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R&D spillovers from Foreign Direct Investment (FDI): The role of firm-level heterogeneity

Yoo Jung Ha[1]

Axèle Giroud[2]

Abstract

Empirical studies about spillovers from foreign direct investment (FDI) have not fully addressed how spillovers are generated on the sender's side and how those are learned on the recipient's. Using the knowledge-based view and the relational view, this paper investigates firm-level factors of FDI spillovers. In conjunction with up-to-date trends in multinational enterprise (MNE) strategy as illustrated in the business network model, this paper examines the case of spillovers arising from innovation-intensive activities of MNE subsidiaries in the host country or, specifically, R&D spillovers from FDI. Our empirical results confirm the evidence of positive backward R&D spillovers from MNE subsidiaries in the downstream industry and forward ones in the upstream industry. A competence-creating (CC) subsidiary of the MNE is found to have a stronger impact on local firms than a competence-exploiting (CE) one. Backward R&D spillovers from CC subsidiaries are generated when mediated by local firm's relative absorptive capacity.

Keywords

Knowledge spillovers, MNEs and local economic development, IB theory, Knowledge-based view, Relational view, Absorptive capacity

[1] Doctoral programme member, Manchester Business School, University of Manchester, UK.
[2] Senior lecturer, Manchester Business School, University of Manchester, UK.

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1. Introduction

Spillovers from foreign direct investment (FDI) are one type of externalities which arise from activities of foreign subsidiaries of multinational enterprises (MNEs). For host countries, FDI spilloves are one source of increasing rates of return and a way to gain access to advanced foreign technology. For MNE managers, FDI spillovers indicate the extent to which MNE strategies alter external market environments in the host country (Chang & Xu, 2008).

Despite the prominence of the issue, empirical studies have not fully addressed how spillovers are generated on the sender's side and how they are learned on the recipient's. Instead, the current conceptual model tends to rely on the assumption about firm homogeneity, leaving within-firm factors in the black-box. In fast-moving international business, the omission of firm-level factors entails empirical and theoretical gaps. The first gap is related to the failure to observer decentralised innovation within the MNE structure and the emerging role of subsidiaries in the corporate competence development (Le Bas and Sierra 2001; Birkinshaw and Hood, 1996; Andersson et al. 2001a, 2001b; Holm and Sharma 2005). The second gap is related to inability to explain performance differentials within an industry, both from the perspective of firm-level and dyadic learning, in place of the industry-structural analysis (Dyer & Singh, 1998).

Therefore the objective of this paper is to investigate firm-level factors in FDI spillovers, by combining the international business and strategy literature with that of FDI spillovers. In conjunction with up-to-date trends in MNE strategy as illustrated in the business network model of the MNE, this paper examines the case of spillovers arising from innovation-intensive activities of MNE subsidiaries in the host country or, namely, R&D spillovers from FDI. We will differentiate R&D spillovers by the role of subsidiaries in the MNE knowledge network, i.e. competence-creating (CC) subsidiaries and competence-exploiting (CE) subsidiaries and also by types of industrial linkages. Furthermore, this paper extends the two theoretical foundations of the business network model, which are the knowledge-based and the relational views of the firm, to redefine the local firm-side factors of FDI spillovers. It will be suggested that the local firm's relative absorptive capacity for dyadic-level organisational learning is the mediator of R&D spillovers, as well as conventional absolute absorptive capacity.

Firm-level factors are often defined in qualitative terms, and conventional economic data do not measure them. Alternatively, this paper uses the Korean Innovation Survey (KIS) data, gathered under the direction of the OECD's Oslo manual. This unique data allows us to use perceptual measurements adopted from the innovation survey data in combination with conventional economic data. By doing so, we can incorporate such qualitative variables as R&D spillovers from CC, CE subsidiaries and firm's network capabilities into the existing economic model.

The remainder of the paper is divided into several sections. The next section will introduce previous literature and theoretical foundations to propose for FDI spillover mechanisms, on both the MNE subsidiary and the local firm side. The hypothesis development section will be followed by the methodology section where we will describe variable specification and measurement issues in detail. Finally, empirical findings will be presented, along with further discussion on new findings, contributions and limitations, and suggestions for future studies.

2. Previous studies and theoretical foundations

2.1. FDI spillovers

FDI spillovers can be practically defined as the aggregate effects of activities by foreign-owned firms or foreign subsidiaries of MNEs on local firms of the host country (Buckley, Clegg, Wang, & Wang, 2009: 5). From the development economics perspective, FDI spillovers are particularly significant for economic growth. One economic agent's investment affects not only its own output but also others' output production, so as to result in undiminished rates of return (Griliches, 1992: 530). Two assumptions place FDI into the context of this general spillover enquiry. Firstly, MNEs have firm-specific technological assets superior to that of domestically oriented firms in the host country as noted in various conceptual and empirical studies (Griffith, 1999). Secondly, MNEs cannot capture all rents arising from its productive activities in the host country (Caves, 1974: 176). As a result, FDI spillovers take place through competition, demonstration and imitation and labour turnover.[3]

[3] Firstly, foreign entry is expected to introduce market competition in the host country market. The presence of the foreign investor creates new markets and motivates innovation and imitation by local firms. The greater market competition also reduces prices of inputs and thereby improves productivity of customer firms, through inter-industry linkages (Griliches, 1992). Secondly, foreign presence comes with the demonstration of non-technological ownership advantages such as managerial practices as well as product technologies (Castellani & Zanfei, 2006; Driffield, 2001) By introducing new technologies, foreign subsidiaries testify that a new production technology is feasible in the host country. This relieves the uncertainty of new innovation and reduces the risk with regard to the acquisition of unknown technology (Crespo & Fontura, 2007: 411) Demonstration effects are likely to

Empirical studies about FDI spillovers, nevertheless, do not always predict positive spillovers. Many studies have shown that baseline models, which present the unmediated association between foreign presence and local firms' performance, tend to report no effect (Marin, 2006). One explanation of inconsistent effect is related to the presence of negative spillovers that cancel out positive effects. The negative spillovers from FDI can be manifold. MNE subsidiaries may squeeze market shares of the existing local firm, thus preventing weak local firms from raising efficiency to the extent that they regain market shares (Aitken & Harisson, 1999; Hu & Jefferson, 2002; Kathuria, 2000; Konings, 2001). Sometimes foreign investors can hoard skilled workers who are in short supply in the local market (Aitken & Harisson, 1999; Lipsey & Sjöholm, 2005).

