Reverse international knowledge transfer in the MNE: (where) does affiliate performance boost parent performance?

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Abstract
We examine the extent to which the knowledge or technological capability of foreign affiliates actually enhances the performance of their parent companies. Our results draw on a firm-level panel of more than 1,600 multinationals and more than 4,000 of their overseas affiliates, covering 46 home and host countries. We find considerable evidence of enhanced parent productivity as a result of their affiliates' performance, which we interpret as evidence of reverse knowledge transfer from affiliates to parents. This effect is robust to different tests including IV estimation and a falsification exercise based on unconnected 'matched' affiliates. We find that both physical and strategic location markedly affects the affiliate-parent relationship, and that distance reduces the positive impact that affiliate performance has on that of the parent.

Highlights

We link effective technology sourcing to firm performance.
While location matters, the position of the affiliate within the parent company determines effective technology sourcing.
We develop a "falsification test" to confirm the importance of the parent-affiliate relationship.

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1 Introduction

The traditional model of the multinational enterprise (MNE) suggests that firms will use foreign direct investment (FDI) as a method of entering foreign markets where they possess some knowledge-based 'ownership' advantage which cannot easily be exploited by some other route. In this model, knowledge is assumed to flow first from parent to foreign affiliate, then possibly – through some externality or 'spillover' effect – from the affiliate to host country enterprises.

However, there has been increasing theoretical and empirical emphasis on models of the MNE which do not rely on the assumption of knowledge or technology flowing exclusively, or even primarily, from parent to affiliate. Support for this perspective has come from theoretical work on the existence of multinationals without advantages (Fosfuri and Motta 1999; Siotis 1999), from empirical analysis of the motivation for FDI (Driffield and Love 2007), and from studies of the importance of knowledge flows from host countries to foreign affiliates and MNE headquarters (Singh 2007; Song and Shin 2008; Criscuolo 2009). This in turn has led to a strand of literature which is concerned not with the analysis of the determinants or effects of intra-MNE knowledge flows, but with developing suitable typologies and taxonomies of affiliates based on the nature and extent of their knowledge linkages with parents and other parts of the group structure (Gupta and Govindarajan 1991, 1994; Kobrin 1991; Birkinshaw and Morrison 1995; Harzing and Noorderhaven 2006). Another strand of literature deals with the nature of the (agency) relationships which can develop between parents and affiliates, and the extent to which knowledge flows can be affected by this (Mudambi and Navarra 2004).

Our concern is less with the nature or extent of knowledge flows between affiliates and parents than with their effects. Specifically, we examine the extent to which the knowledge or technological capability of foreign affiliates actually enhances the performance of their parent companies. We do this by examining the nature of the relationship between affiliate productivity and performance of the MNE parent company, which forms an important missing link in the analysis of intra-MNE knowledge transfers. Although analysis of Intra-MNE knowledge flows suggests that reverse flows are relatively commonplace (Driffield et al 2010; Marin and Giuliani 2011; Harzing and Noorderhaven 2006), there has been little attempt thus far to link knowledge flows from affiliates to the performance of the parent. Morck and Yeung (1991), and the literature which it stimulated, highlights an essential problem in this area: the essential endogeneity of strategic decisions, and the issue of being able to distinguish actual technology transfer or learning effects from apparent market or event-based studies. For example, associations between market responses and certain strategic decisions may be the result of the fact that the market may overvalue certain decisions, or overvalue the management who make them. It is necessary to therefore allow for this endogeneity when seeking to link FDI to performance.

The inherent problem with much of the literature that seeks to link FDI decisions to performance is the issue of 'multiple embeddedness' (Meyer et al 2011; Mudambi 2011). It is known, for example that at the level of the subsidiary links to both the parent and the environment of the affiliate impact both on performance and knowledge transfer between the parent and affiliate, and in both directions (Driffield et al 2010). However, the literature is rather sparse in seeking to determine the effects of this on either firm productivity or financial performance. For example, as Mudambi and Navarra (2004) discuss at length, multinationals have for some time pursued strategies designed to facilitate technology transfer or knowledge transfer between parent and affiliates, but are often faced with agency problems and rent seeking which discourage knowledge sharing. Najafi-Tavani et al (2014) also demonstrate that the influence and embeddedness of an affiliate within the corporate structure increases only when knowledge is transferred back to headquarters. Despite a large literature on multiple embeddedness there are few direct tests of the effects of knowledge transfer on parent performance, and to the best of our knowledge no study examines this with a very large sample across a wide range of countries. Much of the literature in the area of intra-firm knowledge transfer, particularly that concerning transfer from parent to affiliate, focuses on the frictions in the process, particularly the incentives that affiliates may have to avoid such transfer. There is therefore little evidence concerning the magnitudes of these effects, as a direct test of the effectiveness of strategies designed to facilitate knowledge transfer between affiliate and parent, and even less concerning the precise nature of the relationship between knowledge transfer and parent performance. We attempt to fill this gap.

In making the link between affiliate and parent performance, we also allow for the importance of local context in this relationship, and the interaction between local conditions and firm-level performance. For example, Gertler and Levitte (2005) discuss the importance of interactions between local interactions and global networks raise some 'troubling questions about the alleged pre-eminence of the local' in explaining innovation rates. While this highlights the importance of location, it also suggests a greater role not merely for firm strategy or how embedded a multinational is within a given location, but both for the importance of global networks and the degree to which the affiliate is embedded within the parent firm: what Meyer et al (2011) describe as multiple embeddedness. We therefore seek to extend this, by examining both the interactions between the local and global networks, but across a range of countries and sectors. Crucially, we also examine the outcomes in terms of total factor productivity, rather than simply on innovation.

The current paper makes four contributions to the literature. First, extending the existing literature that essentially infers technology sourcing from location patterns, we concentrate on determining the *effect* of affiliates' technological and knowledge capabilities on parent performance, rather than simply determining the direction or nature of knowledge flows between affiliates and parents. We show that this is a missing dimension in the current theory of intra-MNE knowledge flows. Second, we consider a much larger number of MNEs and a wider set of countries than has been attempted previously in analysis of the relationships between MNE parents and subsidiaries. In particular we consider a variety of multinational-affiliate relationships, drawing on more than 1,600 multinational parents and links to over 4,000 overseas affiliates, across 46 countries. This provides a stringent test of possible knowledge transfer effects by considering intra-MNE knowledge transfer across many national borders. Third, we make a methodological contribution. Specifically, we conduct a number of new robustness tests, including GMM and a detailed falsification exercise that seeks to control for the role of common shocks affecting both the parent and its affiliate. In this way we are confident that our results show evidence of the effects of affiliate-parent interaction. Finally, we explore the importance of affiliate location in the scale of the identified effects. We extend the work on multiple embeddedness and competence-creating subsidiaries (Meyer et al 2011; Mudambi et al 2014) by examining the importance of location and distance within the context of affiliate-parent linkages, considering both strategic and physical location in the empirical analysis.

Our results indicate that the technological and knowledge capability of multinational affiliates systematically enhances the performance of their parent companies. We also provide evidence that affiliate location and parent-affiliate distance – across a number of dimensions – play an important role in the effect of affiliates on the performance of their parents.

2. Conceptual framework and literature review

The role of knowledge flows has long been central to the theory of the multinational enterprise. In the 'standard' model of FDI in which knowledge is exploited by a technologically superior MNE, the process first requires knowledge transfer from the MNE to its foreign affiliate followed by the potential for the generation of externalities (i.e. productivity spillovers) from the foreign affiliates to domestic firms . Traditionally, the existence of such flows has been inferred indirectly by attempting to detect spillovers from the presence of MNE activity on the productivity of indigenous firms, rather than by direct observation of such flows.

While research continues on the nature, extent and effects of these 'conventional' knowledge flows, increasingly attention has switched to flows of knowledge running in the opposite direction i.e. from the host economy to foreign affiliates and from affiliates to the MNE parent organisation. The possibility of this form of knowledge sourcing FDI depends on the existence of 'reverse spillovers' in which an externality effect runs from the domestic sector to MNE affiliates. To complete the process, reverse knowledge transfer then occurs between the foreign affiliate and the parent company. This has given rise to a literature classifying different types of affiliates and their relationships with their parents and co-affiliates based largely on the nature of the knowledge and technology linkages between them (Gupta and Govindarajan 1991, 1994; Kobrin 1991; Birkinshaw and Morrison 1995; Harzing and Noorderhaven 2006; Marin and Bell 2010). Although the typologies vary in form, the overwhelming conclusion of the affiliate typology literature is that a substantial minority of foreign affiliates have identifiable two-way knowledge flows with their parent companies, and that uni-directional flows from affiliate to parent are not unknown.

In a detailed analysis of international patent citations, Singh (2007) finds that likelihood of knowledge flows between MNEs' home bases and their foreign subsidiaries is very similar in both directions, suggesting that flows from affiliates to parents are relatively commonplace. Using an official government survey covering 921 foreign affiliates based in Italy, Driffield et al (2010) find that 30% of affiliates experience two-way technology flows between parents and affiliates, with a small minority (6%) experiencing flows running exclusively from affiliates to parents. More importantly, Driffield et al also explore the determinants of these different patterns of intra-MNE technology flows, and find that affiliate investment in R&D and investment in capital-embodied technology plays a significant role in determining the nature of intra-firm technology flows.

Attention has also shifted to the variety of roles played by different types of subsidiaries, and the role of knowledge flows in this. Among the early analyses here was Yang et al's (2008) exploration of the links between the strategic position of the affiliate and knowledge flows, and the finding that conventional parent-affiliate knowledge transfers are larger in the case of subsidiaries acquired with competence-creating motives. Competence-creating subsidiaries create and develop new knowledge assets both for other subsidiaries and for the MNE as a whole (Cantwell and Mudambi 2005; Mudambi et al 2014), a role in which effective reverse knowledge transfer is crucial. The degree to which this occurs is determined by a variety of factors, including the extent to which the subsidiary is embedded into both the MNEs internal networks and the external networks to be found in its host location (Meyer et al 2011), as well as the subsidiary's willingness and ability to play such a competence creation role (Mudambi et al 2014). This in turn has led to a recognition that the generation and transfer of knowledge – or the withholding of such transfer –

can itself become a bargaining game between headquarters and subsidiary, revolving around the willingness of a subsidiary to play such a role versus its ability to do so within the mandate prescribed by the MNE headquarters (Mudambi et al 2014, Mudambi and Navarra 2004). This is a more specific interpretation of the arguments made by Foss and Foss (2005): their essential argument is that if a firm (parent) seeks to too closely control or limit flows of technology outside the organisation , the cost of doing this may outweigh any gains from the knowledge retention. This analysis therefore serves to confirm our approach here, which is that knowledge transfer is not automatic, and neither are its benefits, even within firms.

