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UITJ-2016-0088.R2 - Bring Your Laboratory to My Country: What Is The Role of Foreign Direct Investment?

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Bring your laboratory to my country: What is the role of foreign direct investment?

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Bring your laboratory to my country: What is the role of foreign direct investment?

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ABSTRACT
This article investigates the relationship between multinational enterprises' (MNEs) plans for foreign direct investment (FDI) and their research and development (R&D) offshoring. To examine this issue, we focus our analysis on FDI types that are crucial to MNEs' resource allocation. This is illustrated from the perspectives of intra-firm trade and market targeting. By employing Taiwanese manufacturing survey data and the generalized method of moments approach, we found that MNEs' FDI intensity has significant positive effects on MNEs' decisions to engage in R&D offshoring. Subsidiaries' sales to local markets reveal that the relationship between the R&D offshoring and horizontal FDI is strong and positive in Taiwanese MNEs.

KEYWORDS
Foreign direct investment; multinationals; R&D offshoring

I. Introduction

International R&D investment (globalizing R&D) has become a fast-growing strategy among multinational enterprises (MNEs) in the last two decades.[1] Its twin activities—R&D offshoring (international outsourcing R&D) and R&D foreign direct investment (FDI)—have attracted a significant amount of scholarly attention.[2] Moreover, its determinants, such as firm size (Arvanitis and Hollenstein 2006; Cassiman and Veugelers 1998; García-Vega and Huergo 2011), foreign market size (Arvanitis and Hollenstein 2006), human capital or technology (Arvanitis and Hollenstein 2006; Lewin, Massini, and Peeters 2009), international trade (García-Vega and

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[1]According to a 2005 report from the United Nations Conference on Trade and Development (UNCTAD), one-half of the world's total R&D expenditure and two-thirds of the world's business R&D are conducted by MNEs. Sixty-nine percent of MNEs stated that their share of R&D offshoring was set to increase. Please see UNCTAD (2005) for details. Shackelford and Wolfe (2017) indicates that in 2013, 18 % of U.S. companies' R&D was conducted overseas.

[2]We define R&D offshoring as relocating R&D activities from domestic units to units in overseas countries. R&D FDI describes the MNEs' investment of R&D activities in foreign countries, and it requires MNEs to be involved in managing their overseas R&D units. Our study focuses on the first, but our survey data only show the value of investment (and ratio) of R&D expenditure in domestic units and foreign units; there is no description of which type of overseas R&D activity it is. It is impossible to separate these two activities in this study. Therefore, R&D offshoring in our study includes R&D offshoring and R&D FDI.

Supplemental data for this article can be accessed here.

Huergo 2011), industrial character (García-Vega and Huergo 2011), and destination location (García-Vega and Huergo 2011), have been widely assessed and have been regarded as crucial to the decision-making process. It is not surprising that an environment that is attractive to manufacturing FDI also provides incentives for MNEs to conduct R&D outsourcing. Most determinants of R&D offshoring are also major factors in MNEs' decisions regarding overseas manufacturing investment.[3]

Only a few existing studies have discussed the interaction between manufacturing FDI and R&D offshoring.[4] Gersbach and Schmutzler (2011) employ a theoretical model to explain the link between R&D offshoring and FDI. In their model, an MNE first decides on a manufacturing location (home or host country) and then whether to offshore its R&D activities overseas. Their results show that, under certain conditions, FDI liberalization can instigate the relocation of R&D units and the possibility of R&D relocation makes FDI more attractive.[5] Their results led to two important arguments. First, although MNEs conduct their overseas production ahead of R&D overseas investment, they plan both of these activities when they decide to be multinationals. This argument implies that MNEs' FDI plans are an important determinant in their R&D offshoring[6]; however, there is an endogenous problem: plans for FDI and foreign R&D mutually affect each other.

Second, if MNEs' FDI plans affect their decisions regarding R&D offshoring, the motives leading them to conduct FDI also affect their R&D offshoring. There are two main types of FDI in the literature—namely, vertical FDI and horizontal FDI—with the differences between them being the markets they target and the intra-firm trade flows between parent firms and subsidiaries. Horizontal FDI activities explore and supply foreign (host or local) markets and reduce transportation costs and tariff burdens on MNEs.[7] Vertical FDI activities relocate parts of MNEs' production, either intermediate or final products, to host countries. Vertical FDI reduces the cost of labor and resources needed to serve the home country's market and all other markets. Therefore, the flow of intra-firm trade in, for example, raw

[3]The FDI literature describes a great diversity of FDI determinants. Blonigen and Piger (2014) investigated the differences between these determinants in the literature and used Bayesian statistical techniques to determine which candidates were most likely to be consistently high inclusion determinants. The market size (GDP) of host countries, relative labor endowment and technology, and skill level were included in their discussion.

[4]Here, we define manufacturing FDI as MNEs directly investing their production (manufacturing) sectors in foreign countries. Hereafter, we use FDI instead of manufacturing FDI for simplicity.

[5]This requires sufficiently strong intrafirm communication, sufficiently weak product-market competition, and sufficiently strong external spillovers. See Gersbach and Schmutzler (2011) for an overview.

[6]Another stream of literature discussing the fragmentation of the production process in the global network is the studies of global value chains (GVCs). Several well-known studies such as Baldwin and Venables (2013) and Antràs and Chor (2013) discuss and explore the structure of global integration of GVCs engaging multinationals. As for the relationship between GVC and R&D expenditure, Brancati, Brancati and Maresca (2017) employ firm-level data from Italy to support the argument that GVC participation enhances the probability of innovative activity and performance.

