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The Global Family Patents of Multinational Corporations

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Abstract

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Keywords: Family Patents, Multinational Corporation, Knowledge, Knowledge Diffusion, Multimarket Competition, Rivals, Competitors

Introduction:

Multinational corporations (MNCs) are important generators of innovation and significant drivers of technology diffusion across countries. MNCs are highly innovative and transfer knowledge to their foreign operations (Hymer, 1960; Caves, 1996; Cantwell, 1989) both to overcome liabilities of foreignness (Hymer, 1960; Zaheer, 1995; Shaver and Flyer, 2000) and to successfully compete in these markets (Alcacer, 2006; Berry, 2014, 2015). However, our understanding of the global knowledge diffusion of MNCs is limited because there is no research (of which I am aware) that has actually examined the worldwide patenting and diffusion of

knowledge by MNCs. Although several studies have analyzed patent data from a single patent authority and considered differences in the multi-country innovations of these firms (Singh, 2008; Berry, 2014) or differences in the local versus foreign citations of the patents of these firms (Almeida, 1996; Singh, 2008; Zhao, 2006), these approaches can only provide a partial picture of the generation and diffusion of knowledge by MNCs because it is impossible to know whether firm knowledge is an equivalent patent to innovations in other countries or whether a firm has knowledge that has only been patented in a different country when using data from one patent-granting authority. This incomplete picture limits both our understanding of the global innovation choices of MNCs and the inferences that researchers can make about global knowledge diffusion by these firms. In this paper, I try to correct these limitations by basing both my theoretical arguments and empirical analysis on the actual worldwide family patents of as close to the population of US MNCs as possible.

Building on insights from the multi-market competition and knowledge management literatures, I explore how firm and competitor scope of activities influences the timing and extent of global knowledge diffusion by MNCs. Based on existing patenting policies and procedures across countries, I first identify three types of family patents which are mutually exclusive in terms of when or whether firm knowledge is diffused, including: single-country patents (which include patents of home and foreign-origin that stay in one country), foreign equivalent family patents (where firm knowledge is transferred to another country after being introduced in an originating country) and born global family patents (which are introduced at the same time across several country locations). I then explore how differences in the scope of activities of both MNCs and their home and foreign competitors influence the timing and extent of knowledge diffusion. Extending arguments from the rivalry and multimarket competition

literature, I argue that higher competition from home-country competitors abroad will lead MNCs to pursue foreign equivalent patents to both use and protect firm knowledge (Knickerbocker, 1973; Chen, Smith and Grimm, 1992; Yu and Canella, 2013) while the most extensive global knowledge diffusion is likely to be encouraged by a more extensive scope of knowledge activities by foreign firms in the home country of an MNC, due to the escalation of competition and a higher need for counterattack strategies across the multiple home markets of these foreign competitors (Chen, 1996; Young et al., 2000; Smith et al, 1992).

To analyze these arguments, I created a new database that merges data on the worldwide operations of US MNCs from the Bureau of Economic Analysis (BEA) with patent data from Thomson Innovation's Derwent Patent Database Index (DWPI). The BEA collects detailed data on the worldwide operations of US MNCs through mandatory surveys, which make these data the most comprehensive that are available for the population of US MNCs. My other datasource, the DWPI, is also a comprehensive database of enhanced patent documents from across 44 patent issuing authorities, where experts analyze, abstract and manually index every patent record to create a database of equivalent patents across patent authorities. The empirical results support the argument that higher competition from home country rivals encourages MNCs to diffuse their knowledge through foreign equivalents to both maintain parity across countries and protect firm knowledge from imitation by home country rivals abroad. The results further show that competition from both home and foreign rivals encourages the quickest and broadest type of knowledge diffusion (born global family patents), but that the knowledge that is diffused through these patents is significantly less valuable than the other patent types.

