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The Influence of Dual Knowledge Networks on Radical and Incremental Innovation

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Abstract
Although extant literature has long argued that the embeddedness of firm operations within knowledge communities exerts a significant influence on learning, we know much less about how multiple knowledge networks interact and impact innovation outcomes. In this paper, we explore how varying degrees of embeddedness in both internal and external knowledge networks can introduce competition across these knowledge networks in terms of knowledge domain dominance, organizational tensions and knowledge relevance perceptions, and influence the incremental and radical knowledge outcomes that are generated in the foreign operations of multinational corporations (MNCs). Empirical results from a comprehensive panel of US MNCs show that higher external knowledge embeddedness increases the positive impact of internal knowledge embeddedness on incremental innovation. However, this same combination limits the radical innovation that is generated in foreign operations. Instead, operations with a lower internal MNC embeddedness and a higher external knowledge embeddedness are more likely to generate radical innovations. Overall, this paper contributes to our understanding of global innovation in MNCs by exploring how multiple knowledge communities interact and influence learning and innovation.

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Although extant literature has long argued that the embeddedness of firm operations within knowledge communities exerts a significant influence on learning, we know much less about how multiple knowledge networks interact and impact innovation outcomes. In this paper, we explore how varying degrees of embeddedness in both internal and external knowledge networks can introduce competition across these knowledge networks in terms of knowledge domain dominance, organizational tensions and knowledge relevance perceptions, and influence the incremental and radical knowledge outcomes that are generated in the foreign operations of multinational corporations (MNCs). Empirical results from a comprehensive panel of US MNCs show that higher external knowledge embeddedness increases the positive impact of internal knowledge embeddedness on incremental innovation. However, this same combination limits the radical innovation that is generated in foreign operations. Instead, operations with a lower internal MNC embeddedness and a higher external knowledge embeddedness are more likely to generate radical innovations. Overall, this paper contributes to our understanding of global innovation in MNCs by exploring how multiple knowledge communities interact and influence learning and innovation.

Keywords: Innovation, Embeddedness, Radical, Incremental, MNCs, Internal Knowledge Network, External Knowledge Network

Introduction:

Although extant literature has long argued that the embeddedness of firm operations within knowledge communities exerts a significant influence on learning (Andersson, Forsgren and Holm, 2002; Almeida, 1996; Saxenian, 1990), we know much less about how competing tensions that come from multiple knowledge networks interact and impact knowledge generation. The foreign operations of multinational corporations (MNCs) are simultaneously embedded in multiple knowledge networks, including the internal MNC knowledge network (headquarters and other subsidiaries) and the external or local host country knowledge network and studies have confirmed that each of these knowledge networks positively influence the innovative activities of foreign operations (Almeida and Phene, 2004; Andersson et al., 2002; Berry, 2014; Song, Asakawa and Chu, 2011; Schleimer and Pederson, 2014). But less explored is how interactions across these internal and external knowledge networks impact the type of knowledge that is generated in foreign operations. This leaves a gap in our understanding of
innovation in foreign operations because all foreign operations will have varying degrees of embeddedness within both internal MNC and external host country knowledge networks (Meyer, Mudambi and Narula, 2011). And these varying degrees of embeddedness can introduce competing tensions across knowledge networks that could either create complementary innovation opportunities or stifle creativity through internal conflict or neglect of knowledge domains.

In this paper, we explore how varying degrees of embeddedness in both the internal and external knowledge networks of foreign operations influence the type of knowledge that is generated in these operations to better understand how multiple knowledge communities interact and influence learning and innovation. Although internal and external knowledge networks have been shown to increase the innovative capacities of foreign operations (Almeida and Phene, 2004; Andersson et al., 2002; Berry, 2014; Schleimer and Pederson, 2014), dual embeddedness can introduce competition across these knowledge networks in terms of knowledge domain dominance, organizational tensions and knowledge relevance perceptions. We consider foreign operations to be embedded in a knowledge network when they interact with and receive knowledge from sources within that network and we focus on foreign operations that have knowledge charters or mandates (as evidenced by performing research and development activities). We focus on two types of innovation: incremental and radical. We argue that although there are benefits to being highly embedded in both the internal MNC knowledge network and external host country knowledge network for incremental innovation, a high dependence on the internal MNC knowledge network is likely to limit the radical innovation that is generated in foreign operations. Instead, the combination of a higher embeddedness in the external host country knowledge network along with a lower embeddedness in the internal MNC operations will make foreign operations more likely to generate radical innovation, because their on-going working relationships and linkages with local suppliers, labor pools, educational
institutions and customers make them more likely to embrace and use different and more distant knowledge bases.

We follow existing studies in the innovation literature and consider incremental innovation to include those foreign patents that cite similar technology class combinations to those that already exist (Henderson and Clark, 1990; Rosenkopf and Nerkar, 2001). We operationalize radical in two ways: first, as new technology class combinations (Rosenkopf and Nerkar, 2001; Shane, 2001; Dahlin and Berhens, 2005) and second, through forward patent citations (Dahlin and Behrens, 2005). As part of the empirics, we include all foreign operations of US MNCs in our analysis and control for knowledge mandates (or the assignment to do knowledge activities) through selection models. We consider royalty payments made to parent operations to capture internal embeddedness because this captures access to intangible parent firm assets, including knowledge and management know-how. To capture external host country embeddedness, we consider the use of local knowledge in the prior innovations of foreign operations (as reflected in the backward citations of firms to host country knowledge). Empirical results from a comprehensive panel of US MNCs and the patents generated in foreign operations support most of the arguments made in this paper. The interaction between the internal and external knowledge networks of foreign operations shows that higher external host country knowledge network embeddedness serves to increase the positive impact of the internal MNC knowledge network on incremental innovation, suggesting that dual embeddedness allows foreign operations to incorporate local knowledge and extend internal MNC knowledge in new and unique ways. However, the results also show a higher internal MNC embeddedness dilutes the positive impact of the external knowledge network on radical innovation.