If competence-creating subsidiaries characterised by reverse knowledge flows are indeed a central feature of the new, networked MNEs, then this should be reflected not simply in the existence of such knowledge flows, but in their effects. The increased emphasis on identifying the nature, scale and determinants of knowledge flows from affiliates to parents is of limited value unless it can be shown that there is some effect arising from these flows of knowledge. As Ambos et al (2006) point out, there need be little relationship between the scale of knowledge flows from affiliates to parents and performance effects of this knowledge. Some MNEs may receive very limited knowledge flows from subsidiaries, but it may have a profound effect on operational performance, while others may receive substantial and regular knowledge flows which nevertheless lead to relatively little impact on performance. For example, Belderbos et al (2013) provide evidence from Belgian data that MNE subsidiaries tend to derive productivity benefits derived entirely from international knowledge transfers, suggesting that such affiliates often find it difficult to source knowledge effectively from local sources as might be suggested by the 'dual embeddedness' approach.
However, evidence on the benefit MNE parents derive from reverse knowledge flows, and ultimately from the performance of their subsidiaries, is surprisingly limited. Piscitello and Rabbiosi (2006) find that the impact of reverse knowledge flows on the parent company's innovativeness is greater when person-based mechanisms rather than ICT are employed for transferring knowledge, and where subsidiaries have a competence-creating role within the MNE. However, this is a relatively small study of 84 Italian MNEs using largely qualitative data, using a highly subjective measure of the effect of affiliate knowledge on innovativeness, and gives no indication of the scale of any effect. Ambos et al (2006) examine the flows of knowledge from 66 overseas affiliates to their European headquarters, but again this is a relatively small-scale study and the dependent variable is a subjective valuation by the headquarters of the value of knowledge from the subsidiary. More recently, Kafouros et al (2012) examine the effects of the global knowledge stocks of 114 UK-based MNEs, and find that group performance (measured by labour productivity) is positively linked to the ability of MNEs to access their 'global knowledge reservoirs'. While this represents an advance on previous work, what is still missing from the literature is any large-scale study of the links between affiliate and parent company performance, using more objective measures of the performance benefits arising from the affiliates. In addition, we know little of how the location of affiliates – both physical and strategic – affects the nature of the relationship between affiliate performance and that of the parent.

The role of location and distance in knowledge transfer

Location matters for knowledge and innovation because some locations have distinct localised capabilities and intangible assets that make them attractive (Maskell and Malmberg 1999). These include a country's unique institutional endowments which may form the basis of slowly-changing competitive advantage for some geographical locations (Asheim and Gertler 2005). A key issue for competence-creating subsidiaries is how to continuously combine their ownership advantage or firm-specific assets (FSAs) with the location-specific assets to be found in the relevant host economies (Narula 2014). Accessing effectively the network of knowledge and internationally immobile institutions in the local economy provides a platform for the generation of competences which can be dispersed within the MNE. For example, Andersson et al (2014) demonstrate that the existence of local market conditions that are both dynamic and conducive to competence development at the local level makes it more likely that subsidiaries in one location will contribute to the technological and business competence development of other subsidiaries within the MNE network.

At the same time, the subsidiary is faced with the issue of being sufficiently deeply embedded within the internal MNE network to have its competences recognised, valued, and accepted by other parts of the enterprise (Mudambi and Navarra 2004; Mudambi et al 2014). This 'dual embeddedness' – accessing and using both internal and external networks – becomes 'multiple embeddedness' when it is recognised that subsidiaries can demonstrate not only different types, but also different degrees of embeddedness within the MNE network (Meyer et al 2011). Therefore location in terms of the subsidiary's place in the MNE hierarchy is also relevant, with clear evidence that the relationship between headquarters and subsidiary significantly affects reverse knowledge transfer (Ciabuschi et al 2011; Mudambi et al 2014).

Distance also matters in knowledge transfer. Because of the tacit element of some knowledge, its transfer is a socially organised learning process. Perhaps more surprisingly, distance also matters where codified rather than tacit knowledge dominates: innovation in industries based around 'analytical' knowledge (where knowledge is often formal, science-based and codified) tend to be just as spatially concentrated as those whose innovation processes are based on 'synthetic' knowledge (based on the application or novel combination of existing knowledge) (Asheim and Gertler 2005). In a similar vein, Criscuolo and Verspagen (2008) provide evidence that distance, in terms of geography, cognitive distance and even time, can affect flows of technology in terms of patent citations. This can also have implications for knowledge transfer from competence-creating subsidiaries within the MNE. Narula (2014) analyses the need for 'wide-bandwidth' knowledge pathways within the MNE in order to fulfil the requirements of multiple embeddedness involving both the internal and external environments. However, firms tend to shrink knowledge bandwidth when they become more dispersed, because they are cognitive limits to their coordination and integration capacity. This leads to a problem for the MNE: greater geographical dispersion increases the potential availability of useful locational assets and innovation systems into which competence-creating subsidiaries can tap, but as distance (geographical, technological and organisational) between subsidiaries increases, knowledge exchange among competence-creating subsidiaries becomes more difficult.

Thus the costs of distance influence not only location choice but also influence with whom one chooses to interact. In terms of technology transfer, this becomes an important determinant not merely of technology transfer but of the links between the parent and affiliate, and of the degree of embeddedness of the affiliate in its local environment. Mudambi and Navarra (2004), for example, suggest that distance offers a good deal of independence to subsidiaries, which in turn can lead to opportunism of the affiliate and associated agency problems. A further level of complexity arises both from the degree of ownership and the ability of the firm to coordinate resources, issues typically ignored in the geography literature, but which are central to the technology transfer literature.

3. Hypotheses

The literature reviewed above suggests that there are strong reasons to expect the (productivity) performance of foreign affiliates to have a direct impact on the (productivity) performance of their parents, at least in part both because of knowledge flows running between them. While the literatures on competence creation and multiple embeddedness suggest that distance – physical , economic and institutional – will be important for knowledge transfer between parent and affiliate, less is understood about how distance might mediate the effect of this knowledge transfer. Such work as there is in the area (for example Mudambi and Navarra 2004) examines the problem in terms of agency theory between parent and affiliate. But, there is also the question of whether knowledge created in one environment both be transferred to another environment, but also effectively assimilated, thus generating improved performance. Our key concern is to extend this literature by assessing the scale of these effects, and specifically determining how location and distance affect the impact that affiliate performance has on that of the parent. We consider several aspects of location, both in terms of physical or geographical location, but also in terms of the strategic location and embeddedness of the affiliate within the MNE hierarchy.

Foreign affiliates differ in the extent to which they play certain roles within the MNE, most importantly varying by strategic importance within the parent firm. Recent conceptual and empirical analysis suggests that the nature of the knowledge flows between parent and affiliate depend on the strategic position of the subsidiary and its relative performance (Andersson et al 2001, 2005, 2007). This literature stresses that the more strategically important a subsidiary is to the parent, the more likely it is to be both a source and a recipient of technology and of other forms of knowledge. Specifically, this literature focuses on the performance of the subsidiary, and provides a link between the affiliate's strategic position and the effect this can have on the relationship between affiliate performance and that of the parent.

This extends not simply to flows of knowledge and technology, but more generally to intra-firm transactions within the MNE. For example, Kobrin (1991) suggests that intra-firm transactions are an indicator of knowledge flows within the firm, and thus of the extent to which the MNE is managed in a globally integrated manner. Gupta and Govindarajan (1991, 1994) view the multinational enterprise as a network involving flows of knowledge, capital and goods. Feinberg and Gupta (2004) make the same inference in their analysis of the determinants of R&D location in foreign subsidiaries, positing the relationship between intra-firm transactions and knowledge flows on the understanding that such a link indicates the ability of the MNE to absorb and utilise the R&D output and knowledge sourced by its subsidiary.

One indicator of the degree of embeddedness relates to the ownership status of the subsidiary. For example, wholly-owned subsidiaries are likely to be more integrated within the MNE hierarchy than partly-owned or joint venture enterprises, and have developed communication and management systems which permit effective knowledge transfer (Gupta and Govindarajan 1991, 1994). Driffield, Mickiewicz and Temouri (2014) show that the share of equity taken by foreign firms in their foreign affiliates is determined by their choice of technology, institutional quality at home and abroad, and the desire to prevent technology leakage. They also demonstrate show that wholly-owned subsidiaries are a distinct group within this setting, relying far more than other affiliates on the link between parent and affiliate for further development. Wholly-owned subsidiaries are also more likely to have developed a form of relationship with the parent that positively influences the affiliate's ability to capture the attention of the parent (Bouquet and Birkinshaw 2008; Rabbiosi and Santangelo 2013). Further, extending the analysis of Mudambi and Navarra (2004), one may argue that the higher the degree of ownership the greater the goal congruence, and the less significant the agency problems in hampering knowledge transfer between affiliate and parent. For all of these reasons – enhanced ability to draw attention to the useful knowledge contained within the affiliate, the existence of effective transfer mechanisms and goal congruence – we expect wholly-owned subsidiaries to have a particularly strong effect on the performance of their parent enterprise:

H1a: The effect of affiliate productivity on parent performance is greater for wholly-owned affiliates than for other affiliates.

However, the capacity of a parent to make sense of, and purposefully employ, the available knowledge from a given subsidiary depends not simply on the willingness of the parent to acknowledge the competence-creation abilities of its subsidiary, but on the capacity of the parent to absorb the available knowledge. This will in part be determined by the experience of the parent company in managing foreign affiliates. One particular aspect of this is discussed in detail by Muehlfeld et al (2012). In the context of learning through FDI in acquisitions they argue that firms engaging in a large number of mergers develop routines to maximise the gains from the process of acquisition. This analysis views the ability to gain from mergers as a feature of asset specificity as well as learning, so that firms that acquire repeatedly gain more from the process. We extend this to consider overseas activity more generally, in the context of the relationship between learning and multinationality. This in turn links back to ownership (i.e. firm-specific) advantages which arise as a result of being multinational in scope. These are a subset of the ownership advantages of common governance (Ot) and suggest that multinationality enhances global operational flexibility and thus improves the prospects for productive knowledge flows between affiliates and parents (Dunning 2001). Thus the greater the MNE's experience of being multinational the more likely it is to be able to exercise the advantages of common governance in any specific case – in other words, MNE parents learn about 'being multinational' and are thus able to harness the performance of affiliates more effectively as a result of multinationality:

H1b: The effect of affiliate productivity on parent performance is positively influenced by multinationality of the parent.