Given the co-existence of positive and negative spillovers, it is important to correctly specify conditions in which positive and negative effects can be disentangled. One way is to consider inter-industry FDI spillovers in contrast with those of intra-industry FDI (Blalock & Gertler, 2008; Driffield, Munday, & Roberts, 2002; Javorcik, 2004; Marcin, 2008). A number of empirical studies have confirmed that positive effects are maximised in inter-industry linkages, while negative effects supersede positive effects in inter-firm relations within the same industry (Castellani & Zanfei, 2006; Pack & Saggi, 2001). Still, this model faces a methodological challenge. A complete model has to address both the nature of the shock and the conditions in the recipient side (in this case, local firms) and otherwise the model will overestimate the power of recipient-side factors and undermine the actual significance of the shock (Hays & Franzese, 2007). Those econometric issues are underpinned by the more fundamental conceptual deficiency that the model does not properly un-box within-firm and inter-firm dynamics. We will elaborate this point in the following section.

2.2. Knowledge-based view, relational view of the firm

This paper proposes revisiting the FDI spillovers mechanism by elaborating the firm-level perspective. On Caves' (1974) own admission, the FDI spillover model resides in a restrictive assumption about firm homogeneity. The lack of the firm-level perspective on the local firm side is associated with the following epistemological grounds with respect to technology and innovation: innovation and technology are understood restrictively as codifiable, explicit

benefit host country firms which are small-sized, less export-oriented and those with low-level technological capability (Brambilla, Hale, & Long, 2009) Finally, new knowledge can be introduced to the host country by employing former personnel of MNEs as well as reverse engineering (Mansfield & Romeo, 1980) There are studies confirming local firms' gain from the presence of MNE subsidiaries in the same market (Chang & Xu, 2008; Haskel, Pereira, & Slaughter, 2007; Keller & Yeaple, 2009).

knowledge such as scientific and engineering blueprints (Cantwell, 2001). Firm-specific assets can be mobile within MNE headquarters and overseas subsidiary with no cost (e.g. Horstmann & Markusen, 1989). Such an approach essentially emphasises the role of industry structure, rather than elaborating the conduct of MNE subsidiaries involved in the FDI spillover process. For deeper understanding about the internal working of the MNE and the role of subsidiaries, we may refer to international business theories (Meyer, 2004).

The knowledge-based and the relational views provide the perspectives for international business and strategy theories that can complement the industry-level analysis of FDI spillovers. Firstly, the firm accumulates resources and capabilities as the critical resources specific to the firm (Barney, 1991). This knowledge is rare, valuable, non-substitutable and inimitable (R.V.N.I) and exists in an unstandardised, uncodifiable and tacit form, opposing conventional economics' narrow understanding (Cantwell, 2001). Secondly, firms' search for resources and capabilities takes place beyond the boundary of the firm (Dyer & Singh, 1998). Therefore, a network or inter-organisational ties are part of a firm's strategy in pursuing the critical resources and capabilities (Gulati, Nohria, & Zaheer, 2000). Thirdly, a network is underpinned by network capabilities not specific to any firm. Network capabilities depend on 'generative rules' that govern network formation and represent joint gains of both participants in the network (Kogut, 2000). As we import the new perspective to the economic analysis of FDI spillovers, the following section will specify subsidiary-side, local firm-side factors of FDI spillovers.

2.2.1. Subsidiary-side factors

MNE strategy is increasingly driven by international knowledge sourcing (Chung & Yeaple, 2008; Le Bas & Sierra, 2002) and innovation is decentralised from the home to overseas host countries (Almeida & Phene, 2004; Cantwell, 1995; Frost, 2001; Kuemmerle, 1999; Le Bas & Sierra, 2002). Building on the epistemological shift in the knowledge-based view of the firm and the relational perspective, the business network model of the MNE illustrates that the MNE is a knowledge-creating organisation comprised of a set of subsidiaries, each of which is involved in unique embedded networks in the external environment (Forsgren, Holm, & Johanson, 2005). As a result, the subsidiary emerges as a dynamic unit in the MNE's knowledge creating networks. Based on access and control over network-based resources in the host country, the subsidiary accumulates capabilities over time and nurtures organisational routines to store them (Birkinshaw & Hood, 1998: 780-781).

There are a few ground-breaking studies examining the role of technologically active subsidiary in FDI spillover modelling and thus raising questions about the existing 'pipeline mode'. (Driffield & Love, 2007; Marin & Bell, 2006; Marin & Sasidharan, 2010). In those studies, the role of subsidiary is defined in terms of formal quantitative differences. This approach reflects the earlier proposition that the host country factors are main driving force of MNE distributed innovation network, and that subsidiaries are either asset-augmenting or asset-exploiting depending on their R&D intensity (Kuemmerle, 1999).[4] On the other hand, dynamic evolution of the subsidiary role increasingly results in substantive and qualitative differences among subsidiaries. In Cantwell and Mudambi (2005)'s definition, competence-creating (CC) subsidiaries have mandates related to new product development and new market expansion by drawing on new capabilities, while competence-exploiting subsidiaries (CE) focus on cost reduction and quality improvement by using existing capabilities. Therefore, we suggest a model differentiating R&D spillovers by measuring qualitative differences among MNE subsidiaries.