This paper goes beyond extant research and contributes to our understanding of the global knowledge diffusion of MNCs by providing a comprehensive look at the global

knowledge generation and diffusion of US MNCS, by offering three mutually exclusive categories of global family patents based on the worldwide patenting of these firms, and by analyzing how firm and competitor scope of activities influence global knowledge diffusion. Although the majority of studies analyzing the global innovation of MNCs consider patents from only one patent-granting authority, this paper argues and shows that this underreports the actual global innovative activities of these firms, with over one third of the foreign patents of US MNCs not being transferred to or generated in the US. In addition, although knowledge diffusion has not been examined in the multimarket competition literature, this is both a fundamental and strategic activity of MNCs that has longed been argued to form the basis of the competitive advantages of these firms (Hymer, 1960; Kogut and Zander, 1992; Caves, 1996; Cantwell, 1989), with the results in this paper showing the relevance and importance of incorporating knowledge diffusion into the multimarket competition literature. Overall, this paper contributes to both the knowledge management and multimarket competition literatures by exploring how the actions of different types of multimarket competitors elicit different competitive responses by MNCs in terms of their management and diffusion of knowledge across markets.

"Global" Patents and Family Patents

To explore the global diffusion of knowledge by MNCs, I take as my starting point the idea that internationalizing a patent is an important precondition for technology transfer and knowledge diffusion because if a firm holds a patent right in a country, it is more likely to actively share its proprietary technology with foreign operations and/or relocate production to that country. My assumption is therefore that the international patenting of firm knowledge offers important insights into the global diffusion of knowledge by firms.

However, it is not so easy to study the international patenting of firms because there is no such thing as a "global" patent. If a patent is patented worldwide, it means that an inventor has a collection of different patents across national patent-granting authorities. Because patents are territorial and jurisdiction-specific, intellectual property protection for innovations must be applied for within individual countries. This creates a situation where a single idea might have many individual patents associated with it, depending on the countries in which an inventor seeks protection. A patentee will have patent rights enforceable in a country in which she has a patent. This has given rise to what are called "family" patents.

When an inventor seeks protection for his or her innovations across multiple countries, there will be many equivalent documents associated with this one innovation. These multiple, similar patents can be grouped into a family of patents, which are linked together through *priority* details. Priority is established by the application date assigned in the first country in which the invention was filed for protection. Under the Paris Convention[1], if the invention is filed in another convention country within one year of the original filing, the patent in the second country can claim the original priority date. (And the country in which the priority application was filed is assumed to be the country in which the invention was developed.) After twelve months, innovators may still file for patents in other countries, but the priority from the original filing date (in the original filing country) is no longer granted in other countries. Although not all patent databases track family patents beyond the twelve month filing period (i.e., the European Patent Office PATSTAT data), the DWPI database I use below does track all filings when creating their family patents.

[1] The Paris Convention is an international treaty that is currently administered by the World Intellectual Property Organization (WIPO) and based in Switzerland

In addition to the Paris Convention, innovators may also pursue simultaneous patenting across multiple countries. The Patent Cooperation Treaty (PCT) was concluded in 1970 and one goal of this convention was to eliminate the threat of an inventor's work from being stolen and used in another country. The PCT allows firms to seek patent protection simultaneously by filing a single "international" patent application with the World Intellectual Property Organization (WIPO)[2] instead of filing several separate national or regional patent applications. The granting of these patents remains under the control of the national or regional patent offices in what is called a national phase. For these "international" patents, inventors have 30 months from the filing date of the international application to enter the national phase in any country where patent protection is sought. In addition, since the European Patent Convention (EPC) from 1973, the European Patent Office (EPO)[3] has a centralized patent granting procedure for its member states (with inventors designating in which nations they are seeking coverage) Innovators can choose to file a patent application within any EPO covered country or through the EPO office. In both EPO and specific European country patents, innovators must pay fees to the national patent offices and action against infringers is taken in national courts.[4] Both the WIPO and EPO "international" patents can get very expensive because national fees need to be paid to each country and translations into the language of each country may also be needed.

Based on these patent policies and procedures across countries, I can identify three types of global family patents which are mutually exclusive in terms of when or whether firm knowledge is diffused beyond one country. First, are the single-country patents, which include

[2] Much more information on WIPO patents and the PCT can be found on the WIPO website: http://www.wipo.int/portal/en/

[3] Much more than just the summary information on EPO patents used in this paper can be found at: http://documents.epo.org/projects/babylon/eponet.nsf/0/8266ED0366190630C12575E10051F40E/$File/how_to_get_a_european_patent_052015_en.pdf

[4] Although the European Parliament adopted legislation to enforce patents centrally for 25 participating states in 2012, this isn't in effect during the time period of this study.