[7]See Helpman, Melitz, and Yeaple (2004) for a detailed discussion of firms' choices between exports and horizontal FDI.

materials and components—which could flow either way between home and host countries—is a signal that MNEs have adopted vertical FDI activities.[8]

This article, departing from the extant literature, empirically investigates the relationship between MNEs' plans for FDI and R&D offshoring. It is important to refine this relationship, since we usually think of outward FDI as a possible cause of industrial hollowing out, and R&D activities are one of the indicators that show whether the domestic industry is hollowed out after outward FDI. To examine this issue, we are mainly concerned with FDI types that are crucial to MNEs' resource allocation. This will be characterized from the viewpoints of intra-firm trade (or linkage) and market targeting. No such analysis exists in the FDI and R&D literature.[9]

Because of the nature of our topic, the econometric model that best fits this study is the generalized method of moments (GMM) approach developed by Arellano and Bover (1995) and Blundell and Bond (1998). We believe that their GMM model can handle the following issues found in this study. First, an endogeneity problem occurs after FDI is introduced in the regression where R&D offshoring is the dependent variable.[10] Second, R&D expenditure also constitutes an aspect of MNEs' plans for investment. The data on R&D offshoring are intrinsically persistent and should, therefore, be described using dynamic regression models. Third, this study employs firm-level data, and the GMM can deal with the unobserved heterogeneity among firms.[11]

The data we employ to investigate this issue come from a survey of Taiwanese MNEs. The advantage of using data from Taiwanese MNEs is that, because of the cultural and geographic closeness, the major host country for Taiwanese MNEs is China, which has become the largest recipient of world FDI since 2003 and is one of the most popular host countries for global R&D investment.[12] Taiwanese MNEs' survey data are ideal for revealing the impact of FDI on R&D offshoring.[13]

[8]See Yeaple (2003a), Hanson, Mataloni, and Slaughter (2005), and Ramondo, Rappoport, and Ruhl (2016) for detailed discussions on vertical FDI.

[9]Since different motives for FDI target different markets, and the profit earned from sales supports MNEs' R&D expenditure, our analysis also focuses on MNEs' sales to home and host country markets.

[10]Yang, Wu, and Lin (2010) found that, in China, Taiwanese FDI, measured as accumulated FDI, was mutually causal with R&D expenditure in relation to capital stock. The GMM approach is thus called for in this study on the basis of the theoretical and empirical arguments in the previous literature.

[11]Besides using system GMM to deal with the issues of endogeneity, one can also employ two-stage-least-square (2SLS) regression analysis. Since our study also needed to consider the dynamic nature of our data, we chose system GMM instead of 2SLS.

[12]In 2007, the Economist Intelligence Unit (EIU) surveyed 300 senior executives about where they planned to invest their future R&D activities. The top responses were India (26% of the respondents), the US (22%), and China (14%).

[13]Another advantage of using data from Taiwanese multinationals is that the data are a perfect fit for the conditions under which FDI liberalization enables the relocation of R&D activities (Gersbach and Schmutzler 2011). Because of the cultural, linguistic, and geographic proximity between Taiwan and China, intra-firm communication is easier to develop. Chinese markets were growing fast, and competition levels during our sample period were still at an early stage.

The remainder of this article is organized as follows: in Section 2, we discuss the relationship between the motives for FDI and those for R&D overseas investment. Section 3 describes the data. The econometric models adopted in this article are introduced in Section 4, and the empirical results are presented and elaborated in Section 5. The last section concludes the article.

II. Motives for FDI and R&D offshoring

Although most MNEs employ both vertical and horizontal FDI,[14] different types of FDI constitute different reasons for MNEs to build R&D units in their subsidiaries. In order to meet the demands of local consumers, having R&D facilities in subsidiaries increases efficiency, which is also the reason that some studies have found that market size is significant for R&D offshoring in subsidiaries. Building R&D facilities in affiliates allows MNEs to obtain access to advanced foreign technology. However, if vertical FDI activities mainly take advantage of cheap labor or resources in host countries, there will be a neutral or negative relationship between R&D offshoring and vertical FDI expenditure. The relationship between vertical FDI activities and R&D offshoring is, thus, ambiguous.

A further question is whether the ambiguous relationship between vertical FDI activities and R&D outsourcing can be determined by intra-firm trade, the trade flows between MNEs' parent firms or country and their affiliates. Subsidiaries might import intermediate products from their parent firms or countries.[15] The production of intermediate goods requires a certain level of skill and technology. The importation of intermediate goods from parent firms by MNEs' subsidiaries decreases their need for R&D units.[16] Further, importing intermediate products from parent firms also reveals the nature of the relationship between MNEs' subsidiaries and the parent firms. If affiliates become more independent from their parent firms, there will be a greater likelihood that they will have their own R&D units. Thus, we expect a negative coefficient on importing intermediate goods from parents as a proxy of independency.

Finally, market targeting matters. The home country's market provides MNEs that conduct vertical FDI as an incentive to invest R&D activities in their subsidiaries. After manufacturing, subsidiaries export intermediate or final goods back

[14]Most MNEs employ more than one type of FDI, a situation called complex integration (see Yeaple 2003b).

[15]Ramondo, Rappoport, and Ruhl (2016) empirically determine the motives of US multinationals. One of their findings is that intra-firm trade is concentrated among a small number of large affiliates. Medium-sized affiliates do not ship their products back to parents, but sell to unaffiliated companies. In the case of Taiwanese MNEs, most of the shipments from subsidiaries to the home country sell to parents or other firms in Taiwan. Therefore, we employ a broad definition of intra-firm trade in assessing the trade flow between affiliates and their parents. We not only consider exports and imports between MNEs' subsidiaries and parents, but also between MNEs' subsidiaries and all firms in the home country.

[16]Here, the idea of technology flow is similar to that of technology spillover through intermediate products discussed in the literature. It has been proposed and proven that technology can travel internationally through the exportation and importation of intermediate products. See the summaries in Madsen (2007).

to their parent country. If subsidiaries are located in places that have a better environment or a lower cost for R&D activities than in their home countries, the profits received from selling products support MNEs' R&D expenditure, and MNEs will relocate their R&D investment from their home countries to the host countries. A positive relationship is expected between MNEs' sales in their home countries and R&D offshoring. For horizontal FDI that targets local markets, MNEs have motives to conduct R&D offshoring so that they can match their product supply to the demand of local consumers. The larger the local market is, the more incentive the MNE has to adopt R&D offshoring. Hence, a positive relationship between MNEs' sales in their local (host) country and R&D offshoring is expected.

III. Data

Since 1996, the Ministry of Economic Affairs in Taiwan has published annual surveys of the overseas investments of Taiwanese manufacturing firms (hereafter, ASTM) to report on Taiwanese MNEs' economic and business operations and activities overseas.[17] Each ASTM survey reveals the allocation of Taiwanese MNEs' R&D and production in their parent establishments and subsidiaries for the previous year. From 2004 to 2007, MNEs were also asked how they distributed their sales between the domestic (home) market, the local (host) market, and other foreign markets over the previous year. Their sales to different markets are the main factors influencing their FDI motives, which, from the market targeting perspective, are crucial to our analysis. Thus, the study covers the sample period of 2004 to 2007, which contains information from 2003 to 2006. We use the latter range for the sample period in the remainder of the article.