These dual network interaction results are important because they show how varying degrees of embeddedness across networks jointly impact the knowledge generation outcomes in foreign operations. These results suggest that MNCs face at least two knowledge dilemmas: first, although it is better for incremental innovation outcomes when foreign operations are
highly embedded in both internal and external knowledge networks, that combination limits the radical innovations that are generated in foreign operations. And second, the foreign operations that are best positioned to generate radical innovation (those with high external embeddedness and low internal embeddedness) are also the ones that will be less well connected to the MNC, suggesting that it will be difficult to transfer this knowledge outside of those operations. Overall, this paper contributes to our understanding of global innovation in MNCs by exploring the joint effects of the dual knowledge networks on knowledge generation outcomes in the foreign operations of these firms.

**Innovation and Dual Knowledge Networks**

By their nature, the foreign operations of MNCs are simultaneously embedded in two distinct knowledge contexts: the internal MNC network (headquarters and other subsidiaries) and the external or local host country network. Several scholars have examined the double knowledge network of the foreign operations of MNCs (Gupta and Govindarajanan, 2000; Almeida and Phene, 2004; Phene and Almeida, 2008). Research suggests that not only do foreign subsidiaries receive valuable knowledge from parent firm operations that is then exploited and further developed for the local market (Berry, 2014; Cantwell, 1989; Hymer, 1960), but that subsidiaries also have important relationships with local host country knowledge networks in which knowledge is exchanged with local players, including suppliers, clients, competitors and local universities (Almeida, 1996, Frost, 2001). Studies document distinct advantages that internal and external knowledge networks offer to the innovative capabilities of the foreign operations of MNCs, with each reviewed in turn.

**Internal MNC Knowledge Network:**

Foreign operations that receive technology transfers from their parent firm operations are receiving knowledge that was created in the home market of the MNC for use in the local market of the foreign operations. Intra-organizational knowledge transfers contribute to a subsidiary’s
ability to innovate (Tsai, 2001) and extant research has shown that the MNC is a valuable source of knowledge for a subsidiary (Phene and Almeida, 2008; Berry, 2014). A unified organizational context provides a set of processes and routines within the firm that enables the smooth flow of knowledge into foreign operations (Phene and Almeida, 2008). Continued parent firm knowledge transfers provide foreign operations with a thorough understanding of parent firm know-how and expertise (Taylor and Greve, 2006; Kaplan and Vakili, 2014) because the intra-firm ties associated with transferring such knowledge allow for the more tacit aspects of a firm’s knowledge to transfer successfully to these operations (Hansen, 1999). In addition, parent firm knowledge transfers enhance the ability of these operations to understand the more complex aspects of parent firm knowledge (Szulanski and Jensen, 2006). When foreign operations are highly embedded in the internal MNC knowledge network, they have deep knowledge of the dominant technology of the MNC.

An important advantage of MNCs comes from the sharing of strategic assets throughout the firm’s global network (Gupta and Govindarajan, 2000) and parent firm operations have an interest in making sure foreign operations have access to MNC knowledge because this ultimately benefits the MNC’s global competitiveness across markets (Foss and Pedersen, 2002; Schleimer and Pedersen, 2014; Berry, 2015). The majority of MNCs centralize their knowledge and innovation activities in their home country (UNCTAD, 2005; Berry 2014), although both foreign R&D and foreign-generated innovations have been increasing over the last twenty years (Singh, 2008; Berry, 2014). The high proportion of home-country R&D for most MNCs means that parent firm knowledge plays an important role in the operations of foreign subsidiaries not only at entry but also throughout their existence.

External Host Country Knowledge Network:

Subsidiary external embeddedness is typically defined in terms of the extent to which a unit has developed close relationships with local external actors in the local host country.
knowledge network (Andersson and Forsgren, 1996; Andersson et al., 2002). Foreign subsidiaries have access to important clusters of knowledge, sophisticated suppliers and buyers, and strong educational inputs in the local knowledge network within the host country in which they are located (Porter, 1990; Furman et al., 2002). Cantwell (1989) has argued that technology differs across locations because it is dependent on location-specific factors, such as previously established knowledge bases, the education system and linkages between educational institutions and firms. Within national environments, foreign operations can draw from advanced know-how (Almeida and Phene 2004; Alcacer and Chung, 2007; Singh, 2008) by hiring local engineers and scientists to bring advanced knowledge into firm R&D activities (Chung and Yeaple, 2008; Almeida and Phene 2004; Singh, 2008), they can work with advanced suppliers and they are challenged by demanding customers (Porter, 1990). Customers and suppliers play an important role for the manufacturers’ development of products and processes (von Hippel, 1988). Chung and Yeaple (2008) argue that innovation activities in countries with greater knowledge stocks can allow MNCs to supplement their R&D activities, surmount investment hurdles for new generations of products, remain competitive with industry players, and help firms advance their own knowledge in the technology class.