patents of home and foreign-origin that stay in one country. These can be granted under any one patent granting authority (including home or foreign markets for MNCs), but the common aspect of these patents is that they do not leave the originating country. Second, are the foreign equivalent family patents, where firm knowledge is transferred to another country after being introduced in an originating country. These offer protection for firm knowledge that was generated in one country, but is being used in another country. And third, are the family patents that involve the quickest and broadest type of knowledge diffusion from the start, the born global family patents, which are those that are introduced at the same time across several country locations (with the born global family patent category including both the regional EPO and world-wide WIPO patents). These "global" family patents offer firms the ability to vary their degree of knowledge diffusion both in terms of the speed and extent to which firm knowledge is diffused. With these categories in mind, I now consider the influence of both firm and competitor scope of activities on the diffusion of firm knowledge to understand differences in the timing and extent of knowledge diffusion by MNCs.

Firm and Competitor Influences on Global Knowledge Diffusion:

Research has long shown that the competitive moves of a firm against its rivals are a determining factor in long-term competitive advantage and performance (Smith, Ferrier and Grimm, 2001; Chen and MacMillan, 1992). The multimarket competition literature (Knickerbocker, 1973; Chen and Miller, 1994; Gimeno and Woo, 1999; Yu and Canella, 2013) has examined the importance of industry rivals on firm actions, especially when multinational corporations compete with each other across multiple countries. Firms need to respond to rivals in order to defend their competitive position (Knickerbocker, 1974; Smith et al., 1992) and to

counterattack rival strategies when faced with an escalation of competition (Chen, 1996; Young et al., 2000; Smith et al, 1992).

Extant research suggests that MNCs face two types of industry rivals: home-country based rivals and foreign based rivals. Each of these rivals pushes firms to exploit their firm knowledge across markets in order to remain competitive (Alcacer, 2006; Alcacer, Zhao and Dezso, 2013), but as I argue below, these rivals may elicit different knowledge management and diffusion responses by MNCs and I explore how the strategic moves of home and foreign rivals can influence how firms use and diffuse their knowledge assets both to exploit and protect firm competitive advantages abroad and to match aggressive competitor moves in a firm's home market.

Home Country Rivals

MNCs that come from the same home country represent a distinct organizational population (Martin, Swaminathan and Mitchell, 1998) and several studies have examined competitor interaction and multi-market rivalry from firms headquartered in the same country (Knickerbocker, 1973; Flowers, 1976; Yu and Ito, 1988; Kogut and Chang, 1991; Hennart and Park, 1994; Martin et al., 1998). Knickerbocker (1973) was one of the earliest to explore the impact of domestic rivalry on foreign expansion and he argued that imitation and follow-the-leader behaviors are likely in oligopolistic industries because firms are at greater risk of falling behind domestic rivals in these types of industries. Others have also argued and shown that home-based competition pushes firms to match foreign investments moves in foreign countries (Porter, 1990; Martin et al., 1998; Yip, 2002).

Firms in an oligopolistic industry pay attention to rivals' competitive moves and closely react to them to protect market positions. Firms in oligopolistic industries are characterized as being risk minimizers; they protect their own market position and try to avoid destructive competition (Knickerboker, 1973). Several authors have highlighted the importance of internal coordination and integration when firms are faced with multimarket competition (Golden and Ma, 2003; Yu, Subramaniam and Cannella, 2009). Ghemawat and Spence (1986) have argued that international integration of value added activities is the essence of global competition, which suggests that greater oligopolistic pressure from home country rivals will drive higher integration of firm competitive advantages across firm operations so firms will be competitive in all of these markets (Gimeno and Woo, 1999).

The need to share competitive firm resources across countries increases both the diffusion of firm knowledge and the importance of protecting firm proprietary assets across all markets in which the firm has activities because home-country rival MNCs draw from the same pool of knowledge and talent and are well aware of the products and knowledge of their home-country based rivals. When multimarket rivals originate from the same home country, their access to similar knowledge pools and experience with firm products, knowledge and resources necessitate higher diffusion of firm competitive advantages across all markets in which they compete. Equally important, the actual patenting of this knowledge in foreign markets also becomes important.

