): 159–174.
Li, Quan and Adam Resnick. 2003. “Reversal of Fortunes: Democratic Institutions and Foreign Direct Investment Inflows to Developing Countries.” *International Organization* 57: 175–211.
Locke, Richard and Rachel Wellhausen, eds. 2014. *Production in the Innovation Economy*. Cambridge, MA: MIT Press.
National Science Foundation. 2004. Science and Engineering Indicators: 2004.
Niosi, Jorge and Benoit Godin. 1999. “Canadian R&D Abroad Management Practices.” *Research Policy* 28 (2-3): 215–230.
OECD. 2002a. Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual, Sixth Edition.
OECD. 2002b. “Strategic Investment Promotion: Successful Practice in Building Competitive Strategies.”.
OECD. 2003. “Tax Incentives for Research and Development: Trends and Issues.”.
Pearce, Robert. 1999. “Decentralized R&D and Strategic Competitiveness: Globalised Approaches to Generation and Use of Technology in Multinational Enterprises (MNEs).” *Research Policy* 28: 157–178.
Rama, Ruth. 2008. “Foreign Investment Innovation: A Review of Selected Policies.” *The Journal of Technology Transfer* 33 (4): 353–363.
Ronstadt, Robert. 1977. *Research and Development Abroad by U.S. Multinationals*. New York: Praeger Publishers.
Saxenian, Annalee. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.
Serapio, Manuel and Donald Dalton. 1999. “Globalization of Industrial R&D: An Examination of Foreign Direct Investments in R&D in the United States.” *Research Policy* 28: 303–316.
Steinfeld, Edward. 2004. “China’s Shallow Integration: Networked Production and the New Challenges for Late Industrialization.” *World Development* 32 (11): 1971–1987.
Sturgeon, Timothy. 2002. “Modular Production Networks: a New American Model of Industrial Organization.” *Industrial and Corporate Change* 11 (3): 451–496.
UNCTAD. 2005. “World Investment Report 2005: Transnational Corporations and the Internationalization of R&D”.
Zander, Ivo. 1999. “How Do You Mean ‘Global’? An empirical investigation of innovation networks in the multinational corporation.” *Research Policy* 28 (2): 195–213.
Zeger, Scott and Kung-Yee Liang. 1986. “Longitudinal Data for Discrete and Continuous Outcomes.” *Biometrics* 42 (1), 121–130.