Two issues need to be addressed before we use the ASTM data: some Taiwanese manufacturing firms do not have overseas production facilities, and some firms have no R&D activities whatsoever. The inclusion of these two types of firms in our sample would be problematic, since we discuss the relationship between R&D offshoring and FDI.[18] Upon excluding those MNEs with no production activities in their affiliates and no R&D, our sample included 1,231 MNEs in 2003, 1,145 MNEs in 2004, 1,068 MNEs in 2005, and 1,108 MNEs in 2006.[19]

Table 1 presents the distribution of the host countries in which Taiwanese MNEs invested in 2003 to 2006. China was the largest recipient of Taiwanese MNEs in 2003 to 2006, and its share of investment increased over time. The

[17]The Chung-Hua Institution for Economics Research in Taipei, Taiwan, has been authorized to conduct the survey since 1997.

[18]In this article, we exclude those Taiwanese multinationals that do not have overseas production. However, there are a few Taiwanese multinationals that have only R&D units in their subsidiaries' overseas units. We have also run all our regression analyses including them in the data, and the results show that the difference between including and excluding those firms is minor. The empirical results of the regression analyses based on a sample including multinationals with no overseas production are available upon request.

[19]Originally, there were 1,879, 1,711, 1,667, and 1,769 firms in the years 2003, 2004, 2005, and 2006, respectively.

Table 1. Host countries distribution.

Host country	2003 Freq.	2003 %	2004 Freq.	2004 %	2005 Freq.	2005 %	2006 Freq.	2006 %
USA*	137	11.1	102	8.9	87	8.2	84	7.6
Canada*	2	0.2	1	0.1	2	0.2	2	0.2
Mexico	3	0.2	1	0.1	1	0.1	0	0.0
Central and South America	5	0.4	5	0.4	3	0.3	3	0.3
Western Europe*	9	0.7	10	0.9	11	1.0	11	1.0
Eastern Europe	4	0.3	1	0.1	1	0.1	1	0.1
Hong Kong*	57	4.6	48	4.2	46	4.3	37	3.3
China	827	67.2	829	72.4	780	73.0	833	75.2
Japan*	14	1.1	9	0.8	7	0.7	10	0.9
Malaysia	24	2.0	14	1.2	10	0.9	15	1.4
Singapore*	12	1.0	10	0.9	9	0.8	7	0.6
Thailand	24	2.0	17	1.5	19	1.8	18	1.6
Indonesia	14	1.1	11	1.0	11	1.0	11	1.0
Philippines	11	0.9	9	0.8	8	0.8	6	0.5
Vietnam	29	2.4	26	2.3	33	3.1	35	3.2
Other South Asian Countries	1	0.1	0	0.0	0	0.0	0	0.0
Australia and New Zealand*	3	0.2	3	0.3	2	0.2	0	0.0
Africa	3	0.2	1	0.1	2	0.2	3	0.3
Rest of the world	52	4.2	48	4.2	36	3.4	32	2.9
Total	1231	100	1,145	100	1,068	100	1,108	100

Note: Developed countries are represented by *.
Source: Numbers are computed based on the data in ASTM.

United States and Hong Kong were in second and third place, respectively. The countries represented with asterisks are all developed countries. There is no obvious increase in the number of firms invested in these developed countries; rather, there is a slight decrease. Had Taiwanese MNEs increased R&D offshoring during those years, the expectation would be a negative or insignificant coefficient for the country dummy variable of the developed countries. Table 2 indicates the distribution of Taiwanese multinational firms according to industrial classifications in 2003 to 2006.[20] Electronic equipment and components constituted the main industry among Taiwanese MNEs, produced by almost half of Taiwanese MNEs. This study includes industrial dummy variables to capture the effects of industry differences in R&D offshoring.

IV. The econometric model

This study adopts a dynamic panel data model to determine the relationship between R&D offshoring and its determinants. The dependent variable, R&D offshoring, is the main focus of the study; in particular, two components of R&D offshoring: (1) the amount of R&D offshoring in subsidiaries; and (2) the share of overseas R&D investment. The amount of R&D offshoring

[20]This is not the industrial classification used in the survey. For simplicity, this study only presents the distribution of firms according to the industrial classifications used by the Ministry of Economic Affairs in Taiwan. The distribution of firms according to the industrial classifications used in the ASTM is available upon request.

Table 2. Industrial distribution.

	2003		2004		2005		2006	
Industries	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Primary metal and machinery industries	237	19	250	22	236	22	245	22
Electronic equipment and components	633	51	557	49	508	48	538	49
Chemicals	201	16	194	17	175	16	176	16
Miscellaneous manufacturing industries	160	13	144	13	149	14	149	13
Total	1231	100	1145	100	1068	100	1108	100

Source: Numbers are computed based on the data in ASTM.

conveys the scale of R&D offshoring. Based on previous studies, however, it was found to correlate significantly with the scale of production. Therefore, to avoid the scale effect, the intensity of R&D offshoring, which is measured as subsidiaries' R&D expenditure divided by their total output (*RDI_S*), is used here.

Gersbach and Schmutzler (2011) describe offshoring decisions as decisions by multinationals on the allocation of their production and R&D activities between their home and host territories. Home countries are also naturally concerned about R&D offshoring decisions to relocate domestic R&D investment to host countries. We employ subsidiaries' R&D expenditure share (*RDE_S*), which is measured as the proportion of an MNE's total R&D expenditure devoted to R&D expenditure in its subsidiaries, to address the allocation of R&D activities between home and host countries and concerns regarding R&D relocation. An increase in an MNE's *RDE_S*, taking total R&D expenditure as given, means that the MNE is moving its domestic R&D activities abroad.

As mentioned in the introduction, MNEs' plans regarding overseas manufacturing investment and those relating to R&D activities affect each other. The first independent variable in our models is MNEs' FDI intensity (*FDI_S*), which is measured as subsidiaries' value of output (*VOS_S*) divided by total output from both the parent and the affiliates (*VOS*). There are two ways to set the endogenous explanatory variables in the GMM model. If FDI activities are planned before overseas R&D activities, FDI is treated as a predetermined variable. If MNEs decide to engage in FDI and R&D offshoring simultaneously, displaying the effect of each on the other as discussed in Gersbach and Schmutzler (2011), we treat FDI as an endogenous variable. In this study, we consider both cases. Based on the theoretical prediction in Gersbach and Schmutzler (2011),[21] a positive effect is expected.