By diffusing knowledge to foreign markets, MNCs are more competitive with home country rivals in foreign markets. But by protecting this knowledge through foreign equivalents, MNCs can also preempt imitative behaviors by key home country competitors (Knickerbocker, 1973; Yu and Canella, 2013), who are very familiar with the resources, products and knowledge

of their home-country rivals. Studies have shown imitative behaviors by MNCs when faced with multimarket competition (Yu ad Cannella, 2013), and if an MNC does not seek protection for its knowledge in the foreign countries in which they compete, they could be subject to imitation of firm knowledge by home country rivals, but in foreign markets where firm knowledge is left unprotected. Home country rivals are more likely to introduce this imitative risk than foreign country rivals, given that the majority of MNC R&D expenditures and knowledge generating activities occur in the home countries of these firms (UNCTAD, 2004; Berry, 2014).

This leads to the first hypothesis, which argues that when firms face higher competition from home country rivals abroad, they are likely to use more of their home-generated knowledge in foreign markets to remain competitive with home-based MNC rivals in foreign countries and to protect home country-generated knowledge from imitation. This type of multimarket competitor thus increases the knowledge diffusion by MNCs through foreign equivalents:

> *H1: The higher the competition from home-country rivals in foreign countries, the more likely firm knowledge has higher global diffusion through foreign equivalent patents and the less likely firm knowledge remains a single country patent.*

Foreign Rivals

Similar to home country rivals, foreign rivals also impact the strategic decisions of MNCs in countries throughout the world. However, studies have documented that foreign based competitors may require stronger competitive action and quicker responses to maintain competitive parity, including attacking the competitive moves of foreign rivals in their own home markets (Flowers, 1976; Hutzschenreuter and Grone, 2009).

The idea behind the mutual forebearance hypothesis (Edwards, 1955; Yu and Cannella, 2013) is that vigorous competition in one market is likely to be weighed against the danger of retaliatory forays by competitors in other markets. When firms recognize their interdependence over multiple markets, they may refrain from initiating aggressive actions in each other's important markets (Yu and Cannella, 2013). However, this does not suggest an absence of aggressive competitive moves by firms. Instead, it suggests that aggressive competitive moves will be met with similar types of aggressive responses. Studies on action-response dyads (Chen & MacMillan, 1992; Chen, Smith & Grimm, 1992) suggest that matching a competitor's move indicates a commitment to defend the status quo, neither giving up the current position nor falling into mutually destructive warfare. If rivals match each other, none become better or worse off relative to each other (Knickerbocker, 1973), which help to ensure that competitive capabilities remain roughly in balance.

One aggressive move that can upset the competitive balance is when foreign firms introduce new knowledge into an MNC's home country market. This is a competitive threat that escalates the level of competition that MNCs face in their home market and that requires a similar counter-move by MNCs to maintain parity across markets. Several studies have documented the need to react swiftly to competitor's moves (Flowers, 1976; Terpstra and Yu, 1988; Yu and Ito, 1988), with studies showing that higher competition from foreign-based competitors in an MNC's home market will push MNCs to compete more aggressively in foreign rivals' home markets (Flowers, 1976; Hutzschenreuter and Grone, 2009). Because these foreign firms could either be bringing knowledge from their home markets or bringing in knowledge from third country markets, this threat is likely to lead to a quicker global diffusion of an MNC's knowledge and more of a simultaneous roll-out of firm knowledge across multiple markets. A

more extensive scope of knowledge activities by foreign MNCs in a firm's home country necessitates a commitment to defend the status quo (Chen, 1996; Young et al., 2000; Smith et al, 1992), which means quicker and wider knowledge diffusion by MNCs. Further, MNCs may also find it necessary to introduce new products quicker across all countries to respond to this escalation of threat. Kang, Bayus and Balasubramanian (2010) found that firms facing high multi-market competition tended to respond with new product introductions. The speed of new product introduction relative to rival speed positively impacts firm performance (Lee, Smith, Grimm and Schomburg, 2000) and the faster a firm responds to challenger actions, the greater the firm's profits (Smith et al., 2001a).