Types of Innovation: Incremental and Radical Innovation:

Although internal and external knowledge networks have been shown to increase the innovative capacities of foreign operations (Almeida and Phene, 2004; Andersson et al, 2002), extant literature has not yet explored how complimentary or competing aspects across these different knowledge networks will jointly influence the types of innovation that are generated in foreign operations. Innovation is a process of discovery and learning that generates new technologies or techniques aimed at transforming knowledge into a variety of economic and productive activities and several studies distinguish between incremental and radical innovation (Anderson and Tushman, 1990; Christenson and Rosenbloom, 1995; Tripsas, 1997) and both of these types of innovation are important for MNCs. Incremental innovation takes place within an
already existing range of products, services, businesses or processes for already existing customers in already existing market segments. Incremental innovation pushes existing technology combinations further through continuous improvement, product differentiation or adaptation to specific customer requirements. Incremental innovation can enhance and sustain the revenue and profit streams of firm technologies, especially the profits of MNCs as they exploit and adapt their technological knowledge in foreign countries.

Unlike incremental innovation, radical innovation aims to create fundamentally new businesses, products, or processes. As Schumpeter (1942) first argued, it is most common for radical innovation to derive from a novel mix or application of extant knowledge with new knowledge, with both being mutually transformed and combined. Where incremental innovation pushes the frontier of existing technology paradigms, radical innovation presents new products and processes, based on technology combinations that haven’t been previously explored (Rosenkopf and Nerker, 2001). From a technological perspective, radical innovation departs from existing technological trajectories to produce a new progression along which knowledge development can continue.

Both incremental and radical innovations are fundamental to MNCs because these firms need to not only exploit, but also augment their technological position throughout their operations. MNCs need to exploit their existing know-how and knowledge in new geographic areas and this may require alterations to existing products, services, business processes or production. Incremental alterations can allow MNCs to create products and production processes that increase the appeal and attractiveness of firm products worldwide. At the same time, all firms need to explore new mixes of knowledge and technologies to remain competitive in their global industries. An important underlying motivation for internationalizing firm R&D is to access skills and capabilities that reside overseas (Buckley and Casson, 1976). There are pockets of expertise that develop due to peculiarities of “national innovation systems” (Nelson, 1993) and when firms invest in R&D abroad, they can tap into local knowledge that doesn’t exist
elsewhere. Because MNCs are exposed to new and different consumers and ideas through their foreign operations, these operations are well-suited for both types of innovation.

Although internal and external knowledge networks have been shown to increase the innovative capacities of foreign operations, the dual embeddedness can introduce competition across these knowledge networks in terms of knowledge domain dominance, organizational tensions and knowledge relevance perceptions. Although internal and external knowledge networks have been shown to increase the innovative capacities of foreign operations (Andersson, Forsgren and Holm, 2002; Gupta and Govindarajanan, 2000; Almeida and Phene, 2004; Phene and Almeida, 2008), extant literature has not adequately explored how the joint influence of internal and external knowledge networks impacts incremental and radical innovation outcomes in foreign operations. In this paper, we explore how embeddedness in both internal and external knowledge networks influence the type of knowledge that is generated in foreign operations. Figure One summarizes the different combinations we explore below and the main innovation outcomes that we argue will come from each combination.

**High internal embeddedness and low external embeddedness**

Strong internal knowledge flows from parent to foreign operations are not likely to play the same role in encouraging incremental and radical innovation in foreign operations. When foreign operations are highly embedded in the internal MNC knowledge network, they have strong connections with parent firm knowledge and these operations are more likely to look primarily to the internal knowledge network of the MNC to provide the know-how and knowledge used in these operations versus seeking more diverse knowledge from the local host country market. Research stresses that shared cognitive frames, routines and resources can limit flexibility, and create inertial forces (Benner and Tushman, 2002; Tripsas and Gavetti, 2002). Transfers of parent firm knowledge create shared knowledge frames which can introduce inertial forces against new and more radical technology paths in foreign operations. The strong relationships that are necessary for knowledge transfer (Gupta and Govindarajan, 2000; Levin
and Cross, 2004; Reagans and McEvily, 2003) between the foreign operation and the parent firm are likely to be associated not only with an environment of sharing and mutual understanding with parent firm operations (Reagans and McEvily, 2003), but also with more groupthink and incremental recycling of ideas (Burt, 2004, Hargadon and Sutton, 1997).

Being dependent on knowledge created elsewhere will also mean that the foreign operations have overlapping competencies that are steeped in the parent firm knowledge domain. Active knowledge transfers from parents to foreign operations help to shape the managers in foreign operations (Foss, 1997). This dependence, common knowledge domain, shared knowledge frames will all tend to limit the knowledge generation that is performed to be focused on extensions of parent firm knowledge that can be used in the focal market. These operations are more likely to generate innovations that are based highly on the designs and approaches used in the “incumbent” parent firm operations (Martin and Mitchell, 1998) because of the strong parent firm connections and important role that the internal knowledge network of the MNC plays in these operations. Changes and new approaches are more likely to be focused on pushing existing parent firm generated technologies through continuous improvement, product differentiation or adaptation to specific customer requirements in the local market. Strong internal connectivity with headquarters operations is thus likely to lower the use of more distant host country knowledge, which will make the resulting innovations more incremental in nature. When there is low knowledge embeddedness in the external knowledge network, the influence of the internal MNC knowledge network will dominate, which will positively influence the generation of incremental innovation.

**H1**: High embeddedness in the internal MNC knowledge network is positively associated with incremental innovation in foreign operations.

**Low internal embeddedness and high external embeddedness**

The more subsidiaries are embedded in the local context, the more their activities, resources and knowledge become oriented toward the local context. Subsidiary relationships are
characterized by exchange of information, resources and knowledge with local actors when there is high embeddedness within the local context (Andersson et al., 2002). Relationships with customers and suppliers influence the technological competencies of the foreign operations and enhance learning about local knowledge. A high level of external embeddedness thus provides new knowledge to the foreign operation which can be used in both production processes and product development.