The second independent variables considered here are the imported intermediate products (*PAR_P*) from parent firms to subsidiaries. These intra-firm trade flows are measured in terms of shares and are computed as imports from parent firms divided by total purchases. As discussed earlier,

[21]Criscuolo, Haskel, and Slaughter (2010) employ UK data containing 7,385 enterprises in 1994 to 2000 to empirically discuss why firms with global activities (export and multinational production) have higher productivity. Their results show that globally engaged firms innovate more. Since R&D offshoring is one innovative activity, our positive results corroborate their argument.

the importation of intermediate products is expected to have a negative or zero influence on R&D offshoring. We consider *PAR_P* as an exogenous variable in our regression model because there is no feedback from either R&D intensity in subsidiaries (*RDI_S*) or subsidiaries' R&D expenditure share (*RDE_S*) to (*PAR_P*).

The third group of determinants are the shares of sales in the local market (*SAL_L*) and in the domestic market in the home country (*SAL_P*). We expect positive results for both determinants. Previous studies argue that there is a lag between R&D and profit. We, therefore, assume that R&D expenditure does not affect current sales. R&D could, however, influence future sales. In other words, we believe that *SAL_L* and *SAL_P* in current time are fixed, and unpredictable errors in the same period of time do not affect them. But they will be affected in the future. Therefore, we set both *SAL_L* and *SAL_P* as predetermined variables.

This study also considers R&D intensity in parent firms (*RDI_D*). Some studies (e.g., D'Agostino, Laursen, and Santangelo 2013; Hemphill 2005; Kotabe 1990; Mudambi 2008; Verspagen and Schoenmakers 2004) have found affiliates' R&D expenditure to be complementary to domestic R&D expenditure. By contrast, R&D offshoring is also found to be a substitute for domestic innovation activities (e.g., Bardhan and Jaffee 2005; Manning, Massini, and Lewin 2008; Teece 1988). The sign of the coefficient of *RDI_D* can point to which of these cases is specific to Taiwanese MNEs.

We also consider R&D intensity in parent firms (*RDI_D*) to be a predetermined variable. There are two types of R&D in the R&D literature: market-oriented or adaptive R&D, and knowledge-sourcing or innovative R&D. Market-oriented R&D makes MNEs' products fit local markets' taste. Innovative R&D creates new or next-generation products. In-home adaptive R&D and overseas adaptive R&D target different markets, but in-home and overseas *innovative* R&D are related to each other. It is natural to assume that MNEs made decisions for their domestic R&D facilities before making them for subsidiaries' R&D.

Finally, we included three types of dummy variables in our models; the first is industrial dummy variables. Yang, Wu, and Lin (2010) found that scientific industries have enhanced opportunities to engage in R&D activities. On the basis of the industrial classification of the survey used in this study, we have included primary metal and machinery industries (*Dind_Mach*), electronic equipment and components (*Dind_Elec*), chemical and biotechnology (*Dind_Chem*), and miscellaneous manufacturing industries. The second type is the country dummy variable. Because of the similarity in cultural and geographical closeness, we include a dummy variable that equals one if a multinational's major investing country is China (*Dcon_CHN*).[22] As noted in previous studies, developed countries own advanced technology, which is attractive to global investors. Another country

[22]Most Taiwanese MNEs invest in more than one country. One of the questions in the ATSM asks respondents to list the order of countries in which they invest according to the value of their investment. If the host country in which they invest most is China, their value of *Dcon_CHN* is 1.

dummy is (*Dcon_ADV*), which equals one if an MNE invests in a developed country. We expect all dummies to have positive effects on MNEs' R&D offshoring. All dummies are exogenous variables.

Table 3 summarizes the descriptive statistics of the dependent, independent, and basic background variables in this study. There is a suspected cyclical movement in Taiwanese MNEs' expenditure on R&D activities (*RDE*). In 2004, this reached the bottom and then bounced back. Similarly, 2005 represented the bottom year regarding the R&D of parent firms (*RDI_D*). Overall, R&D intensity (*RDI*) decreased from 2003 to 2006. Although the subsidiaries' R&D intensity (*RDI_S*) dropped in 2003 to 2006, the share of the subsidiaries' R&D expenditure (*RDS_S*) decreased slightly in 2004 and started increasing after 2005. The value of production (*VOS*), as well as FDI measured as a share of the production in subsidiaries (*FDI_S*), increased in 2003 to 2006.

The sales distribution of Taiwanese MNEs shows that local market sales (*SAL_L*) were their major business, and they continued to increase from 2003 to 2006. The stability of the share of MNEs' sales to the Taiwanese market (*SAL_P*) implies that sales to other countries were replaced by sales in local markets and that horizontal FDI was becoming more important to Taiwanese MNEs. From 2003 to 2005, subsidiaries increased their imports of inputs from Taiwan. *PAR_P* increased from 2003 to 2004 and remained the same in 2004 to 2006.

As mentioned in the introduction, R&D offshoring constitutes one aspect of MNEs' investment plans. The previous level of determinants can also affect MNEs' decisions regarding innovation activities. The

Table 3. Descriptive statistics of variables in regression models.

	2003		2004		2005		2006	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Dependent variables								
R&D intensity in subsidiaries (RDI_S; %)	13	169	10	159	5	62	3	18
R&D share expenditure in subsidiaries (*RDE_S*; %)	18	28	17	29	19	31	20	30
Independent variables								
Production share in subsidiaries (*FDI_S*; %)	32	28	35	29	36	29	38	30
Components supplied from Taiwan (*PAR_P*; %)	13	26	14	26	16	27	16	29
Sales share to local markets (*SAL_L*; %)	46	43	48	41	52	41	54	42
Sales share to Taiwan (*SAL_P*; %)	15	28	16	28	15	27	14	26
R&D intensity in parent companies (*RDI_D*; %)	15	133	11	53	8	53	10	50
Basic background variables								
R&D intensity (*RDI*; %)	11	121	6	28	5	49	4	10
R&D expenditure (*RDE*; million NTD)	157	1524	116	545	128	615	147	656
Value of shipment (*VOS*; million NTD)	5589	23,499	6213	27,500	7638	39,700	8259	34,900

Note: NTD is new Taiwan dollar.
Source: Numbers are computed based on the data in ASTM.