These arguments suggest that when foreign firms have more extensive scope of knowledge activities in an MNC's home market, this is likely to encourage the quickest and most extensive type of global knowledge diffusion by MNCs, the born global patents, due to the escalation of competition and the need for counterattack strategies across the multiple home markets of these foreign competitors. Thus,

> *H2: The higher the competition from foreign-country rivals in an MNC's home country, the more likely firm knowledge has the highest global diffusion through born global family patents versus foreign equivalent and single country patents.*

Scope of Firm Activities:

In addition to competitor scope, a firm's own scope of operations will also impact the speed and extent of knowledge diffusion. Although MNCs need to protect their knowledge before exposing and using that knowledge in manufacturing or R&D activities in foreign countries, not all MNCs have the same extent of foreign value chain activities abroad and there are likely to be differences in the ways that firms diffuse their knowledge depending on their scope of foreign operations. It is extremely costly (both in terms of fees and administrative

hassles) to pursue patent protection in multiple countries, and organizations may only seek patent protection abroad for firm knowledge that is actually being used in that market. The WIPO estimates the costs of patenting (including all fees, legal costs, translation costs) to be $16,971 for two countries, $59,397 for seven countries and $119,381 for fifteen countries. Official fees represent approximately a third of total costs and official fees are higher when filing through the PCT system (although this difference decreases when more countries are selected). [5] It may not make sense to pay to take patents abroad if firms have very limited scope in their foreign operations.

In contrast, MNCs that have set up more extensive value chain activities of manufacturing and R&D in foreign countries are more likely to need to both diffuse and protect firm knowledge. The ability of MNCs to coordinate their innovative activities across markets gives rise to competitive advantages (Hymer, 1960; Kogut and Zander, 1992) that can be exploited across markets and both home country generated and third country generated innovations can be used throughout a firm's worldwide operations. Whether a firm has foreign manufacturing operations that serve the local market, the MNC's home country market or third country markets, MNCs need to protect their knowledge before exposing and using that knowledge in foreign markets because firm technology is exposed when firms set up manufacturing facilities in foreign countries. Similarly, when firms are pursuing foreign R&D, these operations are often building off of firm base knowledge or combining knowledge from different countries (Berry, 2014; Kogut and Zander, 1993; Zhao, 2006). A more extensive scope of activities in foreign markets will necessitate more diffusion and protection of firm knowledge in foreign markets.

[5] For more information on the costs associated with patenting in multiple countries, see: http://www.wipo.int/ipstats/en/statistics/patents/wipo_pub_931.html

In one of the few empirical studies related to intellectual property protection and firm scope, Mansfield (1994) surveyed 100 major US manufacturing MNCS and asked about the importance of intellectual property protections across 16 countries. In no industry was there much concern about IPRs protecting the operation of sales and distribution outlets. Instead, there was a tendency to be more concerned with intellectual property protection, the higher the stage of value chain activities. This suggests that MNCs that have higher a manufacturing presence abroad (versus simply having a distribution presence) and more foreign R&D activities are more likely to patent their knowledge across multiple countries to protect knowledge that can be used and exploited across multiple countries. This higher protection is particularly necessary when local employees are hired in foreign markets to use, make or generate firm knowledge.

Thus, the final hypothesis argues that more extensive scope in firm foreign value chain activities will encourage firms to move beyond single country patents and pursue foreign equivalent and born global patents.

> *H3: The more extensive the scope of an MNC's foreign operations, the more likely firm knowledge has higher global diffusion through foreign equivalent and born global family patents and the less likely firm knowledge remains a single country patent.*

Data, Measures and Methods:

Data:

There are several sources of patent family information, and the most well-known come from the European Patent Office (through PATSTAT) and Thomson Innovation's DWPI. Similar across these sources, patent families are based on priority data. One advantage of the datasource used in this paper, the DWPI, is that it includes not only those patents filed during the 12 months after the original priority filing (which can claim the original filing date according to

Paris Convention rules), but also "non-convention" equivalents which were filed after the 12 month period. These more detailed comparisons and inclusion of data beyond the twelve month period are possible because DWPI experts analyze, abstract and manually index every patent record (unlike the EPO data). In addition, because the DWPI is more narrow in its definition of family patents than the INPADOC system used by the EPO data (and PATSTAT), the experts at Derwent argue that these equivalents are more likely to capture the same knowledge being patented in multiple countries. Comparisons across the INPADOC and DWPI data show that DWPI-based family patents cover what are referred to as simple patent families – which means that each patent application across any country has the same originating application specified. In contrast, the INPADOC –based family patents defines patents as any patent sharing at least one originating application in common (but can have more). Thomson Innovation claims that the DWPI is the most comprehensive database of enhanced patent documents.[6]