Regarding radical innovation in particular, several researchers have argued that accessing new knowledge from outside the boundary and technology domain of the organization is more likely to produce radical innovations that breaks from past models (Trajtenberg et al., 1997; Gavetti and Levinthal, 2000), with prior research also showing that more radical process adoption is generated by a concentration of technical specialists (Ettlie, Bridges and O’Keefe, 1984). Being more receptive of local host country knowledge will encourage different approaches and combinations of technology domains. Having access to lower levels of MNC knowledge and higher levels of diverse local host country knowledge can help these foreign operations overcome problems with groupthink or recycling of ideas (Burt, 2004, Hargadon and Sutton, 1997). When these foreign operations draw from diverse clusters of knowledge and know-how in the host country market (Almeida and Phene, 2004; Alcacer and Chung, 2007; Singh, 2008), they can employ best practices, increase efficiencies and further specialize their operations. Further, by exploiting local host country knowledge, these operations can generate innovations that push MNC knowledge forward by combining internal and external knowledge pools. The combination of a higher embeddedness in the host country knowledge network and lower knowledge embeddedness in the internal MNC knowledge network is thus likely to positively influence the generation of more radical innovation in foreign operations. When there is low knowledge embeddedness in the internal knowledge network, the influence of the external MNC knowledge network will dominate, which will positively influence the generation of radical innovation.
H2: High embeddedness in the external knowledge network is positively associated with radical innovation in foreign operations.

High internal embeddedness and high external embeddedness

Finally, we consider the combination of high embeddedness in both the internal MNC and external host country knowledge networks. Thinking about the effect of high embeddedness in both the internal and external knowledge networks on incremental innovation first, the influence of the shared cognitive knowledge frames and strong connections that allow for successful knowledge transfer is likely to augment the importance and dominance of the internal knowledge network to the foreign operations. A deeper reliance on parent firm knowledge has been shown to lock inventors in foreign operations into the dominant parent firm way of thinking and block more radical innovations in these operations (Hargadon and Sutton, 1997). Asakawa (1996) and Song et al (2011) argue that strong internal linkages in the overseas R&D labs of MNCs will lessen the extent of local knowledge use. But this does not mean that the external host country knowledge network will be ignored, but instead it suggests that the knowledge that is sought and used is more likely to extend the dominant knowledge base of the MNC and be highly related to that dominant parent paradigm. Strong ties to the parent organization make interaction and use of competing architectural knowledge much more difficult because decision makers in the headquarters of MNCs tend to favor those foreign opportunities that are market proven and simply confirm what the MNC already knows (Monteiro, 2015). A process of “corporatization” may force attention toward the corporate network at the expense of attention towards external knowledge networks (Asheim and Herstad, 2005), with stronger internal communicative capacity coming at the expense of attention towards external linkages (Blanc and Sierra, 1999).

We argue that there are benefits to being highly embedded in both the internal MNC knowledge network and external host country knowledge network for incremental innovation. This outcome is specific to incremental extensions of parent firm knowledge, given the
arguments above about the strong connections and dominance of the internal knowledge network to the foreign operation. Thus,

\[ H3: \text{The positive effect of internal MNC knowledge embeddedness on incremental innovation is stronger when foreign operations have high embeddedness in the external host country knowledge network.} \]

Thinking about the impact on radical innovation, the arguments above summarize that a deeper reliance on parent firm knowledge will lock inventors into the dominant parent firm way of thinking (Hargadon and Sutton, 1997), which will tend to block more radical innovations from being generated in these operations. When foreign operations are highly embedded in the internal MNC knowledge network, it will be more difficult for those operations to undertake technology initiatives that explore the potential value of diverse host country knowledge (Gupta and Govindarajan, 1994; Schleimer and Pedersen, 2014) because these operations are entrenched in the existing and established products and production processes of the parent firm operations. This suggests that high internal MNC and external host country knowledge network embeddedness will tend to result in less radical innovations in foreign operations. Yamin and Andersson (2011) show that internal embeddedness can dilute the positive impact of external embeddedness on a subsidiary’s importance to production development and this suggests that the internal network influences may even counteract the positive effect of local knowledge in terms of generating diverse and radical approaches to innovation. While technology transfers allow foreign operations to successfully access the knowledge base of the parent firm, arguments from both the innovation and foreign knowledge seeking literatures suggest that foreign operations with more parent firm knowledge transfers are less likely to use more distant knowledge in local host country knowledge networks that might disrupt the dominant technology paradigm of the parent firm. Employees in the foreign operations may not even see the local knowledge as being relevant if it is too distant from the dominant paradigm from the internal MNC knowledge network.
A competing argument is that foreign operations need to be highly embedded in both the internal and external knowledge networks to develop radical innovation. Relationships with local suppliers and other MNC units, local production, joint understanding of architectures and rich communication opportunities may allow these operations to understand complex knowledge from both the MNC and the local environment and foreign operations could utilize both MNC and host country knowledge to develop and transform the knowledge base (Subramaniam and Youndt, 2005) of the MNC. Knowledge coordination between these knowledge networks may allow for more diverse combinations of existing technologies and without higher embeddedness in both knowledge networks, foreign operations could be less likely to be able to generate more diverse and radical innovations. However, the argument that foreign operations with more parent firm knowledge transfers are less likely to use more distant knowledge in local host country knowledge networks that might disrupt the dominant technology paradigm of the parent firm makes the use of more distant knowledge from the external market less likely. The fourth hypothesis argues that high embeddedness in both the internal MNC knowledge network and the local host country is less likely to lead to radical innovation in foreign operations.

\[ H4: \text{The positive effect of external host country knowledge embeddedness on radical innovation is weaker when foreign operations have high embeddedness in the internal MNC knowledge network.} \]