previous level of R&D offshoring should, therefore, be included in our model because data for R&D offshoring are persistent. Including all the determinants discussed earlier, the dynamic linear equation is set as[23]

$$\begin{aligned} RD\_S_{it} = {} & c_t + \beta_1 RD\_S_{it-1} + \beta_2 FDI\_S_{it} + \beta_3 FDI\_S_{it-1} + \beta_4 PAR\_P_{it} \\ & + \beta_5 PAR\_P_{it-1} + \beta_6 SAL\_L_{it} + \beta_7 SAL\_L_{it-1} + \beta_8 SAL\_P_{it} + \beta_9 SAL\_P_{it-1} \\ & + \beta_{10} RDI\_D_t + \beta_{11} RDI\_D_{t-1} + \beta_{12} Dind\_Mach_i + \beta_{13} Dind\_Elec_i \\ & + \beta_{14} Dind\_Chem_i + \beta_{15} Dcon\_CHN_i + \beta_{16} Dcon\_ADV_i + \eta_i + e_{it}, \end{aligned} \tag{1}$$

where RD_S stands for R&D in subsidiaries, which is RDI_S or RDS_S; i represents each of the Taiwanese MNEs; t indicates the year, either 2003, 2004, 2005, or 2006; c_t is the year-specific intercept included to account for common cyclical or trend components in the levels of R&D offshoring; and η_i captures unobserved firm-specific time-invariant effects. e_{it} is the error term.

If we estimate Equation (1) by ordinary least squares (OLS), the estimated parameters will be inconsistent because of η_i. In addition to the inconsistent results, OLS tends to overestimate the coefficient on the lagged dependent variable RDE_S_{it-1} or RDI_S_{it-1}. In order to handle the inconsistency, one can employ a within-groups estimation of a dynamic model, but the cost of using within-groups estimation is that it also introduces all realizations of the disturbances e_{it} into the error term of the transformed model in each period, which produces an underestimation of the coefficient (see Bond 2002).

System GMM, introduced in Blundell and Bond (1998) and Bond (2002), is an augmented system of the first-differenced GMM developed by Holtz-Eakin, Newey, and Rosen (1988) and Arellano and Bond (1991). There are two advantages to employing system GMM in our study. First, the time invariant variables, which are the unobservable individual specific effects, are wiped out in first-differenced GMM but not in system GMM. Second, system GMM employs the levels equation to obtain additional instruments, since the lagged levels of the regressors are sometimes poor instruments for the first-differenced regressors. Bond (2002) argues that if the dynamic model is well-specified and the selected instruments are valid, the estimate of the coefficient on the lagged dependent variable should fall somewhere in between the overly estimated OLS estimate and the underestimated within-groups estimate. We use the rule proposed by Bond (2002) as a safeguard to check the specification of our model.

[23]See Appendix A for a detailed description of our dynamic representation. Since we employ a dataset with a very short time period, it is beyond the limitation of our data to discuss either lagged terms longer than one period or an optimal lag period. The correlation coefficients between independent variables are also listed in Appendix B. The Appendices are available online at www.tandfonline.com/uitj.

V. Econometric results

This study uses two measures to capture the idea of R&D offshoring: *RDI_S* (R&D intensity in subsidiaries) and *RDE_S* (R&D share in subsidiaries). Table 4 presents the econometric results from a model using *RDI_S* as the dependent variable. Table 5 shows the econometric results from a model using *RDE_S* as the dependent variable. In each table, we provide results from within-group (Column 2), OLS (Column 3), first-differenced GMM (Columns 4 and 6), and system GMM (Columns 5 and 7).[24] The reason this study presents results from within-group and OLS is that within-group and OLS regressions provide us with the lower and upper bounds of the lagged dependent variables. The results in Columns 4 and 5 from the GMM regressions are those arising when *FDI_S* is a predetermined independent variable. Columns 6 and 7 state results indicating when *FDI_S* is endogenous. The benchmark of our results is Column 7. Comparing the results from Columns 4 and 5 with those of Columns 6 and 7, we can check whether Taiwanese MNEs made the decisions to engage in R&D offshoring and FDI simultaneously or whether the decision regarding FDI was made first, followed by the decision on R&D offshoring. Also, according to Blundell and Bond (2000), employing the first-differenced GMM procedure to moderately estimate short panels in moderately persistent series could cause large finite-sample biases because of weak instruments. Therefore, we provide the regression results from the first-differenced GMM in Columns 4 and 6 as a robustness check of our model selection.

First, we check the coefficients of the lagged dependent variables in Table 4. Here, all GMM estimators of the lagged dependent variables fall in the range between the lower bound (–0.139) provided by the within-group regression and the upper bound (0.461) yielded by the OLS estimator. The significant RDI_S_{t-1} is consistent with our assumption that R&D offshoring series are persistent data. Our preferred results are from the system GMM estimation. The coefficients of RDI_S_{t-1} in Table 4 indicate that because the instruments used in the first-differenced GMM are weak, the GMM results of the first-differenced are biased in the direction of within groups.

The coefficients of *FDI_S* are negative and significant when system GMM is employed, and *FDI_S* is the predetermined variable, which indicates that if Taiwanese MNEs' FDI decisions are made before those regarding R&D offshoring, FDI negatively affects their decisions on R&D offshoring. The result contradicts our expectation, though not surprisingly so. The denominator of the dependent variable that is also the numerator of *FDI_S* is *VOS_S*, which

[24]AR(2) test statistics are important, but cannot be measured and presented in Tables 4 and 5, due to the short time period covered by our data. A future study with data from a longer time period could solve this issue and provide further evidence for our results.

Table 4. Overseas R&D intensity.