2.2.2. Local firm-side factors

FDI spillovers can vary as a recipient firm's technological capabilities that mediate the successful manifestation of FDI spillover into the local firm's performance change. Technological capabilities can be observed either on the country and industry levels (Konings, 2001; Lipsey & Sjöholm, 2005; Meyer & Sinani, 2009) or on the individual firm level (Blalock & Gertler, 2009; Dimilis, 2005; Girma, Greenaway, & Wakelin, 2001; Kathuria, 2000; Todo & Miyamoto, 2002). Current models focus on absolute absorptive capacity indicated by internal resources, such as R&D expenditures and human capital, or technology gap.

Nevertheless, from the knowledge-based and the relational views of the firm, the process of absorbing outgoing spillovers in local recipients is a rather dyadic process in contrast with the existing framework focusing on single firm's learning. In this view, absorptive capacity is a relative concept that depends on joint network capabilities and is defined in the inter-organisational dyadic relationships (Kogut & Zander, 1992; Lane & Lubatkin, 1998; Phene & Almeida, 2008). Relative absorptive capacity depends on qualitative differences of two firms' knowledge type and organisational routines in the dyadic context. Therefore, in addition to absolute absorptive capacity, it is suggested to add the local firm's relative absorptive capacity in the inter-organisational relationships as a mediator of FDI spillovers on the local firm side.

2.3. R&D spillovers from FDI

[4] Marin and Sasidharan (2010) defined CC and CE subsidiaries but measured their differences based on R&D intensity and export intensity.

The review of the MNE strategy and the emerging role of the subsidiary brings us to a proposition that subsidiary-level innovation is a source of spillovers. FDI spillovers are dynamic in a subsidiary which has its own strategies to fulfil that role and expand it even further. In a majority of empirical studies, employment, capital investment, sales and export are activities that become the source of FDI spillovers in the host country. Given the increasing importance of decentralising MNE innovation and the role of subsidiaries, this study focuses on subsidiary-level R&D activities as a source of externalities in the host country. Therefore, this paper disengtales R&D spillovers that arise from FDI by MNE subsidiaries. Engaging foreign subsidiary-side factors and redefining local firm-side factors, the following section suggests testable hypotheses.

3. Hypothesis development

3.1. R&D spillovers from FDI

In endogenous growth theory, one firm's R&D expenditures generate R&D spillovers to influence the others' production activities (Griliches, 1992). Previous studies have provided mixed evidence of R&D spillovers from innovation-intensive activities of foreign subsidiaries to host country firms. Such studies can be grouped into two categories, depending on what aspect of performance change is probed: general productivity change or new product development. Studies testing the former often fail to find the evidence of FDI-induced R&D spillovers (Driffield & Love, 2007; Feinberg & Majumdar, 2001; Fu & Gong, 2009; Liu & Buck, 2007; Tian, 2007). On the other hand, Bransetter (2006) and Brambilla et al. (2009) examinined a direct impact on local firms' innovation performance to find the positive impact of foreign presence.

The mixed results in previous studies about R&D spillovers from FDI are probably associated with the fact that most cases represent emerging markets, such as China and India. Data tend to be dated before R&D was decentralised into those countries or the concerned countries have not accumulated technological capabilities to attract MNC subsidiaries with innovation-related mandates. In a technologically capable host country, it is expected that R&D activities of MNC subsidiaries will benefit the local firm through R&D spillovers from FDI.

H1: Local firms' performance is positively associated with the presence of innovation-intensive FDI by MNE subsidiaries.

3.2. Industry linkages

It has been assumed that spillovers through vertical input-output linkages involve technology transfer as well as influencing economies of scale and other quantity-side effects (Alfaro & Rodríguez-Clare, 2004; Driffield, et al., 2002; Pack & Saggi, 2001). The significance of vertical spillovers with regard to technological spillovers has been widely supported in comparison with horizontal spillovers (Javorcik, 2004; Kugler, 2006; Marcin, 2008). It is because inter-industry channels are where researchers can disentangle negative competition effects from positive effects that the evidence of positive FDI spillovers is more likely to be observed than through intra-industry interactions. Nevertheless, many studies tend to draw conclusions based on positive competition effects between vertically integrated parties, rather than investigating potential knowledge flows that transactional linkages accompany. To test the role of industry linkage with regard to R&D spillovers, this paper examines transactional linkages between R&D-intensive foreign sectors and associated local firms.

H2a: Local firms' performance is positively associated with the presence of downstream FDI with high innovation intensity.
H2b: Local firms' performance is positively associated with the presence of upstream FDI with high innovation intensity.

3.3. Role of subsidiary

Not all FDI is the same. A firm can be involved in dynamic strategic renewal either by creating new knowledge (exploration) or by simply using existing knowledge (exploitation) (Danneels, 2002; Easterby-Smith & Prieto, 2008: 239; March, 1991).

The subsidiary's innovation mandate influences the type of external network relationships and technology, which are two factors influencing the transferability of technology to local firms (Spencer, 2008). Competence-creating FDI not only replicates codified knowledge of the MNE HQ but also creates new knowledge based on technological resources in the host country. For MNE subsidiaries, the successful learning from local knowledge sources depends on ability to source, assimilate, and combine knowledge (Phene & Almeida, 2008). Therefore, it can be argued that a competence-creating subsidiary's inter-organisational ties will be governed in a way that narrows technological distance in between foreign and local firms. Those competence-creating subsidiaries have to renew organisational routines locally to store new resources and capabilities (Birkinshaw & Hood, 1998), and this is through such efforts as employee training and labour turnover (Spencer, 2008). This indicates greater chance to transfer tacit components of knowledge to local firms. For those reasons, competence-creating type of activities is expected to generate knowledge stocks more beneficial to the host country context than competence-exploiting FDI.