To analyze the worldwide patenting of US MNCs, I created a new database that merges together data on the worldwide operations of US MNCs from the BEA with patent data from the DWPI. Every year, the BEA collects detailed information on the foreign operations of US MNCs, which include data reported for US parent companies and their foreign affiliates. Because the BEA surveys are mandatory, these data provide the most comprehensive information on the operations of US MNCs that is available.[7] In the BEA data, separate survey reports are filed for US parent companies and their foreign affiliates. For foreign affiliates of a given US parent company in a given host country, reporting on a consolidated basis for multiple

[6] Much more information on the DWPI can be found at: http://ip.thomsonreuters.com/product/derwent-world-patents-index

[7] 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.)

affiliates is permitted if the affiliates operate in the same detailed industry or are otherwise integral parts of the same business operations. This means that firms may have multiple affiliates in one annual country report that is returned to the BEA. This also means that I do not have foreign addresses for each foreign affiliate of each US MNC. Instead, I have country information on the foreign operations of these firms. Because I do not know when an MNC has aggregated their affiliate data, I 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.

Given that there are no common numerical identifiers across the BEA and patent databases, I used a name matching program to combine the BEA and Derwent data. I have previously used a name matching program to match all US MNCs with the names in the USPTO data. This program produced a percent match across names and I manually went through all matches across the BEA and USPTO names, using addresses where necessary to check on names that were not exact matches. I started with this match, and used USPTO granted patent numbers to extract the four letter code used by DWPI whenever possible. The DPWI has created a unique four-letter code for the more patent prolific and larger firms in its database. When a unique four letter code was not available, I used the patent assignee name from a USPTO granted patent to match into the DWPI database.

I searched for all DWPI patents that were applied for during the 1989 to 2011 time period that were ultimately granted (sometimes after this time period for the last years of the sample). My BEA-DWPI matching resulted in over two million patents (including patent equivalents – those within the same patent family) and over 650,000 unique family patents that were granted to US MNCs during the 1989-2011 time period. In the analysis below, I restricted the sample to

manufacturing industries (SIC codes 200-399) because there are differences across product versus service based industries (that I intend to explore in another paper) and the majority of the patents (over 70%) were granted to firms whose main industry is manufacturing. After excluding non-manufacturing firms and any data with missing publication years, my final dataset includes 2622 US MNCs who have 429,129 unique family patents. Within each of these family patents, I used the priority application to determine the country of origin (which were the EPO or WIPO applications) and then included all subsequent applications (that were ultimately granted) to analyze knowledge diffusion below.

Measures

Dependent Variable: I use the three categories identified above as my dependent variable in the MLOGIT analysis below. These categories include 1.) single country patents, 2.) foreign equivalent family patents and 3.) born global family patents.

Independent Variables:

To capture the influence of home country competition, I consider the concentration of home country rivals abroad. I calculated a Herfindahl index of the foreign sales of US firms in the focal firm's main industry. The measure is calculated as $HHI = \sum s_i^2$ where s_i is the non-US sales of the i^{th} firm in the industry divided by the total non-US sales of US MNCs in that industry. Conceptually, this measure varies from 0 to 1, with higher values implying a greater concentration of foreign sales among a small number of US MNCs, resulting in stronger oligopolistic competition. Data for this measure come from the BEA.

To measure aggressive competition by foreign firms, I use the measure developed by Berry and Kaul (2015) to capture the importance of foreign rival knowledge in a firm's main

industry. This measure considers patent data from the USPTO only and calculates the ratio of the stock of non-U.S. patents to the stock of total patents in every patent class. Patent stocks were calculated using a 15% depreciation rate (Hall, Jaffe, and Trajtenberg, 2005), and the country of patent origin is based on the country of the patent's first inventor. The ratio of non-US patents for the firm's main industry is calculated as the weighted average of the ratio of non-US patents in all patent classes, with the weights being the frequency with which a patent in a particular patent class maps to that SIC, based on a convergence between patent classes and SICs developed by Silverman (1996)[8].