	Within-Group	OLS	Difference GMM	System GMM	Difference GMM	System GMM
			FDI_S is Predetermined		FDI_S is Endogenous	
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
RDI_S_{t-1}	−0.139***	0.461***	0.178***	0.365***	0.178***	0.351***
	(0.025)	(0.018)	(0.057)	(0.047)	(0.060)	(0.050)
FDI_S_t	−0.029***	−0.019***	−0.024	−0.030***	−0.021	−0.008
	(0.003)	(0.002)	(0.020)	(0.007)	(0.029)	(0.020)
FDI_S_{t-1}	−0.008**	0.019***	0.011	0.023***	0.011	0.015
	(0.003)	(0.003)	(0.008)	(0.007)	(0.011)	(0.011)
PAR_P_t	−0.001	−0.002	0	0.004	0.001	0.003
	(0.002)	(0.001)	(0.008)	(0.003)	(0.008)	(0.003)
PAR_P_{t-1}	−0.001	−0.001	0.003	−0.037***	0.005	−0.033***
	(0.002)	(0.001)	(0.020)	(0.012)	(0.021)	(0.012)
SAL_L_t	0.007***	0.001	0.029***	0.007**	0.029***	0.010**
	(0.002)	(0.002)	(0.007)	(0.004)	(0.008)	(0.004)
SAL_L_{t-1}	0.002	−0.005***	0.007**	0.002	0.007*	0.002
	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)	(0.004)
SAL_P_t	0.003	0	0.015*	0.003	0.016	0.007
	(0.003)	(0.002)	(0.009)	(0.005)	(0.010)	(0.005)
SAL_P_{t-1}	0.006*	0.003	0.007	0.010**	0.007	0.011**
	(0.003)	(0.002)	(0.005)	(0.005)	(0.006)	(0.005)
RDI_D_t	0.019	0.090**	0.04	0.489	0.044	0.725*
	(0.051)	(0.036)	(0.581)	(0.317)	(0.663)	(0.395)
RDI_D_{t-1}	0.106**	0.112***	−0.235	−0.167	−0.248	−0.219
	(0.052)	(0.037)	(0.187)	(0.159)	(0.197)	(0.181)
Dind_Mach	−0.669	0.033	−1.314*	−0.026	−1.342*	−0.116
	(0.571)	(0.209)	(0.748)	(0.248)	(0.754)	(0.266)
Dind_Elec	−1.057*	0.158	−1.364*	0.417	−1.403*	0.152
	(0.585)	(0.193)	(0.805)	(0.355)	(0.816)	(0.416)
Dind_Chem	−1.004**	0.061	−1.352**	−0.04	−1.367**	−0.154
	(0.496)	(0.216)	(0.630)	(0.249)	(0.634)	(0.267)
Dcon_CHN	0.977***	0.370**	1.114**	0.111	1.111**	−0.058
	(0.354)	(0.183)	(0.441)	(0.190)	(0.444)	(0.224)
Dcon_ADV	0.895**	0.507**	1.070**	0.35	1.066**	0.169
	(0.413)	(0.228)	(0.501)	(0.280)	(0.504)	(0.306)
constant	−2.082***	−1.506***	0.000	−1.721***	0.000	−2.336***
	(0.598)	(0.266)	0.000	(0.483)	0.000	(0.650)
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Sargan			0.584	0.071	0.433	0.103
N	2529	2529	1301	2529	1301	2529

Note: The dependent variable is overseas R&D intensity (RDI_S) of Taiwanese MNEs during 2003 to 2006. Time dummies are also included in all regressions but not showing. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses. *P*-value is the *p*-value of the model. Numbers in the Sargan are the *p*-values of Sargan test. *N* is number of observations.
Source: Numbers are computed based on the data in ASTM.

grew at a fast rate in our sample period. The negative coefficient could indicate the fact that R&D expenditure grew at a slower rate than the value of production. The coefficient of *FDI_S* becomes insignificant when it is an endogenous variable. The insignificant and negative coefficients of *FDI_S* from the GMM system estimation together show that using MNEs' overseas

Table 5. Overseas R&D shares.

			Difference GMM	System GMM	Difference GMM	System GMM
	Within-Group	OLS	FDI_S is Predetermined		FDI_S is Endogenous	
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
RDE_S_{t-1}	−0.104***	0.518***	0.226***	0.469***	0.200**	0.447***
	(0.026)	(0.017)	(0.072)	(0.047)	(0.079)	(0.055)
FDI_S_t	0.277***	0.362***	0.221*	0.314***	0.385**	0.552***
	(0.024)	(0.017)	(0.130)	(0.047)	(0.192)	(0.148)
FDI_S_{t-1}	0.005	−0.086***	−0.023	−0.026	−0.068	−0.126*
	(0.025)	(0.019)	(0.052)	(0.048)	(0.068)	(0.073)
PAR_P_t	−0.018	−0.020**	−0.04	0.02	−0.042	0.023
	(0.013)	(0.010)	(0.057)	(0.023)	(0.061)	(0.026)
PAR_P_{t-1}	−0.013	−0.005	−0.086	−0.211**	−0.072	−0.235**
	(0.012)	(0.010)	(0.146)	(0.087)	(0.157)	(0.099)
SAL_L_t	0.039**	0.002	0.165***	0.040	0.189***	0.054**
	(0.016)	(0.012)	(0.050)	(0.025)	(0.056)	(0.027)
SAL_L_{t-1}	0.006	−0.027**	0.050*	0.008	0.057**	0.006
	(0.016)	(0.012)	(0.026)	(0.024)	(0.028)	(0.026)
SAL_P_t	0.021	−0.001	0.125*	0.036	0.160**	0.074*
	(0.022)	(0.016)	(0.066)	(0.034)	(0.075)	(0.038)
SAL_P_{t-1}	0.028	0.006	0.064	0.065**	0.077*	0.078**
	(0.020)	(0.016)	(0.040)	(0.032)	(0.044)	(0.035)
RDI_D_t	−7.061***	−6.637***	−5.351	−4.423**	−3.79	−3.585
	(0.360)	(0.255)	(3.542)	(2.163)	(3.963)	(2.757)
RDI_D_{t-1}	0.092	4.347***	−0.121	2.495**	−0.562	2.444**
	(0.403)	(0.273)	(1.270)	(1.074)	(1.382)	(1.244)
Dind_Mach	−6.784*	1.254	−11.989**	0.454	−12.700**	0.396
	(4.044)	(1.489)	(5.353)	(1.755)	(5.652)	(1.986)
Dind_Elec	−5.627	1.112	−8.228	1.795	−9.186	0.820
	(4.147)	(1.374)	(5.798)	(2.598)	(6.144)	(3.123)
Dind_Chem	−7.209**	−0.266	−9.596**	−1.034	−9.911**	−1.491
	(3.517)	(1.541)	(4.507)	(1.749)	(4.739)	(1.946)
Dcon_CHN	4.312*	2.868**	6.180*	1.072	6.036*	−0.586
	(2.507)	(1.306)	(3.161)	(1.309)	(3.318)	(1.618)
Dcon_ADV	5.152*	3.574**	7.160**	2.817	7.161*	1.882
	(2.930)	(1.622)	(3.604)	(1.952)	(3.782)	(2.190)
constant	12.712***	−0.512	0.000	1.347	0.000	−3.380
	(4.249)	(1.855)	0.000	(3.765)	0.000	(5.002)
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Sargan			0.525	0.129	0.57	0.288
N	2529	2529	1301	2529	1301	2529

Note: The dependent variable is oversea R&D offshoring share (RDE_S) of Taiwanese MNEs during 2003 to 2006. Time dummies are also included in all regressions but not showing. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses. *P*-value is the *p*-value of the model. Numbers in the Sargan are the *p*-values of Sargan test. *N* is number of observations.
Source: Numbers are computed based on the data in ASTM.

production and R&D intensity as major variables to examine the main proposition in Gersbach and Schmutzler (2011) may not be appropriate.