Data and Methods:

Data:

To examine these hypotheses, we combine confidential firm level data on the worldwide operations of US MNCs from the Bureau of Economic Analysis (BEA) with data on the foreign invented patents of these firms from the USPTO. Every year, the BEA collects detailed information on the worldwide operations of US MNCs, which comprise data reported for US parent companies and each of their foreign affiliates.\(^1\) Because the BEA surveys are mandatory,

\(^1\) These data are collected for statistical purposes, with aggregate tabulations of the data released to the public at the industry and country levels.
these data provide the most comprehensive information on the operations of US MNCs that is available.\(^2\)

Separate survey reports are filed for US parent companies and their foreign affiliates in the BEA data. US parent companies are allowed to consolidate their reports for multiple affiliates in the same host country if those affiliates operate in the same detailed industry or are otherwise integral parts of the same business operations. This means that US firms may have multiple affiliates in one annual country report that is returned to the BEA. This also means that we do not have foreign addresses for each foreign affiliate of each US MNC. Instead, we have consistent country-level information on the foreign operations of each US MNC. Because we do not know when an MNC has aggregated their affiliate data, we aggregated all foreign affiliate information to the country level for each MNC in each year. This means that the foreign operations of each MNC refer to the country level of operations for each firm. By aggregating all affiliate operations data to the country level, we are able to match the country foreign operations data from the BEA with the inventor country locations in the patent data.

Because patents from different patent offices across the world may not be comparable to each other, it is common to use data from a single patent granting country (Jaffe and Trajtenberg, 2002) to standardize the measure of innovation. Given that we are analyzing US MNCs, we use data on US patents from the US Patent Office (USPTO). We used the names of firms to match the BEA and USPTO data.\(^3\) We included patent applications from 1989 to 2004 that were ultimately granted by the USPTO to capture new innovations. We found that 3,048 firms applied for patents that were ultimately granted during this time period. We restricted our sample to manufacturing industries because the majority of patents were granted to firms whose

\(^2\) Specifically, the International Investment and Trade in Services Survey Act requires U.S. MNCs to report detailed information on the financial and operating activities of both U.S. parent companies and their foreign affiliates, as well as information on the value of transactions between the parents and affiliates. (See Mataloni, R & D Yorgason, 2006, for a thorough description of definitions and survey methodology used by the BEA.)

\(^3\) We used a name matching program to match firm names across the BEA and patent databases.
main industry is manufacturing. Our sample is comprised of 1,742 US MNCs and their foreign operations from 1989-2004.

The USPTO has recorded the name, address and country of each inventor on each patent. Following standard practice, we consider the country of residence of the inventors as the country where an innovation takes place. For summary information, we follow the majority rule approach and assign a patent to the country with the most number of inventors. (This approach turns out to be very similar to a first inventor approach, as inventor names are not alphabetical and the majority country is often the first listed country on international patents.) Using the majority rule approach, 621 MNCs took out a patent with at least one foreign inventor included. This translates to 35% of US manufacturing MNCs who patent as having at least one foreign invented patent. These firms were granted 37,051 patents with at least one foreign inventor over the time period of this study.

Measures:

**Dependent Variables:** Our dependent variable is a count of the new radical or incremental patent applications (that were ultimately granted). All patents must provide a list of citations to previously granted patents and patent citations are supervised by patent examiners, who verify that the list of patent references included in each patent application is complete before it is analyzed. We use the technology class of the cited patents to determine the incremental or radicalness of the patent. We follow existing studies in the innovation literature and consider incremental innovation to include those foreign patents that cite similar technology class-subclass combinations in their backward citations to those that already exist within the USPTO (Henderson and Clark, 1990; Rosenkopf and Nerkar, 2001). We operationalize radical innovation as new technology class-subclass combinations (Rosenkopf and Nerkar, 2001).

To create these measures, we used the NBER patent data base and the international (based on the icl variable, which is the main four character IPC) technology classifications listed
in that database. We consider technology class combinations that have already been cited from 1976 onwards (which correspond with the beginning of the NBER citations files). For every patent in the NBER database, we created the cited technology combination that exists and then compared the technology class citation combination of the foreign patents of our US MNCs to the already cited technology combination in the pool of all patents (in years prior to the focal patent). If the technology class citation combination has already been cited prior to the application year of the granted focal patent, we categorized the innovation as incremental. If the technology class citation combination has not already been cited (meaning that combination has not previously been cited), it was categorized as radical.

Looking at the dependent variables, of the 3,372 foreign country year observations that generated patents in the final dataset of US MNCs and their foreign operations, 3,065 of these generated incremental innovations while 307 generated radical innovations. This low number of foreign country year observations for radical innovations isn’t surprising, given that to be a radical innovation means combining technology classes that haven’t previously been combined in any USPTO patent.

**Independent Variables:** Our main independent variables are internal MNC knowledge embeddedness and external host country knowledge embeddedness. For internal MNC knowledge embeddedness, we consider transfers of parent firm knowledge to foreign operations. Royalties and licensing fees are paid to parent firms for the use of intangible property, such as patents, industrial processes, trademarks, copyrights, franchises, manufacturing rights or other intangible assets or property rights. While there are difficulties associated with using royalty and license receipts (because these payments require firms to price the value of the technology being transferred and there are different tax rates across host countries), US law requires multinationals to charge the same price for intra-firm transactions on intangible assets as for unrelated arm’s length transactions (Feenstra and Hansen, 1997). Branstetter and colleagues (2006) argue that US multinationals charge the same royalties in different countries to avoid scrutiny from tax
authorities. Technology licensing fees accounting for close to 90 percent of the royalty payments of US MNCs when surveyed about these fees. Knowledge dependence is operationalized as total royalty payments to parent firm operations divided by the total sales of the foreign operation.