H3a: Local firm's performance is positively associated with R&D activities by competence-creating MNE subsidiaries.
H3b: R&D activities by competence-creating MNE subsidiaries have a stronger impact on local firms' performance than those by competence-exploiting MNE subsidiaries.

3.4. Local firm' relative absorptive capacity

The diverse aspects of crowding-out effects have been discussed and tested across a wide body of literature. Whether or not negative effects overweigh positive effects partly depends on the characteristics of local firms (Castellani & Zanfei, 2006). Hu and Jefferson (2002) reported that the negative competitive effects decline over time as local firms accumulate capabilities to catch up. So far, empirical tests have measured local firm-specific factors through size (Keller & Yeaple, 2009), R&D investment, human resources and productivity gap (Blalock & Gertler, 2009) and intangible capital, human resources and investment (Sinani & Meyer, 2004). While those indicators do not fully reflect the first-order conditions for successful R&D with regard to organisational learning, each considers absorptive capacity, which is defined as 'the ability to recognise the value of new information, assimilate it, and apply to commercial ends' (Cohen & Levinthal, 1990). Additionally, absorptive capacity can be relative (Lane & Lubatkin, 1998). Empirical studies confirmed that relative absorptive capacity is essential for the MNC's international knowledge regarding sourcing, therefore it requires skills related to assimilating and combining new external knowledge with existing internal knowledge (Kogut and Zander, 1992; Phene and Almeida, 2008).

H4: The increase in local firms' performance as a result of FDI spillovers is positively related to local firms' relative absorptive capacity.

4. Methodology

4.1. Data

The empirical literature on FDI spillovers uses one of three types of methodology: qualitative case analysis, quantitative analysis of cross-section survey and econometric analysis based on secondary panel or pooled cross-section data (Pack, 2006). This research finds that econometric analysis based on secondary data is suitable for addressing the current research question.

** Table 1 is about here **

Our data come originally from the Korean Innovation Survey, provided by the Science and Technology Policy Institute (STEPI) in Korea. The Oslo Manual of the OECD directs national innovation surveys. KIS is equivalent to CIS by the EU and both are directed by the OECD's Oslo manual. From the data, our data set is made up from 439 firms in the manufacturing sector and contains two observations for each unit of firms throughout the two waves of survey conducted years 2002 and 2005,

Foreign subsidiaries are defined as those where the foreign capital participation ratio is higher than 20%. This follows other studies (Haskel, et al., 2007; Marin & Bell, 2006). Industry-level foreign presence is calculated as the ratio of R&D expenditure in foreign subsidiaries in the industry, which is identified as the two-digit NACE industry classification.

** Table 2 is about here **

4.2. Dependent variable

This paper takes innovation performance of a local firm as the dependent variable. This variable is measured by the number of product patents a firm applied for over the three-year period prior to the survey. Using the three-year cumulative innovation output, we can reduce a bias of taking one year without controlling for year-specific effects. Alternatively, a firm's innovation output can be measured by the ratio of new products in a firm's sales, as seen in previous papers focusing on commercially successful innovation. This paper opts to use patent data, because these embody technological success. Other studies which measured patents as the source of spillovers and firm's innovation performance include Brandsetter (2006) and Crisculous et al. (2007), among many others.

4.3. Independent variables

4.3.1. R&D spillovers from FDI

Our key independent variable is R&D spillovers from FDI. According to the definition shared in the literature (Buckley, et al., 2009), this is measured by the foreign presence indicator and is estimated from the raw data of all respondents in KIS data. R&D spillovers that explain the three-year cumulative innovation performance of local firms is measured based on R&D expenditures of MNE subsidiaries in the final year of each three-year period, as we assume that the final year represents subsidiaries' three-year R&D activities. For instance, for the 2002-2005 data, the industry-level foreign presence or the effect of R&D spillovers from horizontal FDI is calculated from each cross-section data of years 2002 and 2005. By doing so, we observe the contemporaneous effect of R&D spillovers, rather than the lagged effect.

R&D spillovers from horizontal FDI are defined as the share of 'i^{th}' foreign subsidiaries in the total R&D expenditures by all 'i^{th}' foreign and 'h^{th}' local firms in the 'j^{th}' industry. Therefore,

$$HorizontalFDIj = \sum_{i \in j} RDExp_i^{FSUB} \Big/ \sum_{i,h \in j} RDExp_{i,h}$$

In addition to horizontal R&D spillovers, we also examine R&D spillovers through industry linkages generated by downstream or upstream FDI. Industry linkages can be computed from the input output table of South Korea, as provided in OECD's statistical database (http://stats.oecd.org/). Information is available for the year 2000 and 2005 and is the two-digit NACE industry classification. Building on previous studies (Blalock & Gertler, 2008; Javorcik, 2004), backward industry linkages are measured as outputs sold to buyers in downstream industries as a proportion of total output of the industry. Forward linkages are measured as inputs purchased from upstream suppliers as a proportion of total input purchase of the industry.