Our next hypothesis focuses on the location of the subsidiary within the supply chain or wider set of activities of the parent. The focus here is the nature of the relationship between the vertical or horizontal nature of the parent-affiliate relationship, and in turn how this relates to both the motives for FDI and the subsequent knowledge transfer between the affiliate and parent.

The technology sourcing literature has started to develop a framework for analysing both one-way and two-way flows between parents and affiliates. For example, Driffield et al (2010) link technology flows between affiliates and parents to R&D intensity and export intensity of the parent, while Driffield and Love (2007) relate international technology transfer to the motivation for firms to engage in FDI. Marin and Bell (2010) relate the innovative performance of subsidiaries not simply to knowledge flows *per* se, but to the extent of integration to their parent corporation. However, in a recent overview of research on subsidiary knowledge flows in the MNE, Michailova and Mustaffa (2012) point out that few studies of outward knowledge flows from subsidiaries explicitly distinguish between the horizontal and vertical nature of such relationships, and they judge this to be one of the major research gaps in the literature. Here we are able to distinguish between affiliates that are upstream or downstream relative to the parent in the supply chain and affiliates that are horizontal investments, and can establish the performance implications of each.

Theory suggests that technology sourcing activity will be concentrated principally in horizontal or within-sector FDI. As suggested by the recent analysis of Song and Shin (2008), the analysis of technology sourcing, particularly in the context of international technology transfer, typically focuses on this as a horizontal or within-sector phenomenon. The arguments for this date back to Cantwell (1999) and the theoretical analysis of Fosfuri and Motta (1999), who show that it can be profitable for technological laggards in a given sector to invest in the home country of more technologically advanced competitors because the potential learning effects are so strong. This also chimes with the more general literature on FDI and performance: for example, Doukas and Kan (2006) relate the sector of the investment in relation to the core technology of the parent, and show that FDI is more successful when firms engage in within-core sectors. There is also evidence that this is linked more generally to the management of technology or knowledge within the firm (Yang et al 2008). This suggests the likelihood of strong knowledge flows and performance effects running from affiliates to parents where FDI is horizontal in nature.

In terms of vertical relationships, we have to distinguish between the likely effects of upstream and downstream FDI. Linking this to the standard international business analysis of FDI, we argue that upstream FDI is often essentially efficiency seeking in nature[2], designed principally to take advantage of the relative cost of traditional factor endowments (notably labour) within different geographical locations. We would not anticipate significant knowledge flows from the affiliate to the parent under such circumstances with correspondingly little relationship between affiliate and parent performance.

By contrast, downstream FDI is more likely to be market seeking FDI, as firms seek to locate market-oriented activities such as final stages of production or marketing and distribution activities in a location which justifies direct investment. While initially this investment may be based on the ownership advantage of the parent, through time such investments will grow into self-contained production units with the capacity to transfer knowledge back to the parent organisation. This is consistent with the analysis of the global factory (e.g. Buckley 2009) which sets out very clearly how the firm distributes its activities, and also how the information flows are likely to occur as a result. For example, Buckley and Ghauri (2004) distinguish between outsourcing or other forms of contracting and direct ownership, specifically in terms of information and knowledge flows. Where downstream assets are themselves likely to be sources of knowledge for the brandholder in addition to standard technology sourcing from the domestic market – such as how to adapt the product for specific markets or how to engage in effective marketing for example – then a degree of ownership rather than merely market contracting will be maintained. As a result, where market-seeking (downstream) FDI occurs it is likely that knowledge will flow back up the supply chain from affiliate to parent. This is also consistent with the analysis of global value chains, (e.g. Humphrey and Schmitz 2002) that stresses the importance of governance of the supply chain for international technology transfer and upgrading at a local level. This leads to the second hypothesis:

[2] It may of course be resource seeking, though in practice we observe very little FDI into resource industries such as mining or agriculture. Note that we are not suggesting that *all* upstream FDI is necessarily efficiency seeking, simply that there is a link between the direction of FDI and the motivational dimensions discussed in Driffield and Love (2007)

H2: The effect of affiliate productivity on parent performance is greatest for affiliates in the same sector as their parent, followed by downstream affiliates, and is lowest for upstream affiliates.

Our final hypotheses relate specifically to the importance of location and distance with respect to knowledge transfer between affiliates and parents. The literature discussed above in the context of technology sourcing introduces the issue of location somewhat indirectly, but overall the literature suggests that there are two elements to discussing the importance of location. First, there is the more general one, expressed most starkly by Dunning (1998), which is that in terms of international business physical location must first and foremost be aligned with location advantages. Second, however, Dunning (1998) makes a more general point concerning the link between location and performance of FDI, restated in Cantwell et al (2010). This relates to the extent to which location advantages influence not only the location of FDI *per se*, but also the extent to which MNEs interact with local institutions and the performance effects which arise from this. As refined by Dunning and Lundan (2008), this suggests that the institutional locational advantages (Li) enjoyed by a given country or region will not only encourage the inflow of FDI, but will also influence the ability of a multinational enterprise to benefit from that location[3]. This also relates to the more general view of institutions as a source of location advantage, expressed across a range of literatures (see for example North 1990, Babeckỳ and Campos 2011, and Cuervo-Cazzura and Dau 2009).

The issue of location brings together analysis contained in both the innovation and economic geography literatures. In the economic geography literature the key distinction is between the emphasis that the clusters literature places on the importance of hierarchies, the importance of external economies of scale and innovation, and the importance of location for knowledge transfer between local agents. This is expressed, for example, in the work of in Becattini et al (2009) or Bellandi (2001), stressing the link between institutional development at the local level and the global supply chains of the parent firm. By contrast, as seen above, the international business and innovation literature tends to focus on the importance of technology transfer within the firm, across space, and the importance of distance in mediating this process. These ideas converge, albeit with different language, both in terms of the importance of co-location, but also in the extent to which MNEs can leverage location advantages through the ownership of firm-level specific advantages generated elsewhere within the structure of the firm. Further evidence on the importance of location comes from the analysis of Andersson et al (2014) on the importance of conducive local conditions to the development and transfer of technological and business competences among MNE subsidiaries in seven European countries.

Thus one would expect, for example, firms to be more willing to locate their core technology in locations with high degrees of intellectual property rights protection and strong rule of law, and that this in turn would increase the likelihood of knowledge transfer from a given subsidiary with its concomitant implications for enhancing parent company performance. One can make the same point in terms of more general economic conditions such as a high level of indigenous technological development and economic activity[4].

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[3] In the analysis of Dunning and Lundan (2008), the capacity of a given MNE to take advantage of a given set of institutional locational advantages will also be influenced by the firm's own 'institutional ownership advantages' (Oi).

[4] Recent analysis suggests that there is an interaction between the location of the subsidiary and the mandate it is given within the MNE hierarchy which influences the knowledge protection strategy adopted by both competence-creating and competence-exploiting subsidiaries (Sofka et al 2014)

H3a: The effect of affiliate productivity on parent performance is positively influenced by strong host country institutional structures and economic performance.

Hypothesis 3a deals with the absolute level of locational attributes in host locations. However, there is a large literature, discussed for example in Ghemawat (2001) and Johanson and Vahlne (2009), that relates 'distance' between the parent and affiliate – measured in a variety of ways – to the success of the investment. This is linked to a more general literature discussed by Doukas and Kan (2006), who argue that firms often become over-committed to foreign markets, such that their internal resources are unable to sustain the level of multinationality achieved.

The literature on the importance of distance focuses principally on the factors that may limit the ability to coordinate resources across countries (Zaheer, Schomaker & Nachum, 2012). These problems of coordination are rooted in the resource based view of the firm, but are typically expressed empirically in terms of differences between home and host countries with respect to physical, cultural, and political environment **(**Zaheer, 1995, Ghemawat, 2001). This is also related to a large literature that discusses the boundaries of the firm, building on *inter alia* Teece et al (1997) or Buckley and Casson (1998), and concerns the nature of the transactions costs that firms face in coordination between parent and subsidiary. Narula's (2014) analysis of the 'knowledge bandwith' problem in long-distance knowledge transfer among competence-creating subsidiaries is a more recent consideration of the same issue.

The literature on FDI has referred to 'psychic distance' arguing that in general companies seek markets perceived to be similar to their own. This argument dates back to Johanson and Wiedersheim-Paul (1975) and Johanson and Vahlne (1977) and has been applied to language, legal system and culture. Ghemawat (2001), for example, suggests that four dimensions of distance are significant: cultural, administrative, geographic and economic. Mani et al (2007) and Bruton et al (2010) examine this in terms of the FDI decision, but the purpose of the present analysis is to extend this to consider the ability of firms to generate knowledge transfer through this process, leading to improved MNE performance at home. While much of this literature focusses on distance in terms of corruption (e.g. Habib and Zurawicki 2002), it is necessary to see this more generally, in terms not only of institutional differences, for example intellectual property rights, but also economic distance more generally. For example, Dunning and Lundan (2008) and Cantwell et al (2010) express the importance of norms or institutional settings within IB, which, in common with the economic geography analysis of "distance", expresses the importance, not merely of geography, or of national culture in explaining firm behaviour. Boggs and Rantisi (2003) for example highlight the importance within economic geography of differences in norms, conventions or practices as well as formal institutions. Thus, we seek to examine the importance of differences in these phenomena between locations.

H3b: The effect of affiliate productivity on parent performance is negatively influenced by economic and institutional distance between home and host locations.

4. Empirical model and data

4.1 Model

Our objective is to assess the impact of affiliate knowledge flows on MNE parent performance.