To capture external host country knowledge embeddedness, we consider the past local patent citation ratio. We created the ratio of local host country backward citations to total backward citations by dividing the count of patent citations invented in the host country to all worldwide patent citations considering all prior subsidiary patents.

Foreign Operation and MNC Control Variables: R&D has been widely used as a measure of firm investment in knowledge assets (Buckley and Casson, 1976; Morck and Yeung, 1991; Berry and Sakakibara, 2006) and the BEA collects data on the R&D expenditures for each foreign affiliate and parent firm. We created a measure of parent firm R&D intensity by dividing total US R&D expenditures by total US sales. We include the log of total country operations to control for the size of foreign operations in the specific foreign country. We also included the log of MNC worldwide assets.

We include a control for manufacturing integration with other MNC operations. The BEA collects information on product transfers to and from both parents and affiliates. This measure includes both intermediate and final products (and does not break this information down). We created our measure by aggregating information on the product outflows to parent and affiliated operations in other countries. We then scaled this measure by total subsidiary sales. (More specifically, we created a ratio of the sum of total exports to the parent firm plus total exports to other third-country affiliates and divided that total by the sales of the foreign operation.) We also include the product diversity (Palepu, 1985) of each firm to capture the

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4 To lessen concerns about reported values for royalty payments, we have run the results below excluding all tax haven countries. It is countries that have much lower tax rates that are argued to drive discriminatory royalty payments within MNCs and the results do not change after dropping these countries.
technological diversity of a firm and use a herfindahl type index that considers sales across three-digit SIC codes. We used the following formula to calculate this variable:

\[
\text{Product Diversity} = \sum_{i=1}^{n} P_i \times \ln\left(1/P_i\right)
\]

where \( P \) is the proportion of the firm’s sales within the each \( i^{th} \) 3 digit SIC code.

For country controls, we include several variables that can impact the attractiveness of doing R&D in that location. Several studies have shown many country level variables to significantly influence foreign R&D locations (Ambos and Ambos, 2009; Berry, 2006; Alcacer and Chung, 2007; Chung and Yeaple, 2009) and we incorporate many of these host country location attributes. We start by including the log of GDP to proxy for host country size and the lagged difference in GDP per capita to capture growth in each country. Geographic distance can impact performance because it may be difficult to oversee and conduct business activities in distant countries and we include a measure of the geographic distance of the host country to the US. These time-varying variables come from the World Bank’s World Development Indicators. We include a measure of political uncertainty for each country using Henisz’ (2000) PolConV time varying values.

We capture the strength of host country knowledge in the technology class of the new foreign patent itself. We used patent inventor country and main IPC (International Patent Class) technology class data to calculate the percent of worldwide patents in each technology class that are generated in the host country of the foreign operation in each year. We used patent stocks for both the numerator and denominator for this variable, calculated using a 15% depreciation rate (Hall, Jaffe, and Trajtenberg, 2001). We also created a herfindahl measure of technology diversity in the host country, considering the proportion of country patents in each USPTO technology class to create this measure. We controlled for differences in the protections for firm intellectual property across countries. We used Park’s (2008) updated index of patent protection (from the original Ginarte and Park (1997) index). This measure incorporates the unweighted
sum of separate scores for coverage, membership in international treaties, duration of protection, enforcement mechanisms, and restrictions.

As noted above, because we incorporate a measure for royalty payments, we also include a variable to capture differences in tax rates across countries. While firms are supposed to apply fair market values for all within-firm payments, differences in tax rates can impact the price that is reported. Hines (1995) and Grubert (1998) found that host country income tax rates can be used to control for the effects of tax incentives on reported intra-firm royalties. We consulted the World Tax Database at the University of Michigan to gather time-varying tax rates for host countries. We used the reported corporate tax rate and generated the difference from the US corporate tax rate for each country for each year. Table One describes the various measures used, and Table Two provides summary statistics and correlations.

***Insert Tables One and Two about here***

**Methods:**

To examine our first hypothesis, we used a HECKPROB model at the firm level of analysis. Some MNCs may not consider foreign markets at all in their knowledge activities and we incorporate a first stage equation to select those operations that perform R&D to limit this selection bias. We use a variation of Heckman’s selection model capable of estimating binary outcomes in both the selection and estimation equations. The bivariate PROBIT model with sample selection (HECKPROB) produces a series of coefficients that have been adjusted to account for firms doing R&D in the host country. These models are jointly estimated by using full information maximum likelihood estimation. We included year fixed effects in all analyses and also clustered by the parent-country operation.

It is necessary in Heckman-style models to include a unique variable that predicts the outcome in the selection equation but not in the estimation equation. The exclusion restriction we included is the extent of import penetration into the US, which is measured as the ratio of
foreign imports to US domestic shipments using data from Schott (2004). A higher share of imports into the US domestic market suggests that foreign firms have advanced capabilities to compete with US firms. This would lead to increasing pressures to become more competitive across foreign markets, which is likely to require increasing attention to differences across markets (through higher local R&D expenditures) by US firms (Hutzschenreuter and Grone, 2007). We would not expect foreign competitor import penetration in the US to have a significant impact on US firm foreign invented patents in foreign countries because this will depend more on the capabilities and experiences of the foreign operations (as it is difficult to successfully generate any innovations). There is a significant difference in model fit when we include import penetration in the first stage. Inclusion of this variable in the second stage confirms that it does not have a significant relationship with firm foreign patenting. To examine how the internal and external embeddedness of foreign operations impacts the incremental and radical innovations generated in these operations, we ran separate models predicting incremental and radical patent generation in foreign operations.