Downstream FDI for the 'jth' industry is about the foreign presence in the 'kth' sectors for which sector j is supplying intermediate inputs (Blalock & Gertler, 2008). The downstream FDI index is obtained by multiplying the backward linkages (between the sector with foreign presence and that of the local firm) with the equivalent horizontal foreign R&D ratio of the concerned downstream foreign sector.

$$DownstreamFDI_j = \sum_{k,k \neq j} BL_{jk} \cdot HorizontalFDI_k$$

Upstream FDI for the sector j is about foreign presence in the 'lth' sectors from which sector j is purchasing intermediate inputs (Javorcik, 2004). Upstream FDI index is the multiplication of the equivalent horizontal FDI ratio of the concerned upstream sector and forward linkages between the foreign upstream sector and that of the local firm.

$$UpstreamFDI_j = \sum_{l,l \neq j} FL_{jl} \cdot HorizontalFDI_l$$

4.3.2. R&D spillovers from CC and CE subsidiaries

We also decompose R&D spillovers from horizontal, downstream and upstream FDI into those arising from competence-creating FDI (or CC FDI) and competence-exploiting FDI (or CE FDI). To begin with, horizontal CC FDI (CE FDI) is computed as the share of R&D expenditures by CC subsidiaries (CE subsidiaries) within the industry. In the computation process, type dummy variables are used to extract relevant subsidiaries, as shown below.

$$HorizontalFDI_{j,type} = \sum_{i \in j} RDExp_i^{FSUB} \cdot Typedummy \bigg/ \sum_{i,h \in j} RDExp_{i,h}$$

R&D spillovers from CC FDI (CE FDI) in the downstream and upstream are then computed as the ratio of R&D by FDI type in the same sector, upstream or downstream industry of the local firm.

The types of subsidiary are identified by means of the factor analysis and this is base on firms' responses to the question asking about the perceptual importance of ten innovation initiatives. The rotation method used is Varimax with Kaiser normalisation. As a result, SPSS extracted two latent components, which account for 84.0% of total variances (Table 3).

** Table 3 is about here **

Component 1 is named 'competence-exploiting innovation' or CE, as it related to activities based on existing capabilities, such as cost reduction, improvement of existing products and adjustment to changing external environments in the current markets. Component 2 is named 'competence-creating innovation' or CC, as it requires exploration of new capabilities, with the aim of new product development and entry to new markets. The factor analysis not only identifies what types of innovation-intensive FDIs are under way in South Korea but also provides factors scores. We identify that the subsidiary is involved in CC FDI if the firm's assigned factor score is higher than the median score in the sample. Similarly, the firm is identified as the source of CE FDI if the firm's factor score is higher than the median score. This measurement rules out that a firm is exclusively involved in either CC FDI or CE FDI. If a firm earns scores higher than the median scores in both categories, it will be regarded as having an equally high number of projects concerning both activities.

4.3.3. Relative absorptive capacity

In the related studies, relative absorptive capacity is measured by technological fit among associated partners (Dyer & Singh, 1998; Phene & Almeida, 2008). Alternatively, we can use a firm's experience as a proxy (Kale, Dyer, & Singh, 2002). Likewise, we measure relative absorptive capacity with the significance of network-based knowledge for local firm's innovation. The rationale is that the past experience of identifying, utilising and commercially benefiting from network-based knowledge indicates that the local firm has relative absorptive capacity to learn by assimilating internal resources with foreign resources and adjust its organisational routines. Three knowledge sources are considered: knowledge from relationships with competitors (network 1), with customers in the downstream industry (network 2) and with part suppliers in the upstream industry (network 3). This proxy for relative absorptive capacity is measured on the Likert scale from zero (no use of the knowledge source) to five (very important).

4.4. Model and estimation method

This baseline model for a domestic firm's performance change is adopted from an augmented knowledge production function. Following Crespi et al. (2007), this baseline model assumes that innovation performance is determined by internal resources represented by R&D expenditures and R&D staff of a local firm and external resources represented by residuals. Those two indicators are also commonly used in other empirical studies as indicators of absorptive capacity of the local firm.

We test this model with the multilevel modelling. Our data suffice multilevel modelling. In the multilevel analysis, it is desirable to have around 20 units of groups in the higher-level clusters, while the size of each cluster could be any (Rabe-Hesketh & Sktrondal, 2009: 62). Level 2 consists of individual firms which are equivalent to clusters in the general multilevel setting. For Level 1 we have observations of each unit, which are akin to repeated observations taken from two experiments. Three-year time gap between the two waves of the survey can allow enough variance within the group.

Among a few available multilevel modelling methods, we choose the random effects model. This model is summarised in most textbooks as follows:

$$yij = \beta Xij + \zeta j + \varepsilon\ ij$$

i is for Level 2 (i.e. a firm as its own cluster) and j is for Level 1 (i.e. each observation).ζj is called as the random intercept. This has a normal distribution $\zeta j \rightarrow N\ (0, \varphi)$ and this accounts for the cluster j's random deviation from the overall mean.[5]

Lastly, as our dependent variable is the count data, we use STATA command concerning the random-intercept negative binomial model. Heteroscedasticity is treated with the bootstrap option. Our dependent variable includes a number of zeros. STATA does not handle the zero-

[5] Introduction of the random intercept is underlined by the view that the cluster i is sampled from the population clusters. In addition to the random intercept, we can also introduce the random slope coefficients βs in the above model. By comparing the goodness-of-fit of random intercept and random coefficients models by virtue of Akaike Information Criterion (AIC), we conclude that the random intercept model better fits the our sample than the alternative random coefficients model.

inflation issue in this count data model. Instead, we tested the zero inflated model in the each cross-sectional setting to confirm that estimation results were not different from empirical results which we will discuss in the next section.

5. Empirical findings

5.1. Estimation results

This section starts with the results for the R&D spillovers from FDI. Then the sources of R&D spillovers will be decomposed by types of subsidiary role with regard to innovation, namely, some from competence-creating (CC) FDI and others from R&D spillovers from competence-exploiting (CE) FDI. In addition, each model addresses the extent to which relative absorptive capacity of local firms in the inter-organisational learning context would mediate R&D spillovers from FDI. The findings are summarised in Table 4.

** Table 4 is about here **

Our first model consists of three parts. Firstly, Model 1a tests the effects of R&D spillovers from FDI via three routes: horizontal spillovers from the same sector, forward spillovers from upstream FDI and backward spillovers from downstream FDI. Secondly, Model 1b controls for three types of relative absorptive capacity of the local firm, measured by network 1 with competitors, network 2 with customer firms in the downstream and network 3 with part suppliers in the upstream. The last part is Model 1c where R&D spillovers from FDI are decomposed into the main effect and the effect mediated by a local firm's relative absorptive capacity in the dyad network.