Where they exist, theory suggests such knowledge flows are likely to be productivity enhancing, as their effect is to transfer some of the productive capability of the transferor to the recipient. We therefore adopt a relatively standard approach from the literature, linking the productivity of the parent to the productivity of the affiliate in order to capture knowledge flows. The rationale for this is that total factor productivity captures the ability of the firm to combine a given set of inputs in order to generate outputs. Holding capital, intermediate inputs and labour constant, this is explained merely in terms of knowledge and technology. Equally, if the quality of either input increases, this will increase the returns to that input, and in turn increase total factor productivity. Technology is therefore seen to be embedded in total factor productivity: indeed Driffield (2001) demonstrates in the context of spillovers from FDI, that total factor productivity by the inward investor is an important determinant of technology transfer to the domestic sector.

We therefore begin by specifying a simple model of the total factor productivity of the parent, explained in terms of a vector of variables X, and the total factor productivity of the affiliate.

$$TFP_{it}^{P} = \beta_1 TFP_{it}^{A} + \beta_2 X_{it} + \alpha_i + \gamma_t + e_{it} \qquad (1)$$

where the key variables are TFP_{it}^{P}, the total factor productivity of multinational parent i in year t, and TFP_{it}^{A}, the total factor productivity of an affiliate of same parent i in the same year t. The equation also includes other control variables such as the capital / labour ratio of the parent (X_{it}), different combinations of fixed effects, including industries (59) and countries (46), and year effects (γ_t). Finally, the most detailed specifications also control for fixed effects (α_i) where each parent-affiliate combination represents a fixed effect. The key parameter is β_1, which indicates the elasticity of parent productivity with respect to affiliate productivity.

Within this framework the crucial methodological problem is to identify the causal relationship between affiliate and parent performance, and deal with the problem of endogeneity. For example, there may exist a simple firm-level correlation that better performing parents have better performing affiliates, but this does not necessarily infer knowledge or technology transfer. Related to this is the problem of endogeneity in the relationship between total factor productivity of the parent and of the affiliate. This may occur, for example, if the parent decides to invest in new technology in both locations, or upgrades the technology in the affiliate because of higher technical specifications demanded by the parent. This would then result in a relationship between affiliate and parent productivity which again need not infer knowledge transfer.

We control for the former issue with a series of estimation approaches that are discussed in detail below, employing weights related to location-specific factors that may otherwise bias the results. We also employ the panel data generalized method of moments instrumental variables estimator (GMM-IV) to deal with the issue of endogeneity. Finally, we employ a rigorous falsification test (described in more detail in the results section) to distinguish between firm-level and country-level effects. For example, we hypothesise that technology transfer is driven not only by the affiliate location, but also by the performance of the affiliate, and by the precise nature of the link between parent and affiliate. This is consistent with both the embeddedness literature and the technology sourcing literature, though the technology sourcing literature has typically been unable to identify this. However, if technology sourcing is really merely a feature of location, as suggested by the macro literature, then the precise nature of the parent- affiliate links will not matter, and country-level effects will dominate firm-level effects. This is important in the present context, not merely in terms of verifying our results, but also in the wider context of the importance of place and space and the interaction between firm-level effects and location-specific effects. One may test this by linking parents to 'matched affiliates' identical to the actual affiliates but drawn from the population of host country firms. If the matched affiliate generates the same positive result as the actual affiliate, then this suggests that (firm-level) knowledge transfer or linkages are less important than location. We discuss this issue in more detail below.

Dependent variable

We employ the measure of total factor productivity developed by Levinsohn and Petrin (2003) (hereafter called LP), and explained in detail by Petrin et al (2004). Production technology is assumed to be Cobb Douglas, but allowed to vary by industry:

$$y_{it} = \beta_0 + \beta_l\, l_{it} + \beta_k\, k_{it} + \beta_m\, m_{it} + \omega_{it} + \eta_{it} \qquad (2)$$

Where the key variable are: y_{it}, the total revenue of firm *i* in year *t;* l_{it}, the number of workers; k_{it}, the total fixed capital of firm *i* in the same year; and m_{it}, the expenditure on intermediate inputs of firm *i* in year *t*. All variables are measured in logarithms. The error includes two components, namely the transmitted productivity component given as ω_{it}, and η_{it}, an error term that is uncorrelated with input choices. Considering that the unobservable part of production might affect the firm's input, leading to the well-known simultaneity issue in production estimation (Olley and Pakes 1996, Levinsohn and Petrin 2003), equation 2 is re-specified in more general terms:

$$y_{it} = \beta_l\, l_{it} + \phi_{it}(k_{it}, m_{it}) + \eta_{it} \qquad (3)$$

, where

$$\phi_{it}(k_{it}, m_{it}) = \beta_0 + \beta_k\, k_{it} + \beta_m\, m_{it} + \omega_{it}(k_{it}, m_{it}) \qquad (4)$$

We calculate the total factor productivity following Petrin et al., (2004)'s methodology[5] that implements LP's approach using third-degree polynomials (Wooldridge 2009).

Control variables

Total factor productivity is the portion of outputs which is not explained by the amount of inputs used in the production. In order to establish a vector of other control variables, we rely here on the efficiency literature that seeks to establish measures of productivity differences across firms, and subsequently to explain them. The key variable over which firms have control is the ratio of inputs, specifically capital to labour. This variable then captures the efficient input choice of a given firm, and also any frictions that the firm may have in moving towards the efficiency frontier (see for example Fare et al 1994). While the estimation and explanation of differences in total factor productivity is a discipline in itself, the common set of control variables in the literature are for

[5] The calculation of the total factor productivity is performed in STATA using the 'Levpet' package code provided by Petrin et al., (2004) that implements LP's approach.

example labour quality, intangibles, and debt. However, while these are not available for the full sample of firms, they are available for just over half. Inclusion of these generates significant collinearity, without adding to the explanatory power of the model[6]. We therefore include only capital per worker to maximise sample size and country coverage without compromising econometric efficiency.

4.2 Data and descriptive statistics

Our analysis draws on Orbis, an accounting dataset with detailed accounting and financial information published by Bureau van Dijk. Crucially this dataset includes ownership data and allows the linking of parents and subsidiaries[7]. The records of each company include information on its subsidiaries or affiliates, defined as firms where the parent company has an ownership stake corresponding to a minimum of 25.01%[8] . These affiliates are identified by company name and country. As information on the link between the affiliate and the parent is only available for the last year in which the parent appears in the data, we assume that the two firms were linked during all years in which their information is available (the same assumption is made by Budd et al. (2005), who use the European version of these data, Amadeus). Moreover, we consider only firms that have information available on sales, capital and employment levels. After the data linking and some attrition resulting from missing data, we employ data from 1,673 parent companies and 4,196 overseas affiliates: in total we have 21,173 observations in our data set across 46 countries, where each observation corresponds to a unique parent-affiliate-year combination. Table 1 presents the key summary statistics. As one would expect, we find that affiliates have much smaller average workforces, levels of sales and also much smaller average level of capital than their parent companies . Affiliate TFP on average is 8.177 and parent TFP is 9.356. Parent's profitability (return on sales) is 0.095. Monetary values were converted into Euros using exchange rates retrieved from the IMF. The data cover the period from 1996 to 2007, and are centred around 2002, with a small standard dispersion (2.6 years). Each parent-affiliate match appears on average 4.57 times (standard deviation of 3.0), which facilitates a longitudinal analysis thereby controlling for time-invariant (observed and unobserved) heterogeneity. The distance variables in Table 1 show that, on average, parents are located in countries with better IPR regimes, more established rule of law, and higher economic development than the countries where their affiliates are located. It also shows that 52.6% of the parent-affiliates pairs located in the same continent, and the average geographic distance is 4,145 kilometers.

Table 2 presents the country distribution of firms, separately for multinational parents and overseas subsidiaries, along with the most important variables used in our analysis, including average affiliate TFP, average parent TFP, sales, capital and employment. Our data cover 46 countries, including many OECD countries and also the largest developing nations. Unsurprisingly, parents are concentrated in developed countries, with significant numbers in Denmark, Finland, France, Germany, Japan, the Netherlands, Spain, Sweden, the U.K. and the U.S.A., which account for

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[6] In order to test this, we ran various factor loadings and parametric regressions using a vector of variables, including intangible assets, capital and debt structures, investment ratios, average earnings (as a proxy of labour quality) and free cash flow as different indicators or measures of firm heterogeneity. After dealing with the essential problem of collinearity, we established that capital / labour ratios capture most of the unexplained heterogeneity, without recourse to other variables, for which coverage is not as great. We therefore include only the capital labour ratio to capture unexplained differences in firms, in the spirit of the large efficiency literature, based on frontiers, see for example Fare et al (1994). The results from these procedures are available on request.

[7] The extensive benefits of these data, for both the link between parents and subsidiaries, and also the use in the modelling of location are discussed in detail in Ribeiro et al (2010), who also highlight the advantages of these data over official data.

[8] We subsequently test the sensitivity of our results to the parent's share in the affiliate.

79.3% of all parents. The majority of overseas subsidiaries are found in China, Denmark, Estonia, Finland, Germany, Greece, Ireland, Japan, Latvia, the Netherlands, Poland, Portugal, Singapore, South Korea, Spain, Sweden and the UK and the US, which account for 89.1% of all overseas subsidiaries included in our data set.

5. Results

5.1 Baseline results

The first empirical task is to establish the baseline relationship between affiliate and parent productivity. This involves an estimation of equation (1) without any detailed consideration of issues relating to location or distance. The baseline analysis serves two purposes. First, if such a baseline relationship cannot be econometrically established there is little point in examining the impact of locational factors on the relationship. Second, the size of the coefficient of the baseline estimate gives an indication of the importance of the affiliate-parent relationship and therefore of the importance of the various locational factors. Table 3 reports the main estimates for the baseline models (columns 1-3). Column 1 is the basic ordinary least squares regression, controlling for parent-affiliate fixed effects and year effects. The results suggest that affiliate productivity has a positive and highly significant effect upon parent productivity, with an elasticity of 0.086; in other words, on average every 10% increase in affiliate productivity results in an increase in parent productivity of around 0.9% . In order to examine the robustness of these results[9], columns 2 and 3 test some of the underlying assumptions of the approach.