Results:

Before discussing the empirical results, it is interesting to consider some of the trends in the combined BEA and USPTO dataset regarding incremental and radical innovation in the foreign operations of US MNCs. First, only about 10% of the foreign operations of US MNCs have patents and only about 20% do R&D. This suggests that it is important to incorporate controls for foreign R&D and foreign subsidiary knowledge mandates, given that the majority of the foreign subsidiaries of US MNCs do no R&D and generate no patents.

***Insert Table Three about here***

Table Three reports results from the HECKPROB model, including a selection equation for foreign operations that do R&D. These models report the impact of the internal and external knowledge networks on the incremental and radical innovation generated in foreign operations,
conditional on firms doing R&D. Across all four reported models, the correlation between the error term in the outcome model and the error term in the selection model (rho) is significantly different from zero across each column, confirming the necessity of the selection models.

We start by considering the main effects of the embeddedness variables, to get a sense for the relationships across the main effects for internal and external embeddedness and the type of innovation, controlling for all other variables. Model I in Table Three shows that the coefficient for internal embeddedness has a positive and significant relationship with incremental innovation, after controlling for the knowledge mandate of the foreign operation. In addition, Model III in Table Three shows that internal embeddedness has a negative and significant relationship with radical innovation. There is a statistically significant difference across the coefficients for internal embeddedness in Models I and III ($z=2.01, p<.05$), which supports the logic behind Hypothesis One – that high internal embeddedness is associated with incremental and not radical innovation in foreign operations. Marginal effects (not reported in the interest of space, but available upon request) show internal knowledge embeddedness increases incremental patents by a factor of 1.09, holding all other variables constant.

Model III in Table Three shows that the coefficient for external embeddedness has a positive and significant relationship with radical innovation. However, Model I in Table Three also shows that the coefficient for external host country knowledge embeddedness has a positive and significant coefficient with incremental innovation. Thus, although external host country knowledge embeddedness has a statistically significant influence on radical innovation, it does not have a significantly different effect on incremental versus radical innovation. Although this result supports the logic behind the second hypothesis – that higher external host country embeddedness will be related to radical innovation – these results also show that higher external host country embeddedness is related to incremental innovation.

We now move on to considering the interaction effects across the internal and external
knowledge networks. The coefficients for the interaction effects are shown in Table Three, with Model II reporting the results for incremental innovation and Model IV reporting the results for radical innovation. In the third hypothesis, we argued that the positive effect of internal MNC knowledge embeddedness on incremental innovation is stronger when foreign operations have higher embeddedness in the external host country knowledge network. The results in Model II show that the coefficient for the interaction is positive and significantly related to incremental innovation.

In the fourth hypothesis, we argued that the positive effect of external host country knowledge embeddedness on radical innovation is weaker when foreign operations have higher embeddedness in the internal MNC knowledge network. The results in Model IV show that the coefficient for the interaction is negative and significantly related to radical innovation. These results suggest that when internal embeddedness is low, high external embeddedness has the largest impact on radical innovation. In contrast, when internal embeddedness is high, the positive effects from high external embeddedness are significantly decreased. These results both support the fourth hypothesis that high internal embeddedness will dilute the positive effects of high external embeddedness on radical innovation and provide some support for the second hypothesis (that radical innovation outcomes are highest when foreign operations have high external embeddedness and low internal embeddedness).

The controls behave mostly as expected. Many of the controls have the same impact on incremental and radical innovation estimations, including the positive and significant effect from parent R&D intensity, foreign operation R&D intensity, country patent protection, country technology diversity and foreign operation size. In terms of the selection equation, several of these variables also have the same impact across the incremental and radical innovation estimations, including, manufacturing integration, parent R&D intensity, country size and MNC size. These results suggest that larger MNCs that are more R&D intensive tend to do both R&D and generate innovations in larger countries with higher intellectual property protections in
place. These controls also highlight the importance of examining the internal and external
embeddedness, given the differential effect that these variables have on knowledge outcomes in
foreign operations.

Discussion:

This paper furthers our understanding of global innovation in MNCs by exploring how
embeddedness in internal and external knowledge networks influences innovation outcomes in
the foreign operations of MNCs. Although existing studies have shown that both internal MNC
and external host country knowledge influence the innovative activities of foreign operations
(Andersson et al., 2002; Gupta and Govindarajanan, 2000; Almeida and Phene, 2004; Berry,
2014; Schleimer and Pederson, 2014), we know much less about how interactions across these
internal and external knowledge networks influence the types of innovations that are generated in
foreign operations.

Throughout this paper, we have been careful to articulate our belief that both incremental
and radical innovations are fundamental to MNCs. Parent firm knowledge provides firms with
advantages that can be exploited in foreign countries (Hymer, 1960; Buckley and Casson, 1976;
Zaheer, 1995). However, exploiting this knowledge in new geographic areas may require
alterations to existing products, services, business processes or production. As argued above,
incremental alterations allow MNCs to create products and production processes that increase the
appeal and attractiveness of firm products worldwide (with the summary statistics showing that
the majority of foreign innovations by US MNCs are incremental in nature). Equally important,
firms need to explore new mixes of knowledge and technologies to remain competitive in their
global industries. It has long been argued that MNCs are in a unique position to gain competitive
advantage by tapping into knowledge that doesn’t exist outside of a particular host country and
integrating streams of diverse knowledge across their geographically dispersed operations
(Cantwell, 1989). Because MNCs are exposed to new and different consumers and ideas through
their foreign operations, both incremental and radical innovation help these firms compete throughout their worldwide operations.