Model 1a finds that the coefficient for R&D spillovers from upstream FDI is statistically significant and positive. Neither of R&D spillovers from horizontal FDI and Backward R&D spillovers from downstream FDI is significant. This finding is different from previous ones emphasising positive and significant backward spillovers rather than either horizontal or forward spillovers. Model 1b shows that the coefficient for network 2 is positive and statistically significant, indicating that a firm which is capable of picking up backward R&D spillovers from downstream customers tends to perform better on average than others. The mediating effect of this network-related capacity in the manifestation process of backward R&D spillovers is tested in Model 1c by means of an interaction term. Its coefficient indicates that local firm's capability to manage network with customers plays a positive mediating role in R&D spillovers from downstream FDI. It is noted that those without such relative absorptive capacity do benefit from R&D spillovers from downstream foreign-owned customers, as reflected in the insignificant coefficient for the pure effect of downstream FDI. This finding suggests backward R&D spillovers from downstream FDI are contingent on network capabilities.

Model 2 tests R&D spillovers arising from the competence-creating activities of subsidiaries. Model 2 consists of three parts with the same structure as the previous Model 1. In Model 2a, horizontal R&D spillovers from FDI by competence-creating subsidiaries (CC FDI) are negative and statistically significant. This indicates that CC FDI can entail crowding-out effects in terms of market demands and perhaps skills, along with positive knowledge spillovers.

Another distinct effect from CC subsidiaries is described in Model 2c, which tests interaction terms between FDI spillovers and concerned absorptive capacity to boost inter-organisational learning. Firstly, the coefficient for the interaction term related to horizontal CC FDI is not statistically significant any more. If we set aside specification issues, this result indicates that negative horizontal R&D spillovers from CC subsidiaries seem to be inconclusive if local firm-side factors are introduced in the model. Model 2c find that positive backward R&D spillovers hold for the local firm which has high relative absorptive capacity. On the other hand, the main effect of backward R&D spillovers is now negative. This shows the presence of downstream CC subsidiaries have a crowding-out effect on the local firm which lack network-related absorptive capacity.

Despite differences in negative horizontal spillovers, Models 2a and 2b report that R&D spillovers from CC subsidiaries share commonality with average R&D spillovers as tested in Model 1b in the following aspects: CC subsidiaries generate strong positive forward R&D spillovers regardless of the local recipient's relative absorptive capacity and have no statistically significant backward R&D spillovers. Model 2b again confirms that the capability for the local firm to learn from networking capability with customers has a positive and statistically significant effect on the local firm's overall performance.

Model 3 is regarding R&D spillovers from CE subsidiaries with the same procedures. The results are identical to Model 1 except for the magnitude of coefficients. This indicates that R&D spillovers from FDI, if we do not distinguish the sources in terms of the subsidiary role, are dominated by R&D spillovers from CE subsidiaries.

Additionally, all models test the result about conventional absorptive capacity, which is included as control variables throughout model estimation. The coefficients for local firm's internal resources for R&D, namely the log of R&D expenditures and the log of R&D-related staff, are positive and statistically significant in all models. This result is consistent with other empirical findings: as in the case of FDI spillovers arising from employment, capital investment, sales and export of MNE subsidiaries, R&D spillovers need absorptive capacity of local firms to materialise as performance change of local firms.

5.2. Discussion

Rounding up those empirical results, we can discuss our hypotheses as follows. Hypothesis 1 about positive horizontal R&D spillovers is not confirmed. Hypothesis 2a about positive backward R&D spillovers is confirmed under the condition that the local firm fulfils relative absorptive capacity for inter-organisational learning. Hypothesis 2b about positive forward R&D spillovers is accepted and this does not require mediating factors on the local firm side. Hypothesis 3a is accepted if we consider forward R&D spillovers and backward R&D spillovers from CC subsidiaries. However, backward spillovers from CC subsidiaries hold only when the local firm fulfils required relative absorptive capacity for inter-organisational learning. Our test results also confirm Hypothesis 3b: the coefficient for the interaction term between downstream FDI and the network variable is 1.030 for CC FDI (Model 2c), compared with 0.792 for CE FDI (Model 3c). Hypothesis 3b also holds for the main effect of forward R&D spillovers, as the coefficient for the main effect of upstream FDI is 5.405 for CC FDI (Model 2c), compared with 2.538 for CE FDI (Model 3c). Finally, our empirical findings indicate that Hypothesis 4 is accepted for the positive mediating role of local firm's relative absorptive capacity in the case of backward R&D spillovers from FDI.

This paper reports a few new findings. Firstly, there are positive R&D spillovers through industry linkages in the presence of innovative MNE subsidiaries. Formerly, studies focused on reverse knowledge flows resulting from localised knowledge sourcing strategies of MNE subsidiaries and assessed the impact on MNE subsidiaries' performance. R&D spillovers arising from those FDI were uncertain. Our study finds that R&D by MNE subsidiaries has positive effects on potential local partners where mutual industrial linkages and meeting network capabilities are fulfilled. Secondly, R&D spillovers from FDI can be greater when there are more CC subsidiaries than CE subsidiaries. Previously, R&D spillover studies rarely differentiated spillovers arising from different subsidiary mandates. It has been discussed that general productivity spillovers vary depending on quantitative differences of MNE subsidiaries, such as R&D and export intensity (Marin & Sasidharan, 2010). Our finding strengths the previous results by showing that CC subsidiaries, due to their mandate and qualitative differences in their activities, are more likely to contribute to local firms through R&D spillovers in particular. Thirdly, our finding suggests positive and negative R&D

spillovers coexist in the vertical linkages and therefore R&D by CC subsidiaries acts as a double-edged sword to local upstream industry. The existing literature has mainly observed positive backward spillovers. This paper shows that CC subsidiaries can generate negative backward spillovers for local firms with weak relative absorptive capacity. This means that those local suppliers can be in a precarious position due to potential negative competition effects among local suppliers due to the entry of foreign customers. Fourthly, this paper proposes that some R&D spillovers can be substantiated only when the local firm's relative absorptive capacity is introduced as a mediator. Existing FDI spillover literature has focused only on absolute absorptive capacity as a local firm-side factor. Overall, by assessing dynamic subsidiary role and local firm's relative absorptive capacity as two factors of R&D spillovers from FDI, this paper demonstrates the combination of two disparate strands of literature on international strategy and management literature and FDI spillovers can enrich our understanding about the dynamic process of FDI spillover generation.