While the parent-affiliate fixed effects used in Table 3 above control for time-invariant heterogeneity, it remains possible that our estimates suffer from a simultaneity or endogeneity bias. For instance, parents and affiliates may suffer from demand shocks that occur at the same time and that could facilitate the misleading interpretation of an effect from affiliate productivity to parent productivity. In addition, to some extent the productivity of a parent may transmit to productivity of overseas affiliates. In order to solve or at least alleviate this issue, we draw on a generalized method of moments (GMM) estimator that instruments for current-period affiliate TFP using average sector TFP and lagged values of affiliate TFP. At the same time, we also control for parent-affiliate fixed effects and year effects. Average Sector TFP refers to average of total factor productivity within sector (2 digits) for the current period year. The results are shown in column 2 of Table 3. The GMM-IV estimator still displays a positive and significant estimate on affiliate TFP, suggesting that endogeneity is not a problem and the causal impact from affiliate productivity on parent productivity is real. Moreover , the coefficients (available on request) on the instruments are positive and highly significant in the first stage of IV estimator, and the Sargan test of over-identification and tests of weak-identification and under-identification indicate that the instruments are valid and of good quality.

Our final robustness test is to apply different weight to our main results in Table 3. Even with a relatively large sample one could argue that our sample of parents and affiliates is still not precisely representative of the country distribution of foreign direct investment in the world, and this could distort our findings. To shed light on this matter, we rerun the baseline model but now weighting each observation using the levels of outward FDI flows of the home country of the parent MNE (using data from UNCTAD and WDI from the World Bank). The results (column 3) suggest that

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9 In order to test the robustness of the results, we experimented with lagged (1st, 2nd, 3rd and 4th) values of affiliate total factor productivity. All estimates displayed positive coefficients with a significance level of 1%. These results are available on request.

there is no bias arising from the global pattern of FDI flows. As shown in Table 2, more than a quarter of affiliates in our sample are from the UK, and about a quarter of parents are from the US. We therefore re-estimate the reverse knowledge transfer effect for the subsample of US overseas affiliates in the UK (column 4 of Table 3), and the effect of the subsample of US overseas affiliates in other remaining countries (column 5 of Table 3). We find that both estimates are positive and at the significance level of 1%, while the effect is higher for US overseas affiliates in the UK subsample.

Having established the solidity of the baseline result, columns 6 and 7 then consider the effect of the ownership status of the affiliate and the extent of parents' international scope (i.e. hypotheses 1a and 1b). In both cases the effects are as expected: the relationship between affiliate and parent performance is much higher for wholly-owned subsidiaries, and the degree of multinationality of the parent positively affects the relationship between affiliate performance and that of the parent. In both cases the size of the effect is substantial: for example, wholly-owned subsidiaries have, on average, an effect on parent productivity almost 50% higher than that of other types of affiliate, presumably because of their greater embeddedness in the MNE hierarchy[10].

5.2 Testing the importance of parent affiliate linkages: a falsification test

In order to further test the reliability of our results, we are concerned to differentiate between firm-level effects and country-level effects. The baseline results suggest that there is a strong and consistent relationship between affiliate performance and that of the parent, and that both embeddedness of the affiliate and multinational experience of the parent have a role to play in this. However, it is still possible that we have simply established the importance of the links between *countries* for technology sourcing, in line with the macro literature in the area, rather than definitively showing a link between specific parents and affiliates at *firm* level.

As mentioned before, one concern about our preferred interpretation of the international knowledge transfer results is that they may arise out of shocks that simultaneously hit the productivity of parents and affiliates. For instance, a worldwide increase in technology capability in a given industry could presumably raise the productivity of the affiliate that operates in that industry while at the same time raising the productivity of the parent of that same affiliate. Even if this alternative explanation is unlikely to apply in the context of our highly diverse set of matched multinationals and affiliates, this correlation conceivably could be strong enough to survive the controls we have previously considered leading us to incorrectly interpret our results as evidence of international reverse knowledge transfer effects.

In order to examine these issues in more detail we conduct the following falsification test. We carry out a matching exercise, to identify foreign affiliates that are very similar in nature based on a number of characteristics, employing propensity score matching analysis (Rosenbaum & Rubin 1983). Once we have identified these matched affiliates, we replace the actual subsidiary in a given parent-affiliate pair with its matched subsidiary, and then re-run the analysis. In order to do this, we require that each match is in the same industry and location, and of a similar size, age and

[10] We also test for differences between effects associated with variations in ownership structure. Results (not shown) indicate the reverse knowledge transfer effect is greatest for wholly-owned subsidiaries compared with the other groups, while the difference between majority and minority-owned affiliates is not significant.

capitalisation as the 'true' affiliate. The idea is therefore to select information from affiliates that are very similar to the matched 'true' affiliate, and therefore would be subject to the same shocks as the matched counterpart.

This is important to the analysis. We are interpreting the productivity effects from affiliate to parent as evidence of knowledge transfer which can only occur within the MNE.; thus any productivity effects should only occur within genuine affiliate-parent pairs, not between matched pairs unrelated through ownership. Therefore, if the falsification exercise results in similar or at least significant estimates of productivity effects (and therefore of apparent knowledge transfer effects), then we would have to at least revisit and perhaps even change our interpretation of our previous estimates. However, if this falsification exercise results in insignificant estimates of productivity effects, then that would be consistent with our interpretation of genuine international knowledge transfer within multinationals. This is also important in distinguishing between firm-level effects (specifically the links between parent and subsidiary performance) and more straightforward 'location' effects, captured simply by where firms locate their subsidiaries.

Propensity score matching, introduced by Rosenbaum & Rubin (1983) and further developed by Heckman, Ichimura and Todd. (1997, 1998), has now been widely adopted to test the existence of a causal relationship (Heckman & Robb 1985). It has been long argued that the quality of matching exercise is largely influenced by the data structure (Heckman, Ichimura, and Todd, 1997; Zhao 2004). Affiliates included in our analysis are already similar within the same (two-digit) industry and country even before adding more restrictive conditions on the matching exercise: the average propensity score difference between an affiliate and other affiliates in each cell of the relevant country and industry is as small as 0.016, and this feature allows us an adequate 'like-for-like' comparison in the matching exercise. Sample size in the control group is crucial in improving matching quality (Smith 2000; Driffield and Yang 2012), allowing selected matches to become closer and closer to exact matches (Caliendo and Kopeinig 2008, Heckman, Ichimura and Todd, 1997). There are over 4,000 affiliates included in our matching exercise, and this number is at least comparable to other papers using matching methods. Moreover, for each affiliate included in our data, on average there are 35 other affiliates (with a standard deviation of 52.9) to be matched which located within the same country and industry. In order to find more precise matches, we aim to find one matched affiliate which is very close to the true affiliate in terms of the propensity score using nearest neighbour matching (see the similar approach conducted in Greenaway & Kneller 2008). The variables included in the matching exercise are: total factor productivity, employment, sales, intermediate inputs, capital, age, number of affiliates, and year. We also consider several transformations of these variables (squares, cubes, interactions of two and three variables) in order to obtain a more precise correspondence between the matched affiliates.

Table 4 presents descriptive statistics on the quality of the match obtained. These variables are measured in ratios. We divide the difference of the two figures ('true' affiliate and 'matched' affiliate's value) by the mean of the same two figures. The results indicate a very good quality in the matching, as the average ratios are always low. On average the propensity score difference between matches is -0.00045, suggesting matched affiliates are very similar to true affiliates. The regression results based on the matched affiliate data are presented in Table 5. We attach weights each observation, based on the inverse of the absolute difference in the propensity score of the affiliate and its match. In other words, these results attach greater importance to affiliates that are better matched. The relationship between affiliate TFP and parent TFP disappears when matched affiliates are used which do not have a direct relationship with the 'parent'. Thus the relationship between affiliate and parent TFP arises only when real affiliates are matched to their true parents. To provide more robustness, we also obtain results when we match on the 'matched' affiliate's TFP in addition to the other matching variables (second column of Table 5) – again, the effect of affiliate TFP disappears. We take the results from this falsification test as important evidence against a spurious relationship between affiliate productivity and parent productivity and in a favour of a causal interpretation of our findings.

5.3 Effects of location and distance

Table 6 shows the importance of location in the supply chain. These results highlight both the importance of linkages, and the apparent direction of knowledge transfer within the firm. As hypothesized (H2) larger effects are evident in horizontal than in upstream or downstream FDI. There is no evidence of knowledge transfer from affiliate to parent down the supply chain, but there is significant evidence of knowledge transfer up the supply chain from affiliates. This is consistent not so much with the technology sourcing hypothesis, but with the standard analysis of ownership advantages. It is suggestive of FDI being employed to better link directly to customers, with knowledge concerning how to tailor products for particular market or how to adapt produces based on particular demand or local conditions being transferred to the parents. The results concerning the importance of horizontal FDI are both the strongest, and suggestive of technology sourcing. As we discuss above, much of the technology sourcing literature focuses on horizontal effects: in the present case a 10% increase in productivity of horizontal affiliates generates a 1% increase in productivity of the parent (Table 6 column 4). Driffield et al (2010) discuss the nature of both one and two-way flows of technology between affiliate and parent, and our findings here provide further evidence of the mechanisms by which technology sourcing occurs. This suggests that technology sourcing occurs firstly through the assimilation of technology into the affiliate from the host economy, and then subsequently through the transfer process to the parent. To the best of our knowledge this is the first time anyone has been able to quantify this effect.

The only situation in which upstream FDI generates productivity effects from affiliate to parent is where the affiliate is specifically focused on R&D activities: indeed, the effect of upstream R&D is larger than any other effect (Table 6 column 2). This is consistent with the technology sourcing hypothesis, and specifically with the literature on R&D affiliates being used as listening posts to absorb learning spillovers from geographical proximity in knowledge-intensive home locations (Pearce, 1999; Niosi, 1999).

The final two sets of results focus on the importance of physical location, and distinguish between location *per se* and distance. Here we focus on a number of dimensions of location, including intellectual property right protection, patenting, economic development and the rule of law. In addition we consider profitability of the affiliate. The process here is to interact affiliate total factor productivity with the various location factors, in order to examine the extent to which location impacts on the knowledge transfer process defined above. The results concerning location are presented in Table 7.