The influence of parent markets and the importation of parts from parents in R&D offshoring were insignificant in our sample. However, the results in Table 4 demonstrate that MNEs' sales to local markets significantly increased their R&D offshoring. The positive coefficient of *SAL_L* confirms our expectation that the demand in local markets promotes multinationals' R&D offshoring when they conduct horizontal FDI.[25] The other explanatory variables, such as *RDI_D*, and the dummy variables are not significant.

Table 5 tells a similar but slightly different story from that in Table 4. The coefficients of the lagged dependent variable are significant and fall in the efficient range [−0.104, 0.518]. System GMM still provides a more efficient estimation. *FDI_S*, however, is positive and statistically significant, regardless of whether it is treated as predetermined or endogenous. FDI, in relation to the share of the value of the shipment from subsidiaries, leads the relocation of R&D activities in terms of increasing the share of R&D expenditure in subsidiaries. Our results support one of the major findings in Gersbach and Schmutzler (2011).

Regarding intra-firm trade, the results in Table 5 illustrate that while importing intermediate products from parent firms has no significant effect on *RDE_S* from the market targeting view, sales to local markets have a positive effect on *RDI_S* if *FDI_S* is set as an endogenous variable. The effect of Taiwanese markets on R&D offshoring is not very significant. Therefore, based on our results, the type of FDI affecting R&D offshoring in Taiwanese multinationals during 2003 to 2006 was primarily horizontal in nature. The share of R&D expenditure in subsidiaries may be a substitute for R&D intensity in the home country. The coefficient of RDI_D_t is negative when *FDI_S* is a predetermined variable. Finally, the country dummy for both *Dcon_CHN* and *Dcon_ADV* is insignificant when system GMM is employed. The *RDE_D* and industrial dummy variables have no significant relationship with *RDE_S*.[26]

VI. Conclusion

Although the determinants of R&D offshoring have been assessed in many previous studies, less attention has been paid to the role of FDI. Previous research assumes that MNEs' decisions to engage in FDI and R&D offshoring are sequential, with FDI as the forerunner, followed by R&D offshoring. Based on the argument from the theoretical analysis in Gersbach and Schmutzler (2011), MNEs' decisions to engage in FDI and R&D relocation mutually affect each other. This study empirically investigated the relationship between FDI and R&D offshoring. We approached the issue from the

[25]It is interesting to note how important Chinese markets, which make up 70% to 75% of our data, are to our results. In our unreported results, we perform all GMM regressions on a dataset that excludes all Taiwanese MNEs whose investments are in China. Most of the coefficients in the unreported results are similar to those in Tables 4 and 5, except the coefficients of *SAL_L*, which become insignificant. The results without China as host country are available upon request.

[26]We also replaced the three industrial dummy variables with 33 dummy variables according to the industrial classification used in the ASTM. The results tell the same story: industrial difference does not result in different levels of R&D offshoring and intensity among Taiwanese MNEs.

perspective of FDI type by borrowing from both market targeting and intra-firm trade to capture the phenomena of vertical and horizontal FDI. In order to deal with the endogeneity of FDI and the persistence of R&D offshoring data, we employed a dynamic GMM panel data model. The data consisted of survey data on Taiwanese MNEs, which provided us with a close look at this issue in relation to the world's greatest FDI recipient, China.

We selected two variables to capture R&D offshoring. In addition to the R&D intensity of subsidiaries, we also included the R&D share in subsidiaries, which was measured as the ratio of the R&D expenditure share in subsidiaries to the MNE's total R&D expenditure, as one of the dependent variables. Our results first indicate that R&D share and intensity in subsidiaries' data are persistent. Second, the FDI intensity in subsidiaries had a positive relationship with their R&D offshoring, measured as a share of R&D, indicating that FDI and R&D offshoring decisions (allocation) mutually affect each other among Taiwanese MNEs. We, thus, supported Gersbach and Schmutzler's (2011) argument. Third, market targeting is important. While horizontal FDI targeting local markets (host countries) increased R&D offshoring, we did not find evidence demonstrating that vertical FDI targeting home markets (source country) matters in R&D offshoring.

Our results provide further support for incentive policies that help host countries attract FDI. The benefit of getting MNEs' production on board is greater than that of increasing GDP and employment. It also includes R&D units and technology coming from MNEs in the future. The importance of market size was again proven. Even more importantly, exporting products back to MNEs' home markets also increased their R&D expenditure in their affiliates.

The major limitation of this study is the very short time period panel data we employ. A future study with a longer time period would provide a robust check of or support for our results. Another future work should explore the effect of the time-varying host country variables, such as the host country's market size and intellectual property rights (IPR) protection, on R&D offshoring.[27] Based on recent studies of global value chains, the outsourcing vs. integration decision of MNEs depends on many economic characteristics of host countries. Market size, for example, is one of the main advantages of developing countries as they compete with advanced countries to receive FDI and the global R&D stock. Determining which type of multinational firm is willing to invest R&D in its subsidiaries due to the potential revenue from sales in local markets increases the efficiency of such fiscal or tariff incentives.

[27]We have also done GMM regression analyses with IPR as one of our regressors. Since some regions (Central and South America, Western Europe, Eastern Europe, Other South Asian Countries, Australia and New Zealand, and Rest of the World) have no IPR data, we exclude them from our data. The results show that IPR has no significant impact on *RDI_S* and *RDE_S*. The results are available upon request. A future study able to consider regional IPR could provide a complete analysis of this topic.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Antràs, Pol, and Davin Chor. 2013. "Organizing the Global Value Chain." *Econometrica* 81 (6):2127–2204. doi:10.3982/ECTA10813.

Arellano, Manuel, and Olympia Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics* 68 (1):29–51. doi:10.1016/0304-4076(94)01642-D.

Arellano, Manuel, and Stephen Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58 (2):277–297. doi:10.2307/2297968.

Arvanitis, Spyros, and Heinz Hollenstein. 2006. "Determinants of Swiss Firms' R&D Activities at Foreign Locations: An Empirical Analysis Based on Firm-Level Data." Zurich, Switzerland: Swiss Institute for Business Cycle Research (KOF), Working Paper (127).