To explore my third hypothesis, I developed two measures using the BEA data to capture the foreign scope of an MNC's activities. First, foreign affiliates report their sales by industry. Using the reported manufacturing and distribution industry codes, I calculated the total foreign assets for all MNC operations that only report distribution sales. I then calculated the total foreign assets for all MNC operations that report manufacturing sales (and these operations can also report other industry codes and many do report both a manufacturing and a distribution industry code in their total sales). Using these measure, I then divided the total foreign assets that include manufacturing (and can include distribution) by the sum of the assets of foreign operations that include manufacturing (and can include distribution) plus assets of foreign operations that only include distribution sales). This gives me the proportion of an MNC's foreign manufacturing assets to total foreign assets. My second measure captures the proportion of an MNC's foreign R&D expenditures to the total worldwide MNC expenditures. Each of these measures are intended to capture higher scope of value chain activities in foreign markets.

[8] The Silverman concordance maps patent classes (IPC) to industries (SIC) by calculating the proportion of patents in each IPC that belong to a particular SIC using data from the Canadian patent office.

I also include several controls. First, I control for the value of firm knowledge, I consider the forward citations of a patent. Forward citations have been shown to be positively and significantly related to the value of a patent (Trajtenberg, 1990; Harhoff et al., 1999; Hall et al., 2005). To create my measure, I added up the total patent forward citations across all patents within the patent family. Because both industries differ and the time period that a patent has been in existence differs, I created a measure that compares the number of forward citations a family patent receives to the average number of forward citations for any family patent in the same technology class, granted in the same year. The DWPI reports the International Patent Classification (IPC) codes and I used the 3 digit code (including one letter and two numbers) which represents the section and class to create this weighting. (This limits the problem of young patents closer to the end of the time period having less time to accumulate citations.) Second, I control for whether the family patent itself is a multi-country inventor patent. Prior research has shown that these patents are more likely to diffuse across MNC operations (Berry, 2014). I control for the R&D intensity of the unit from which the patent originated (for WIPO patents, I mostly used the US operations, but if the US was not one of the specified countries on the patents, I used the largest firm foreign operation that was specified), the product integration of the originating country operations and the size of the originating country operations. I also controlled for the R&D intensity of the MNC, the size of the MNC, the debt of the parent firm operations and the extent of offshore outsourcing of the parent firm. For the originating country, I control for the size, growth and openness. These controls are expected to influence not only the resources of the originating unit, but also the connections that have been established across some of the operations.

All variables are described in Table 1 (including data sources). Tables 2 and 3 show summary stats and correlations for all variables.

Insert Tables 1, 2 and 3 about here

Methods:

To examine my hypotheses, I used a multinomial logit (MLOGIT) model (at the family patent level of analysis) to analyze significant differences across single country patents, foreign equivalent family patents and born global family patents identified above. A Hausman test to check for the Independence of Irrelevant Alternatives (IIA) assumption in MLOGIT models iteratively drops one option and tests whether the coefficients significantly change. The results from this test (and separately run Small-Hsiao tests) show that the three categories are independent of each other. In an MLOGIT model, the probabilities of occurrence of each option are normalized with respect to one of them, usually the one that occurs most frequently in a given sample. In the current sample, single country patents and foreign equivalent family patents occur with a similar frequency and so I chose to use single country patents as the base category. This allows the results to be compared to the base case of no knowledge diffusion. I included year fixed effects for the first year the patent application was submitted (anywhere) and clustered by the parent-country operation.

For robustness, I also examined the count of countries in which a family patent has been granted for each family patent. I consider foreign equivalent and born global family patents separately in this count analysis to be able to compare how home and foreign based rivals impact the diffusion of knowledge across these two categories. Count data are often non-normally

distributed and my dataset has excess zeros (from single country patents that have not been diffused to any country). Because it employs a two regime model, a zero-inflated count model is appropriate for modeling count data with excess zeros and I use a zero inflated negative binomial (ZINB), which has a distribution that is a mixture of a binary distribution probability model that governs whether a count number is zero (meaning the family patent remains in only one country) or a positive number. The positive part of the distribution is modeled using a negative binomial error structure. Because this method models two separate processes for knowledge that does not diffuse and knowledge that does diffuse, it allows me to control for unobserved differences that might drive firms to diffuse some patents versus others. Because MNCs differ in the number of countries in which they have operations, I use the exposure option to incorporate these differences. I include the total number of countries in which a firm has operations in the exposure term in each of the models below. In the models below, country operations were clustered using a robust variance estimator.