To avoid collinearity we interact the locational variables with affiliate performance one at a time, though as a control variable in each case we also include the location factor in the regression to allow for the possibility that it is simply the location that may influence parent productivity, rather than the presence and performance of the affiliate *in* the given location. The first result from Table 7 shows an insignificant coefficient on the IPR variable, but a positive and significant coefficient on the interaction between affiliate performance and IPR protection. In other words, although parent performance is, on average, no higher in locations with high levels of intellectual property rights protection, the impact of affiliates on their parent's productivity is much higher where IPR protection in the host country is strong. This is consistent with relatively high levels of affiliate-parent knowledge transfer occurring in locations with high levels of intellectual property rights protection. It is also indicative that high levels of total factor productivity in such locations are driven by the desire to access technology or knowledge rather than simply by efficiency considerations, driven by the types of working practices permitted in some host countries. Similar effects are noted for the measures of host economy economic development, rule of law, technological sophistication, and for the impact of affiliate profitability. In all cases, strong institutional and economic performance in the host location enhances the ability of affiliates to benefit parent performance via reverse knowledge transfer, consistent with H3: however, the magnitudes of these effects are consistently significantly smaller than for IPR protection.

While Table 7 considers affiliate location, the results of Table 8 demonstrate clearly that distance plays a key role in the nature of technology transfer between affiliate and parent, in terms of physical, economic and institutional distance. In all cases distance, however measured, reduces the effectiveness of knowledge transfer between affiliate and parent, and therefore reduces the impact of the former's productivity on that of the latter. As with location the biggest effects are in terms of IPR distance, which is twice as important as the general technology differences between countries, and some 70% more important than geographic distance. Finally, there is also some evidence that regionalism is important: the final column of Table 8 shows a positive and significant 'same continent' effect.

We illustrate the importance of distance in Figure 1, the margin plots relating high, average and low distance to the relationship between affiliate and parent productivity as the affiliate moves from a low productivity state to a high productivity one. All variables have been standardised, ranging between -1 and 1 (with zero on average and a standard deviation of one). Standardising the distance variables provides a more transparent comparison of the impact of different distances on the effect of reverse knowledge transfer. These graphs show the impact of affiliate productivity on its parent productivity when an affiliate moves from low (-1) to high (1) productivity. They key comparison is the relative slopes of the lines, comparing the importance of low distance (■) with high distance (▲), while the third line (●) represents mean distance, for comparison. Taking the top left figure first, it shows that the productivity increase in an affiliate from low to high productivity improves parent productivity much more when the countries have low IPR distance compared with a similar example when IPR distance is high. Similar patterns could be found in the other distance measures, confirming our underlying hypotheses concerning knowledge transfer and knowledge sourcing. Further, these figures demonstrate the asymmetry in the effects of distance. As affiliate productivity improves, the greatest impact on parent productivity is where economic development in the host country is greater than the home country

6 Discussion and Conclusions

Although there is now a substantial body of literature indicating that both technology sourcing FDI and reverse knowledge transfer from affiliates to MNE parents is relatively commonplace, there has been no systematic, large-scale study of the effects of such knowledge transfer. This forms an important missing link in the theory and analysis of intra-MNE knowledge transfers, located between studies of productivity spillovers from MNE affiliates to domestic firms and research on the nature and determinants of knowledge flows within the multinational corporation.

Using a large dataset of affiliates and parent matches, we find strong and consistent evidence that affiliate productivity has a positive effect on parent productivity. These results still hold when we consider instrumental variables and other tests of robustness. In addition, a falsification exercise based on the use of carefully matched affiliates suggests that the results are not driven, for instance, by common shocks affecting the productivity of both parents and affiliates, nor from effects arising from the tendency for 'good parents' to have 'good children'. We conclude that the results are real, and are the result of reverse international knowledge flows from affiliates to parent corporations.

We also highlight the importance of location in this relationship. Strategic location, in terms of wholly-owned affiliates and location in the MNE supply chain, influence the affiliate-parent relationship in ways that are both intuitive and consistent with theory. Physical location, in terms of affiliate locations with well-performing economies and highly developed institutional structures, interacts with affiliate productivity in ways that boost parent performance. As expected, distance, in terms of physical, institutional and economic dimensions, acts to reduce the positive impact which affiliate performance has on the parent company.

While it is natural to infer that the identified effects arise from the knowledge sourcing behaviour of foreign affiliates in host economies, we cannot discount the possibility that at least some of the productivity effects arise from competences generated within the affiliates themselves. In other words, rather than simply acting as conduits for knowledge and technology from the host economy, affiliates may, through their own R&D efforts, generate knowledge which can then be transferred back to the parent (Bell and Marin 2004; Marin and Bell 2010). The strong productivity effects from affiliates located in countries with well-developed institutional and economic structures certainly accords with the hypothesis of technology sourcing, but it may also be the case that it is easier for affiliates in such economies to develop knowledge competencies internally. However, it seems unlikely that the effects identified in the empirical analysis can be derived principally from such an affiliate-enhancing process; the results are simply too strong, too consistent, and too widespread to be the result of access to anything other than the knowledge stocks of advanced host economies.

To the best of our knowledge this is the first paper to examine international knowledge transfer and its apparent productivity effects on such a large scale. In the context of the dominant theoretical paradigm , it also offers some insight into the relative importance of (firm-specific) ownership advantages and more general location advantages, in the creation of (productivity) growth. While we highlight the importance of location in the technology sourcing and technology transfer process, we also show that location in itself is not sufficient; it must be linked to firm-level effects, specifically the ability of the affiliate to generate productivity growth in the host country. This finding has resonance with the related spillovers literature, as well as the more general literature on firm location. Much of the literature on FDI and productivity growth simply uses a measure of foreign activity, such as output or employment. This suggests that further work on spillovers should focus on the interaction between firm- specific and location-specific factors. The lack of sensitivity to this of previous work may well explain the lack of consistency in findings regarding the importance of FDI for international technology transfer.

Our findings help to highlight the importance and interpretation of 'distance' within international business and economic geography. Boggs and Rantisi (2003) discuss in general how economic geographers have come to interpret distance, and the significance of distance, not being merely a physical phenomenon. Rather, distance matters precisely because it limits knowledge flows in inter-firm and firm-organization linkages. Equally, in the CAGE analysis of Ghemawat (2001), the term 'distance' typically no longer refers simply to physical distance, but to the extent to which separation is a barrier to knowledge exchange. International business then interprets this in the form of questioning the extent to which strategy can overcome this, through intra- and inter-firm networks for example. Thus our findings with respect both to distance and the strategic positioning of the affiliate within the value chain also inform the wider literature on the boundaries of the firm. We highlight here that distance, both physical and economic, hinders knowledge flows, but that institutional and technological distance is potentially more important than physical distance in terms of limiting international technology transfer within and between firms. To this extent, we build on the analysis of Mudambi and Navarra (2004), who argue that the main hindrance to international knowledge transfer within the firm is the principal -agent relationship between the parent and the affiliate. We demonstrate the importance not merely of distance as a hindrance to knowledge flows but also of the ability of the firm to manage the process. Firms with higher levels of multinationality are less likely to suffer from this problem, as are those with strategic links between affiliates and parents, while high levels of embeddedness also facilitate knowledge flows.

More broadly the findings that we present here have a number of implications for theory, particularly in a spatial context. For example, Un and Cuervo-Cazurra (2008) find that while foreign MNE subsidiaries tend to invest less in R&D than domestic manufacturing firms in Spain, this is entirely because of lower expenditure on external R&D. They conclude that the transfer of technology and knowledge from other parts of the MNE acts as a substitute for the purchase of external R&D, while affiliates' internal R&D acts as a complement to the technology and knowledge transferred from other parts of the MNE. This is consistent with the analysis of Criscuolo et al (2005) who show that that when MNEs engage in R&D activities overseas, they often seek to use a variety of resources associated with the innovation systems of the home country, not simply the parent company's technological competences. Both of these approaches stress the importance of affiliates' capacity to tap into the wider MNE network. By contrast, we show that knowledge transfer within the firm requires the interaction between the global network of the MNE and the location advantages derived from the location of the affiliate. Neither the global network nor the affiliate location is a sufficient condition for this, independent of the other. Equally, we extend the understanding of both intra-firm and inter-firm technology transfer that has essentially been developed through the more standard 'spillovers' approach. We highlight the importance not merely of location of the affiliate, but of the embeddedness in the parent of the affiliate, and the position of the affiliate within the global value chain. Further, this contributes to the extensive literature that models MNEs as networks, highlighting the importance of inter-firm relationships for international knowledge transfer within the firm. Typically, technology sourcing activity leads to knowledge flows back up supply chains to the parent, but requires productivity growth within the affiliate. This suggests that the literature characterising technology sourcing activity through an extended network of listening posts needs to be extended in two ways: first, to consider the actions of the affiliates in terms of generating productivity growth; and second to consider the interactions between the affiliate and the locality, and the importance of the strategic location of the affiliate, in generating knowledge transfer to the parent.

From the perspective of the home economy of the parent MNE, our results lends some support for the contention that offshoring of R&D/innovation can be beneficial. Driffield et al (2009) find evidence that technology sourcing FDI coming from the UK generates positive productivity effects on home (i.e. UK) industry. More generally, Castellani and Pieri (2013) find that European regions from which firms perform R&D offshoring have higher productivity growth. They therefore argue that the concerns of R&D offshoring leading to 'hollowing out' of European competitiveness are overstated, and that European public policy should encourage firms to engage in global R&D projects and access complementary assets and technologies abroad. Our findings complement this research: notably, we find that the effects on parent MNE performance arising from the performance of overseas affiliates is strongest where those affiliates engage in R&D activity, consistent with the capacity of affiliates both to generate knowledge internally, but also to access complementary assets and knowledge in the host economies. And by drawing attention to the interaction of strategic and physical location of affiliates in generating positive effects from reverse knowledge transfer, we show the importance of both the internal and external knowledge networks that foreign affiliates are uniquely able to access.

Our analysis employs a large international dataset covering a number of years. While this has a number of advantages, there are of course limitations to statistical analysis of this kind. We have no detailed information on how productivity-enhancing knowledge flows occur within multinational corporations, and therefore the precise mechanisms by which these effects manifest themselves. This suggests the value of insights obtained from detailed survey data on and from longitudinal in-depth studies of the knowledge transfer processes with individual MNEs. Overall therefore, while we present a significant improvement on a largely macro-based literature, and a hitherto unexplored link to theory in the interpretation of the results, more remains to be done. This involves a more sensitive approach to allowing for heterogeneity across locations. At the same time, it demands a more detailed analysis of a wider set of indicators of innovation and technology transfer, within a geographically diverse and representative data set.