Baldwin, Richard, and Anthony J Venables. 2013. "Spiders and Snakes: Offshoring and Agglomeration in the Global Economy." *Journal of International Economics* 90 (2):245–254. doi:10.1016/j.jinteco.2013.02.005.

Bardhan, Ashok Deo, and Dwight M Jaffee. 2005, "Innovation, R&D and Offshoring." *Fisher Center for Real Estate & Urban Economics*, UC Berkeley, CA.

Blonigen, Bruce A, and Jeremy Piger. 2014. "Determinants of Foreign Direct Investment." *Canadian Journal of Economics/Revue Canadienne D'économique* 47 (3):775–812. doi:10.1111/caje.12091.

Blundell, Richard, and Stephen Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87 (1):115–143. doi:10.1016/S0304-4076(98)00009-8.

Blundell, Richard, and Stephen Bond. 2000. "GMM Estimation with Persistent Panel Data: An Application to Production Functions." *Econometric Reviews* 19 (3):321–340. doi:10.1080/07474930008800475.

Bond, Stephen R. 2002. "Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice." *Portuguese Economic Journal* 1 (2):141–162. doi:10.1007/s10258-002-0009-9.

Brancati, E., R. Brancati, and A. Maresca. 2017. "Global Value Chains, Innovation and Performance: Firm-level Evidence from The Great Recession." *Journal Of Economic Geography* 17 (5):1039–1073. doi:10.1093/jeg/lbx003.

Cassiman, Bruno, and Reinhilde Veugelers. 1998. "R&D Cooperation and Spillovers: Some Empirical Evidence." *Universitat Pompeu Fabra Economics WP* (328).

Criscuolo, Chiara, Jonathan E Haskel, and Matthew J Slaughter. 2010. "Global Engagement and the Innovation Activities of Firms." *International Journal of Industrial Organization* 28 (2):191–202. doi:10.1016/j.ijindorg.2009.07.012.

D'Agostino, Lorena M, Keld Laursen, and Grazia D Santangelo. 2013. "The Impact of R&D Offshoring on the Home Knowledge Production of OECD Investing Regions." *Journal of Economic Geography* 13 (1):145–175. doi:10.1093/jeg/lbs012.

García-Vega, María, and Elena Huergo. 2011. "Determinants of International R&D Outsourcing: The Role of Trade." *Review of Development Economics* 15 (1):93–107. doi:10.1111/j.1467-9361.2010.00595.x.

Gersbach, Hans, and Armin Schmutzler. 2011. "Foreign Direct Investment and R&D-offshoring." *Oxford Economic Papers* 63 (1):134–157. doi:10.1093/oep/gpq024.

Hanson, Gordon H, Raymond J Mataloni Jr, and Matthew J Slaughter. 2005. "Vertical Production Networks in Multinational Firms." *Review of Economics and Statistics* 87 (4):664–678. doi:10.1162/003465305775098080.

Helpman, Elhanan, Marc J Melitz, and Stephen R Yeaple. 2004. "Export versus FDI with Heterogeneous Firms." *American Economic Review* 94 (1):300–316. doi:10.1257/000282804322970814.

Hemphill, Thomas A. 2005. "US Offshore Outsourcing of R&D: Accommodating Firm and National Competitiveness Perspectives." *Innovation* 7 (4):351–356. doi:10.5172/impp.2005.7.4.351.

Holtz-Eakin, Douglas, Whitney Newey, and Harvey S. Rosen. 1988. "Estimating Vector Autoregressions with Panel Data." *Econometrica* 56 (6):1371–1395. doi:10.2307/1913103.

Kotabe, Masaaki. 1990. "The Relationship between Offshore Sourcing and Innovativeness of US Multinational Firms: An Empirical Investigation." *Journal of International Business Studies* 21:623–638. doi:10.1057/palgrave.jibs.8490344.

Lewin, Arie Y, Silvia Massini, and Carine Peeters. 2009. "Why are Companies Offshoring Innovation? the Emerging Global Race for Talent." *Journal of International Business Studies* 40 (6):901–925. doi:10.1057/jibs.2008.92.

Madsen, Jakob B. 2007. "Technology Spillover through Trade and TFP Convergence: 135 Years of Evidence for the OECD Countries." *Journal of International Economics* 72 (2):464–480. doi:10.1016/j.jinteco.2006.12.001.

Manning, Stephan, Silvia Massini, and Arie Y Lewin. 2008. "A Dynamic Perspective on Next-Generation Offshoring: The Global Sourcing of Science and Engineering Talent." *Academy of Management Perspectives* 22:3.

Mudambi, Ram. 2008. "Location, Control and Innovation in Knowledge-Intensive Industries." *Journal of Economic Geography*, 8(5), 699–725.

Ramondo, N., V. Rappoport, and K. J. Ruhl. 2016. "Intrafirm Trade and Vertical Fragmentation in Us Multinational Corporations." *Journal Of International Economics* 98: 51–59. doi:10.1016/j.jinteco.2015.08.002

Shackelford, Brandon, and Raymond M. Wolfe. 2017. "U.S. Companies Performed $73 Billion in R&D outside the United States in 2013." InfoBrief. https://www.nsf.gov/statistics/2017/nsf17317/

Teece, David J. 1988. "Capturing Value from Technological Innovation: Integration, Strategic Partnering, and Licensing Decisions." *Interfaces* 18 (3):46–61. doi:10.1287/inte.18.3.46.

UNCTAD. 2005. *World Investment Report*. New York and Geneva: UNCTAD.

Verspagen, Bart, and Wilfred Schoenmakers. 2004. "The Spatial Dimension of Patenting by Multinational Firms in Europe." *Journal of Economic Geography* 4 (1):23–42. doi:10.1093/jeg/4.1.23.

Yang, Chih-Hai, Yi-Yin Wu, and Hui-Lin Lin. 2010. "Outward Investment to China and Local Innovation of Taiwanese Manufacturing Firms." *Japanese Economic Review* 61 (4):538–557. doi:10.1111/j.1468-5876.2009.00498.x.

Yeaple, Stephen Ross. 2003a. "The Complex Integration Strategies of Multinationals and Cross Country Dependencies in the Structure of Foreign Direct Investment." *Journal of International Economics* 60 (2):293–314. doi:10.1016/S0022-1996(02)00051-X.

Yeaple, Stephen Ross. 2003b. "The Role of Skill Endowments in the Structure of US Outward Foreign Direct Investment." *Review of Economics and Statistics* 85 (3):726–734. doi:10.1162/003465303322369849.