The fact that backward spillovers from downstream CC subsidiaries influence local firms selectively depending on absorptive capacity of the local firm needs further discussion. One hypothesis is that CC subsidiaries would generate positive spillovers for capable local suppliers through formal and informal contacts, but that CC subsidiaries can potentially erode market demands of incapable local part suppliers by introducing competition, either through imports from global suppliers, or through accompanying suppliers from subsidiaries of global suppliers operating in the host country. Also, our data could not fully explain the reason why local customers do not seem to require relative absorptive capacity in collecting R&D spillovers from foreign-owned suppliers. For now, our explanation is that in local vertical integration the customer firm in the upstream conventionally has strong bargaining power that facilitates the collection of spillovers from its part suppliers. These findings draw our attention to the need to understand spillover issues in the context of the interaction between strategies of MNC subsidiaries and informal business environments in the host country industry.

6. Conclusion

Previous studies have contributed to identifying diverse channels of spillovers from FDI. However, empirical results have been rather mixed, partly due to the fact that firm-level factors are not conceptually incorporated into the FDI spillover mechanism. To address the drawback of this firm homogeneity assumption, this paper imported insights from recent development in the theory of the firm and MNC strategies. Building on models suggested in existing studies, this paper tested the factors that arise as a result of MNE's strategic and organisational changes and the examination of internal dynamics within the firm regarding learning. Given the prevalence of decentralised innovation within the MNC structure and the dynamic role of subsidiaries in the corporate competence development, this paper specifically disentangled spillovers arising from R&D activities by MNC subsidiaries or, namely, R&D spillovers from FDI. Then R&D spillovers were further decomposed into some arising from CC subsidiaries and others arising from CE subsidiaries. This paper also examined horizontal, backward and forward R&D spillovers from foreign competitors, customers and part suppliers. This paper went one step further by introducing local firm's relative absorptive capacity as the mediator of R&D spillovers.

Iimplications from empirical findings are threefold. Firstly, the host country government may promote the establishment of competence-creating MNE subsidiaries. Secondly, local firms need to be capable of learning from network relationships as well as accumulating internal resources for innovation. Finally, MNCs are more likely to achieve complementary technological advantages in the host country which has accumulated not only technological capabilities but also experience in inter-organisational learning and appropriate network capabilities.

This paper presents one of the first empirical studies to use the innovation survey data collected under the guidance of OECD's Oslo manual for the FDI spillover analysis. We link two waves of the survey and designed research that suits multilevel data consisting of repeated observations of a firm. In return for the novelty in the variable identification and measurement, the estimation process shows that this data set may not be a perfect substitute for conventional longitudal economic data in that we could not examine the lagged effects and dynamic time effects.

Finally, this paper suggests that further analysis of vertical integration in each industry is required to explain other local firm-side factors that affect the collection of spillovers other than relative absorptive capacity. For instance, bargaining power between buyer and sellers in the local vertical integration may explain the division of 'relational rents' (Dyer and Singh, 1998). This is reserved for future research.

Appendix

Table 1. Original KIS dataset and a multilevel data

	All firms	**Foreign ownership over 20%**
KIS2002	3,775	202
KIS2005	2,744	221

Data based on 439 firms

Table 2. Technology grouping in manufacturing industries

Technology class	NACE code	Classification of manufacturing industries
Low technology	15, 16	Food and beverages, tobacco
	17, 18, 19	Textiles, leather, footwear
	20, 21	Wood, paper, paper products
	22	Furniture
Medium-low technology	26	Non-metallic mineral products
	27, 28	Metals products
Medium-high technology	25	Rubber and plastics products
	29	Machinery and equipment, n.e.c.
	34, 35	Motor vehicles, aircraft and spacecraft
High technology	23, 24	Coke, refined petroleum, chemical industry
	30, 31, 32	Electrical apparatus, computing machines, communications equipment
	33	Medical, precision and optical instruments
Miscellaneous	36	Other manufacturing

Source: Schmiedeberg (2008).

Table 3. Rotated Component Matrix: mandates of foreign subsidiaries

	Component	
	1	2
Work environment improvement	.850	.361
Labour cost reduction	.818	.425
Other production cost reduction	.797	.468
Total institutional change effect	.785	.413
Quality improvement	.741	.559
Flexible production	.738	.460
Total new market initiative effect	.651	.627
Product diversification	.420	.847
New product introduction	.380	.845
Market power expansion	.554	.751

Table 4. R&D spillovers of FDI by subsidiary role and on local firm capacity

	CC subsidiary	CE subsidiary
On local firms with weak relative absorptive capacity	Negative backward spillovers Positive forward spillovers	- Positive forward spillovers
On local firms with strong relative absorptive capacity	Positive backward spillovers -	Positive backward spillovers -