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Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Obs
Multinational parents			
Total Factor Productivity	9.356	0.648	21173
Profitability	0.095	0.085	20548
Turnover	13669.8	24995.1	21173
Capital	15886.9	27032.6	21173
Employment	55355.3	73116.1	21173
Intermediate inputs	8821.8	18823.4	21173
Multinationality (OSTS)	0.709	0.200	21173
Affiliates			
Total Factor Productivity	8.177	0.639	21173
Profitability	0.054	0.094	20264
Turnover	649.0	3510	21173
Capital	690.5	3835.2	21173
Employment	2532.2	9637.5	21173
Intermediate inputs	438.6	2496.0	21173
Survey year	2002.4	2.6	21173
Linkage			
Upstream FDI	0.046	0.211	18308
Downstream FDI	0.181	0.385	18308
Horizontal FDI	0.318	0.466	18308
Wholly owned	0.381	0.486	21173
Distance			
IPR regimes	0.239	0.367	20091
Technological capability	-0.013	0.264	12807
Economic development	8673.4	12279.4	21020
Geographic distance (in kilometres)	4145.2	3590.0	21020
Rule of law	0.182	1.021	20914
Same Continent	0.526	0.499	21020

Notes: All monetary firm variables are in millions of Euros. 'TFP, parents (affiliates)' is total factor productivity of multinational parents (affiliates). 'Turnover, parents (affiliates)' is annual sales of the multinational parents (affiliates). *Capital* of parents (affiliates) is capital stock of the multinational parents (affiliates). *Employment* in parents (affiliates)' is number of employees of multinational parents (affiliates). 'Profitability, parents (affiliates)' is return on sales of parents (affilaites). *Multinationality* of the parent is the ratio of number of overseas subsidiaries to total subsidiaries.

Measures of type of FDI: *Upstream FDI* is a dummy if an affiliate is the upstream of its parent. *Downstream FDI* is a dummy if an affiliate is the downstream of its parent. *Horizontal FDI* is a dummy if parent and affiliate are in the same 3-digit industry code. *Wholly owned* is a dummy equal to one if parent owns at least 98% share of its overseas affiliate.

All distance variables are relative measures, home country versus host country, based on the following measures:

IPR Regime is taken from the IPR index in Park (2008).

Technological capability is measured by the share of resident patent applications in the total number of applications.

Economic development is measured as the countries' GDP per capita. *Technological Capability* and *Economic Development* data are from World Development Indicators database.

Geographic distance is great circle distance between capitals of the parent and affiliate country. Taken from the CEPII dataset.. The *Rule of law* index is from the Worldwide Governance Indicators database.

Table 2: Number of firms and key variables per country

Country	N Affiliate	TFP	Sales	Capital	Emp.	N Parent	TFP	Sales	Capital	Emp.	ROS
Australia	30	8.26	380.8	549.4	2461.1	13	9.11	3950.8	4945.1	19439.7	0.12
Austria	17	8.58	758.4	1654.8	2389.2	10	9.06	3323.9	3266.1	13162.5	0.08
Belgium	12	8.86	3619.6	5015.2	12114.1	32	9.26	5953.0	6439.5	25952.7	0.09
Brazil	13	8.61	775.4	1278.0	6122.3						
Canada	5	8.40	690.2	421.8	3689.0	7	9.12	1464.1	2250.0	5430.8	0.25
China	282	7.78	266.9	197.7	2292.1	1	8.20	513.6	788.7	12499.0	0.04
Czech	18	8.29	710.1	656.8	4648.7	1	9.25	4293.6	2114.9	23201.2	0.04
Denmark	177	8.00	170.0	112.6	698.1	59	8.62	1538.9	1604.1	11739.3	0.09
Estonia	92	7.00	22.8	14.8	332.3	22	7.37	32.7	29.8	545.3	0.12
Finland	60	8.02	204.4	154.7	896.3	51	8.94	3174.6	3128.5	11385.3	0.08
France	34	9.06	8522.3	11663.7	29066.8	86	9.39	9889.1	14560.1	57027.0	0.09
Germany	154	8.62	1074.7	1117.8	3036.5	92	9.36	12821.9	16142.7	53617.8	0.07
Greece	103	7.86	129.0	97.4	574.6	6	8.55	1336.8	1577.4	7723.2	0.08
Hong Kong	6	8.87	1820.4	5145.6	20516.9	10	8.14	878.8	6215.0	9994.2	0.13
Hungary	12	8.51	1299.2	1083.9	4891.2	2	8.33	361.6	449.6	3190.6	0.05
Iceland	1	8.47	255.5	225.6	504.5	6	8.34	347.9	364.1	1725.0	0.04
India	4	7.72	60.4	45.4	1336.6						
Indonesia	18	7.85	238.6	270.5	4389.5						
Ireland	75	8.69	1083.3	1314.1	1075.3	23	8.80	1720.0	1401.5	6956.2	0.08
Italy	10	8.56	2094.4	2894.5	6470.5	27	9.08	9120.1	15982.7	27135.5	0.10
Japan	69	8.64	2746.4	2547.3	8724.4	207	9.25	10019.6	10497.6	36187.1	0.06
Latvia	66	7.02	20.9	13.9	248.1						
Liechtenstein	1	7.63	18.9	12.5	237.4	1	9.18	1617.4	1720.8	14382.0	0.09
Lithuania	48	7.22	70.6	44.4	485.7	2	6.87	16.3	15.0	606.6	0.06
Luxembourg	12	8.05	226.2	404.2	6279.0	10	8.98	5206.6	6012.7	21652.7	0.08
Malaysia	28	7.93	261.5	227.5	2248.9	13	8.29	605.8	974.2	8651.7	0.15
Mexico	2	8.37	218.3	444.3	951.0	4	9.47	5284.1	9817.2	29507.5	0.28
Netherland	178	8.66	2049.1	1936.4	4573.0	102	9.07	6421.0	5741.5	23965.6	0.06
New	5	8.26	593.0	1541.5	5276.9						
Norway	7	8.43	536.8	449.4	2942.2	20	9.05	4330.1	5225.8	12038.6	0.13
Philippines	9	8.15	427.5	737.6	4826.6						
Poland	193	7.74	143.3	134.9	1302.6	5	8.65	1857.6	1387.5	6050.2	0.07
Portugal	160	8.04	272.9	425.0	1057.6	10	8.87	2882.9	4191.5	5831.6	0.11
Romania	1	9.01	2174.5	3714.6	56357.8						
Russia	42	7.55	75.6	51.5	642.2	3	9.82	14924.0	48549.6	222608.9	0.35
Singapore	152	8.11	369.4	217.2	815.3	30	8.28	1268.8	1999.0	10740.0	0.13
South Africa	14	8.18	679.9	1089.9	21454.6	5	8.88	1568.9	1193.4	13418.2	0.07
South Korea	149	7.90	152.5	115.8	456.7	6	7.58	72.3	54.2	559.9	0.08
Spain	341	8.52	570.7	626.0	1718.7	74	8.90	3391.6	5733.1	12409.9	0.13
Sweden	125	8.23	739.0	658.6	3277.6	98	8.78	2589.8	2827.7	17321.0	0.07
Switzerland	22	8.68	802.3	1040.0	7223.0	42	9.20	5455.5	6762.5	33072.5	0.08
Taiwan	23	7.64	213.4	217.5	1109.5	32	8.44	1300.9	1492.1	11852.9	0.07
Thailand	55	7.54	77.1	62.5	1148.5	1	7.48	87.4	90.0	4812.5	0.09
Turkey	9	8.48	1106.1	720.4	2892.3	2	9.04	1661.2	2187.1	8256.8	0.22
UK	1,212	8.23	459.8	450.0	2122.6	135	9.11	6594.3	8291.1	36560.2	0.10
US	150	8.64	1816.5	2552.4	9656.2	423	9.09	6248.2	7251.8	32533.3	0.11

Notes: The above table contains 1,673 multinational parents and their 4,196 overseas affiliates. The left panel shows characteristics of affiliates, and the right panel shows characteristics of multinational parents. 'Emp.' refers to employment, 'ROS' to return on sales. All monetary variables are in millions of Euros.

Table 3: Effect of Affiliate TFP on Parent TFP– baseline results.

	(1) Baseline	(2) GMM-IV	(3) Weight	(4) US-UK	(5) US-others	(6) Ownership	(7) Multinationality
TFP, affiliate	0.086***	0.134***	0.090***	0.145***	0.053***	0.074***	0.046*
	(0.009)	(0.021)	(0.009)	(0.015)	(0.015)	(0.010)	(0.023)
Capital, parent	0.094***	0.095***	0.072***	0.072***	0.133***	0.094***	0.094***
	(0.011)	(0.012)	(0.012)	(0.023)	(0.028)	(0.011)	(0.011)
TFP, affiliate*Wholly Owned						0.034**	
						(0.016)	
TFP, affiliate*multinationality							0.059*
							(0.033)
Constant	7.561***	7.129***	7.671***	7.192***	7.458***	7.554***	7.547***
	(0.155)	(0.153)	(0.183)	(0.322)	(0.385)	(0.155)	(0.155)
R-squared	0.96	0.96	0.96	0.954	0.975	0.96	0.96
No. observation	21173	13735	21056	3884	2890	21173	21173
F statistics	109.28	90.99	93.49	78.26	13.23	102.09	101.60

Notes: Dependent variable: TFP of multinational parents. All variables are in logarithms. 'All columns control for parent-affiliate fixed effect and business cycle effect. In column 2 under-identification test statistic is 401.164 with Chi-sq(2) P-val 0.000; Weak identification test statistic is 213.5. Sargan test statistic (over-identification test of instruments) is 1.285 with Chi-sq(1) P-val 0.2570. In column 3 Weights are home country FDI outflows. Column 4 includes only US overseas affiliates in the UK. Column 5 includes only US overseas affiliates outside the UK. Some observations are not included in Column 3 due to lack of FDI data for Lichtenstein and Taiwan. Values in parentheses are robust standard errors. Significance levels: *: 0.10; **: 0.05; ***: 0.01.