We argue that there are benefits to being highly embedded in both the internal MNC knowledge network and external host country knowledge network for incremental innovation. And our empirical results show that higher external host country knowledge network embeddedness increases the positive impact of the internal MNC knowledge network on incremental innovation. This suggests that dual embeddedness allows foreign operations to incorporate local knowledge and extend internal MNC knowledge in new and unique ways. Because the innovation outcome is incremental, these innovations are likely to be extensions of already existing technology and production processes, which can provide important extensions of parent firm knowledge to the local market context. However, this same combination of dual embeddedness will limit the radical innovation that is generated in foreign operations. And the results show that a higher internal MNC embeddedness dilutes the positive impact of the external knowledge network on radical innovation. Instead, we argue that a combination of higher embeddedness in the external host country knowledge network and lower embeddedness in the internal MNC operations will make foreign operations more likely to generate radical innovation because their on-going working relationships and linkages with local suppliers, labor pools, educational institutions and customers make them more likely to embrace and use different and more distant knowledge bases. Our results confirm that those operations with a lower internal MNC embeddedness and a higher external knowledge embeddedness are more likely to generate radical innovation.

These dual network interaction results are important because they show how varying degrees of embeddedness in both knowledge networks jointly impact the knowledge generation outcomes in foreign operations. They point to knowledge trade-offs that MNCs will confront when trying to tap into multiple knowledge networks. Although high embeddedness in both internal MNC and external host country knowledge networks positively and significantly
influence incremental innovation outcomes, this same combination will tend to limit the radical innovation outcomes in foreign operations. Prior research has argued that several challenges arise from multiple embeddedness (Meyer et al., 2011), with Andersson et al. (2007) showing that external embeddedness may reduce subsidiary interest in contributing to the overall performance of the MNC. The results in this paper suggest that the foreign operations that are best positioned to generate radical innovation (those with high external embeddedness and low internal embeddedness) are also the ones that will be less well connected to the rest of the MNC. This has larger implications because when foreign operations have fewer connections with other MNC operations, it will be more difficult to share and transfer the innovations that are generated in those foreign operations (Hansen, 1999). Extant research shows that organizations tend to have biases that block them from seeing potentially more effective or alternative problem-solving approaches (Nelson and Winter, 1982), with firms are often being less receptive to knowledge from abroad (Gupta and Govindarajan, 2000), instinctively reacting negatively to external ideas - the so-called “not invented here” syndrome. Without the strong intra-organizational relationships (Almeida, Grant and Song, 1998; Phene and Almeida, 2008) that can come from being highly embedded in the internal MNC knowledge network, it will be difficult to share the radical innovation generated in foreign operations because knowledge sharing is facilitated by relationships (Hansen, 1999; Levin and Cross, 2004). Future research could certainly explore how MNCs can successfully learn from foreign operations that are not highly embedded in the internal knowledge network of the MNC.

One limitation of our study is that we do not have access to knowledge charters of foreign operations, or the changing knowledge mandates of these operations. Through our empirical approach, we control for the assignment of knowledge responsibilities in foreign operations by using a selection equation for foreign R&D assignment, using this to proxy for knowledge mandates. We argue that this allows us to focus on those foreign operations that actually have a mandate or the resources to generate innovations. While it could be argued that foreign
subsidiaries that receive higher levels of knowledge transfers from parent firm operations may be “chartered” to generate incremental innovation, we believe that it is unlikely that MNCs would assign foreign operations to only perform incremental innovation, or purposefully limit the types of innovations that are generated in foreign operations. Further, given that subsidiary charters can change over time, we believe that our time-varying inclusion of foreign affiliates that do R&D better allows for some evolution in subsidiary mandates over the time period we are studying. Of course, we would welcome future research with access to subsidiary charters to tease out some of these potential issues.

Overall, this paper contributes to our understanding of global innovation in MNCs by highlighting the joint effects of the dual knowledge networks on innovation outcomes. We explore how varying degrees of embeddedness in both the internal and external knowledge networks of foreign operations influence the type of knowledge that is generated in these operations to better understand how multiple knowledge communities interact and influence learning and innovation. Empirical results from a comprehensive panel of US MNCs and the patents generated in foreign operations show that higher external host country knowledge network embeddedness serves to increase the positive impact of the internal MNC knowledge network on incremental innovation, while higher internal MNC embeddedness dilutes the positive impact of the external knowledge network on radical innovation.
References:


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<td>0.26** (0.04)</td>
<td>0.06** (0.03)</td>
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<td>-0.01 (0.01)</td>
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<td>Intercept</td>
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<td>0.21** (0.09)</td>
<td>0.02* (0.01)</td>
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<td>Selection Equation</td>
<td>dependent variable R&amp;D? N/Y (0/1)</td>
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<td>Manufacturing Integration</td>
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<td>0.17* (0.03)</td>
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<td>0.02* (0.01)</td>
<td>0.01 (0.01)</td>
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<td>-0.15** (0.03)</td>
<td>-0.14** (0.03)</td>
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<td>Coefficient 1</td>
<td>Coefficient 2</td>
<td>Coefficient 3</td>
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<td>Parent R&amp;D Intensity</td>
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All independent variables are lagged by one period and all models include robust standard errors; Significance level (two-sided): † <10%, *<5%, **<1%
Figure One: Dual Knowledge Network Embeddedness and Knowledge Type Outcomes:

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<th>Internal Embeddedness:</th>
<th>Low</th>
<th>High</th>
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<tr>
<td>External Low</td>
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<td>Incremental</td>
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<tr>
<td>Embeddedness: High</td>
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