Table 5. Model 1: R&D spillovers from FDI

	Model 1a		Model 1b		Model 1c	
	Coeff.	P>|z|	Coeff.	P>|z|	Coeff.	P>|z|
Log of R&D staff	0.240 (0.101)	0.017 (**)	0.268 (0.104)	0.010 (**)	0.252 (0.101)	0.013 (*)
Log of R&D expenditures	0.186 (0.072)	0.010 (**)	0.180 (0.063)	0.005 (***)	0.183 (0.663)	0.004 (***)
Horizontal FDI	-0.683 (0.597)	0.253	-0.936 (0.607)	0.123	-0.662 (0.744)	0.374
Downstream FDI	1.879 (1.317)	0.154	1.524 (1.285)	0.236	-0.773 (1.559)	0.620
Upstream FDI	1.791 (0.782)	0.022 (**)	2.572 (0.727)	0.000 (***)	2.441 (0.827)	0.003 (***)
Network 1 (with competitors)			-0.004 (0.058)	0.944		
Network 2 (with customers)			0.239 (0.058)	0.000 (***)		
Network 3 (with part suppliers)			-0.022 (0.0533)	0.678		
Horizontal FDI&Network 1 (with competitors)					-0.146 (0.154)	0.343
Downstream FDI&Network 2 (with customers)					0.777 (0.217)	0.000 (***)
Upstream FDI&Network 3 (with part suppliers)					0.052 (0.159)	0.745
Constant	-0.024 (0.526)		-3.659 (0.494)	0.000 ***	-2.916 (0,487)	0.000 (***)
No. of obs	446		442		442	
Wald chi2(d/f) Prob > chi2	48.06(5) 0.000	 (***)	94.30(8) 0.000	 (***)	90.54(8) 0.000	 (***)

1. Figures in parentheses are heteroscedasticity-corrected standard errors.
2. * Significance at the 10% level.
   ** Significance at the 5% level.
   *** Significance at the 1% level.

Table 6. Model 2: R&D spillovers from CC subsidiaries

Dependent variable: Product patent	Model 2a Coeff.	Model 2a P>|z|	Model 2b Coeff.	Model 2b P>|z|	Model 2c Coeff.	Model 2c P>|z|
Log of R&D staff	0.243	0.013	0.291	0.003	0.278	0.006
	(0.098)	(**)	(0.099)	(***)	(0.101)	(***)
Log of R&D expenditures	0.178	0.010	0.171	0.007	0.170	0.008
	(0.070)	(**)	(0.064)	(***)	(0.064)	(***)
Horizontal CCFDI	-1.132	0.081	-1.287	0.045	-1.104	0.190
	(0.650)	(*)	(0.641)	(**)	(0.843)	
Downstream CCFDI	0.634	0.570	0.051	0.963	-3.196	0.057
	(1.116)		(1.111)		(1.682)	(*)
Upstream CCFDI	4.068	0.000	5.057	0.000	5.405	0.000
	(0.988)	(***)	(1.051)	(***)	(1.138)	(***)
Network 1 (with competitors)			0.004	0.948		
			(0.055)			
Network 2 (with customers)			0.254	0.000		
			(0.058)	(***)		
Network 3				0.314		
(with part suppliers)			-0.053			
			(0.053)			
Horizontal CCFDI&Network 1 (with competitors)					-0.133	0.443
					(0.173)	
Downstream CCFDI&Network 2 (with customers)					1.030	0.002
					(0.326)	(***)
Upstream CCFDI&Network 3 (with part suppliers)					-0.047	0.852
					(0.250)	
Constant	-2.891	0.000	-3.551	0.000	-2.820	0.000
	(0.477)	(***)	(0.462)	***	(0.456)	***
Number of observations	446		442		442	
Wald chi2(d/f)	45.05(5)		78.22(8)		70.06(8)	
Prob > chi2	0.000	***	0.000	***	0.000	***

1. Figures in parentheses are heteroscedasticity-corrected standard errors.
2. * Significance at the 10% level.
   ** Significance at the 5% level.
   *** Significance at the 1% level.

Table 7. Model 3: R&D spillovers from CE subsidiaries

	Model 3a		Model 3b		Model 3c	
	Coeff.	P>|z|	Coeff.	P>|z|	Coeff.	P>|z|
Log of R&D staff	0.235 (0.100)	0.019 (**)	0.265 (0.105)	0.011 (**)	0.249 (0.075)	0.001 ***
Log of R&D expenditures	0.186 (0.072)	0.010 (**)	0.176 (0.064)	0.006 (***)	0.178 (0.048)	0.000 ***
Horizontal CEFDI	-0.462 (0.588)	0.432	-0.689 (0.606)	0.255	-0.420 (0.644)	0.514
Downstream CEFDI	1.308 (1.247)	0.294	0.798 (1.216)	0.512	-1.572 (1.391)	0.259
Upstream CEFDI	1.882 (0.743)	0.011 (**)	2.744 (0.711)	0.000 (***)	2.538 (0.854)	0.003 ***
Network 1 (with competitors)			0.005 (0.057)	0.936		
Network 2 (with customers)			0.237 0.058)	0.000 (***)		
Network 3 (with part suppliers)			-0.023 (0.054)	0.672		
Horizontal CEFDI&Network 1 (with competitors)					-0.133 (0.130)	0.305
Downstream CEFDI&Network 2 (with customers)					0.792 (0.201)	0.000 ***
Upstream CEFDI&Network 3 (with part suppliers)					0.074 (0.152)	0.625
Constant	-2.875 (0.504)	0.000 ***	-3.488 (0.479)	0.000 ***	-2.708 0.374	0.000 ***
Number of observations	446		442		442	
Wald chi2(d/f)	50.76(5)		86.03(8)		95.44(8)	
Prob > chi2	0.000	***	0.000	***	0.000	***

1. Figures in parentheses are heteroscedasticity-corrected standard errors, except those in Model 3c.
2. Significance at the 10% level.
   ** Significance at the 5% level.
   *** Significance at the 1% level.

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