Table 4: Descriptive statistics – quality of parent matches

Variable	Mean	Std. Dev.	Obs
Panel A: benchmark			
TFP difference	-0.0007	0.07337	3157
Capital (per worker) difference	0.02072	0.934874	3157
Profit (per worker) difference	-0.62429	28.09397	3157
Sales difference	0.032727	0.991751	3157
Employees difference	0.014939	0.934439	3157
Intermediate inputs difference	0.021116	0.88311	3157
Age difference	0.01233	0.949417	3156
Subsidiary difference	0.024144	1.270273	3157
Same sector	1	0	3157
Same country	1	0	3157
Same year	0.41305	0.49246	3157
Probability difference	-0.00045	0.014133	3157
Panel B: matching also on TFP			
TFP difference	-0.00236	0.069105	3160
Capital (per worker) difference	0.006864	0.971878	3160
Profit (per worker) difference	0.003629	1557.053	3160
Sales difference	0.007039	0.941313	3160
Employees difference	0.00681	0.860331	3160
Intermediate inputs difference	0.001029	0.964318	3160
Age difference	-0.01214	0.988634	3160
Subsidiary difference	0.010578	1.300338	3160
Same sector	1	0	3160
Same country	1	0	3160
Same year	0.406329	0.491225	3160
Probability difference	-0.00065	0.015612	3160

Notes: The 'difference' variables are measured in terms of a rate, defined as the ratio between 1) the difference between the value of the variable for the original affiliate and the matched affiliate, and 2) the mean of the two values. The 'same' variables (sector, country, and year) are dummies equal to one if the variable takes the same value in the original and matched affiliates. 'Probability difference' corresponds to the difference between the probabilities of being an affiliate of the original and matched affiliates.

Table 5: Falsification test based on matched affiliates

	benchmark	matching on TFP
TFP, 'affiliate'	0.0194	-0.0150
	(0.02)	(0.02)
Capital, parents	0.141***	0.156***
	(0.01)	(0.01)
Constant	7.421***	7.453***
	(0.25)	(0.26)
No. parents	1,265	1,281
No. affiliates	2,158	2,130
No. observation	11,589	11,484
R-squared	0.77	0.76
F statistics	19.55	23.33

Notes: Dependent variable: TFP of multinational parents. This imposes weights (inverse of the absolute difference in the propensity scores of the true and matched affiliates). It also includes parent-'affiliate' fixed effects and business cycle fixed effects. *TFP, 'affiliates'* is TFP of the matched affiliate. Values in parentheses are robust standard errors. Significance levels: *: 0.10; **: 0.05; ***: 0.01.

Table 6: Effect of Affiliate TFP on Parent TFP, different types of FDI

	(1) Upstream FDI	(2) Upstream RD FDI	(3) Downstream FDI	(4) Horizontal FDI
TFP, affiliate	-0.004	0.122***	0.055***	0.095***
	(0.021)	(0.032)	(0.016)	(0.018)
Capital, parent	0.124***	-0.222***	0.058***	0.069***
	(0.041)	(0.067)	(0.012)	(0.016)
Constant	7.932***	10.864***	8.415***	7.458***
	(0.531)	(0.891)	(0.210)	(0.267)
R-squared	0.97	0.99	0.98	0.97
No. observation	851	95	3305	5816
F statistics	25.96	16.41	24.27	53.14

Notes: Dependent variable: TFP of multinational parents. All variables are in logarithm. 'TFP, affiliates' is TFP of the affiliate. *Capital, parents* is capital per worker of the multinational parents. All columns control for parent-affiliate fixed effect and business cycle effect. *Upstream FDI* is a dummy if an affiliate is upstream of its parent. *Upstream RD FDI* is a dummy if an affiliate is principally engaged in research and development. *Downstream FDI* is a dummy if an affiliate is downstream of its parent. *Horizontal FDI* is a dummy if parent and affiliate are in the same 3-digit industry code. Values in parentheses are robust standard errors. Significance levels: *: 0.10; **: 0.05; ***: 0.01.

Table 7: The role of location on international knowledge transfer

	(1)	(2)	(3)	(4)	(5)
TFP, affiliate	0.099***	0.062***	0.078***	0.130***	0.109***
	(0.014)	(0.021)	(0.021)	(0.021)	(0.021)
Capital, parent	0.145***	0.146***	0.147***	0.147***	0.140***
	(0.019)	(0.019)	(0.019)	(0.020)	(0.022)
TFP, affiliate*IPR	0.093***				
	(0.014)				
IPR regime, host country	0.017				
	(0.012)				
TFP, affiliate*Economic		0.041***			
		(0.011)			
Economic development, host country		-0.004			
		(0.016)			
TFP, affiliate*Law			0.028***		
			(0.010)		
Rule of law, host country			0.006		
			(0.007)		
TFP, affiliate*ROS				0.013*	
				(0.007)	
ROS, affiliate				0.017***	
				(0.004)	
TFP, affiliate*Technology					0.030***
					(0.007)
Technology, host country					0.046***
					(0.013)
No. observation	20124	21020	20914	20264	17347
R-squared	0.949	0.947	0.947	0.946	0.944
F statistics	59.22	58.18	58.25	57.39	50.97

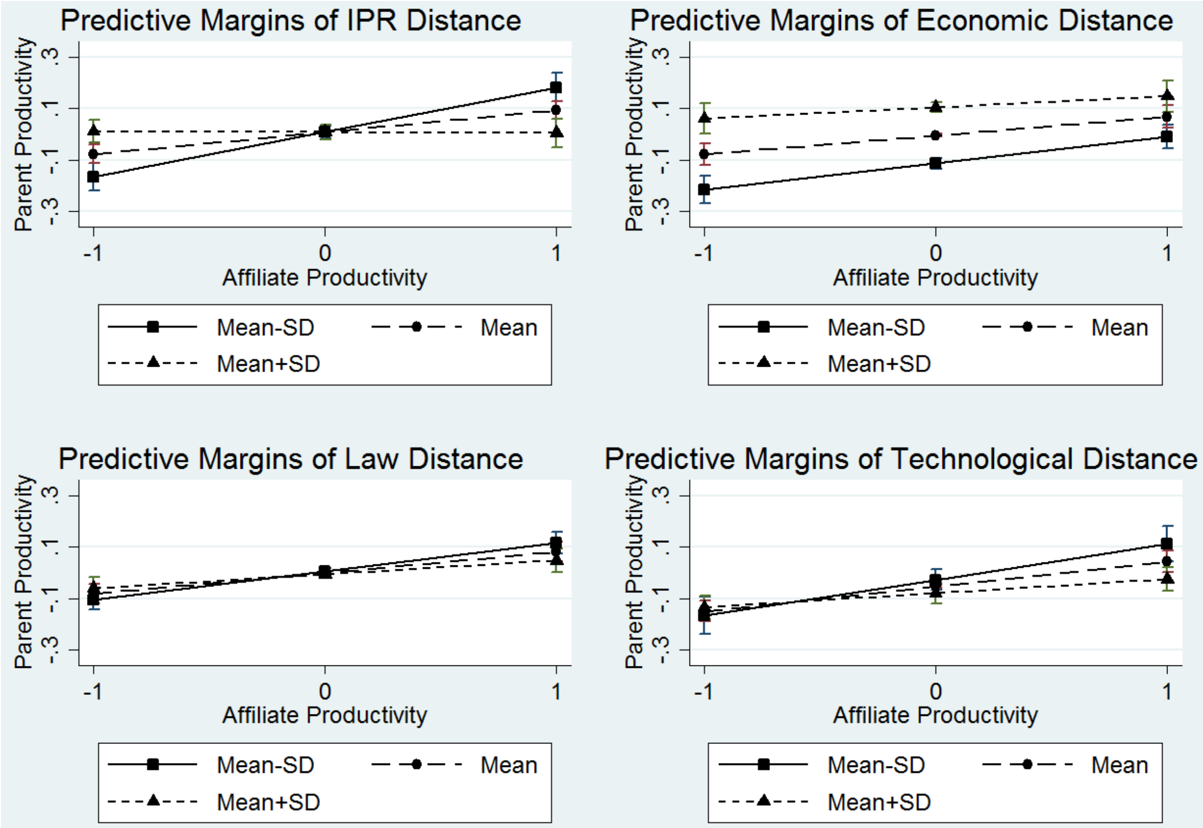
Notes: Dependent variable: TFP of multinational parents. All columns control for parent-affiliate fixed effects and year effects. All variables have been standardised. Values in parentheses are robust standard errors. Significance levels: *: 0.10; **: 0.05; ***: 0.01. See Table 1 for more details on variables.

Table 8: The role of distance on international knowledge transfer

	(1)	(2)	(3)	(4)	(5)	(6)
TFP, affiliate	0.085***	0.073***	0.126***	0.081***	0.097***	0.112***
	(0.017)	(0.021)	(0.020)	(0.019)	(0.021)	(0.020)
Capital, parent	0.146***	0.144***	0.146***	0.147***	0.145***	0.147***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.024)	(0.019)
TFP, affiliate*IPR Dist.	-0.088***					
	(0.015)					
IPR Distance	-0.000					
	(0.013)					
TFP, affiliate*Econ. Dist.		-0.029**				
		(0.015)				
Economic Distance		0.108***				
		(0.010)				
TFP, affiliate*Geography			-0.052***			
			(0.016)			
TFP, affiliate*Law Distance				-0.027***		
				(0.008)		
Rule of law Distance				-0.006		
				(0.006)		
TFP, affiliate*Tech. Dist.					-0.042***	
					(0.010)	
Technology. Distance					-0.027	
					(0.020)	
TFP, affiliate.*Same continent						0.064***
						(0.018)
No. observation	20091	21020	21020	20914	12807	21020
F statistics	58.51	68.03	63.28	59.511	38.52	62.26
R-squared	0.949	0.947	0.947	0.947	0.948	0.947

Notes: Dependent variable: TFP of multinational parents. All columns control for parent-affiliate fixed effects and year effects. All variables have been standardised. Values in parentheses are robust standard errors. All distance variables are relative measures, home country versus host country. Significance levels: *: 0.10; **: 0.05; ***: 0.01. See table 1 for more details on variables.

Figure 1 – Predictive margin plots illustrating the importance of distance



Notes: The above figure shows the predictive margin plots, illustrating the importance of distance in reverse knowledge transfer. All variables have been standardised, to range between -1 and 1 (with zero on average and a standard deviation of one). The margin plots relate high, average and low distance, to the relationship between affiliate and parent productivity when the affiliate moves from a low productivity state to a high productivity one.