Results:

Before discussing the hypotheses, it is interesting to consider the raw data. Figure One shows the proportions of the three categories of family patents from the DWPI data. The average number of countries to which each of the different categories are diffused (not counting the originating country) are: single country patents – 0; foreign equivalent patents – 32; and born global family patents – 61 (with WIPO patents being higher in number than EPO patents). These three categories thus reflect differences in the speed and extent of knowledge diffusion by MNCs.

The pie chart (in Figure One) reveals that although smaller in number, the foreign originating patents of US MNCs have a higher rate of diffusion than US originating patents, with ninety percent of all foreign originating patents diffused to other countries and only thirty-eight percent of US originating patents diffused outside the US. Second, these numbers confirm that the US is an important location for innovation by US MNCs, with sixty-five percent of the patents of US MNCs originating in the US and almost two-thirds of these US originating patents remaining in the home country.

Also noteworthy, the raw data reveal the importance of including multiple patent authorities when analyzing the global innovations of MNCs. I am able to capture more foreign country generated patents than a single-country source could reveals. When looking at all of foreign originating patents (including the multi-country originating country patents), over one third of the foreign patents of US MNCs have not been transferred to the US, (with "foreign" patents referring to 2% of foreign invented single country patents, 18% of the foreign equivalent family patents and all 15% of the born global patents).

Insert Figure One and Tables 4 and 5 about here

Turning to the empirical results, Table 4 shows results from the MLOGIT analysis at the family patent level of analysis. Coefficients in MLOGIT models express how much the given variables influence the probability relative to the base case. Here the base case is single country patents. This means that the coefficients reveal statistical differences across the coefficients from the category under consideration and the base case. The first column of Table 3 shows the results comparing foreign equivalent family patents with single country patents, and the second column shows the results comparing born global family patents with single county patents. I

report marginal affects for each of these comparisons in columns 3 and 4, respectively. I also report the marginal effects for the comparison between the foreign equivalent family patents and the born global family patents in the fifth column.

Comparisons across the three patent categories largely support the hypotheses developed above. The first hypothesis argued that the higher the competition from home-country competitors, the more likely MNCs will pursue foreign equivalents patents. For this hypothesis, the main variable of interest in Home Rivals Abroad and Columns 1 and 2 in Table Four show that foreign equivalent family patents have significantly higher competition from home country rivals abroad. The odds ratio shows that foreign equivalent family patents relative to single country patent have a 1.92 times higher herfindahl index. Although not hypothesized, the results show that higher competition from home country rivals abroad also influence born global patents, with the odds ratio showing that born global family patents have a 1.89 times higher herfindahl index than single country patents. There is no significant difference across foreign equivalent and born global family patents. Although these results show support for Hypothesis One, the significant difference across born global family patents and single country patents suggest that home country competitors play a broader role than was hypothesized and this will be discussed more below.

The second hypothesis argued that the most extensive global knowledge diffusion is likely to be encouraged by a more extensive scope of knowledge activities by foreign firms in the home country of MNCs. To examine this hypothesis, I considered the extent of foreign patenting in the MNC's main industry in the USPTO (to cover the home market of US MNCs). This hypothesis receives support as Column Two shows that born global family patents have significantly higher Foreign Rivals in the US than single country patents. The odds ratios show

that born global family patents relative to single country patent have a 1.16 times higher foreign patenting proportion in the USPTO than single country patents. Interestingly, foreign equivalent family patents actually have a significantly lower foreign rival patenting proportion than either single country patents or born global family patents. These results support the logic outlined in Hypothesis Two.

The third hypothesis argued that more extensive scope in firm foreign value chain activities will encourage firms to move beyond single country patents and pursue foreign equivalent and born global family patents. Columns 1 and 2 in Table 5 show that both foreign equivalent and born global family patents have significantly higher MNC foreign manufacturing proportions and foreign R&D proportions than single country patents. Regarding MNC foreign manufacturing proportion, the odds ratios show that foreign equivalent family patents relative to single country patent have a 1.61 times higher foreign manufacturing proportion. The corresponding increase is 1.49 for born global patents. There is no significant difference across foreign equivalent and born global family patents. Hypothesis Three is thus supported.

Control variables that are significantly different across patent categories include the value of firm knowledge, the size of the foreign operation in which the innovations originates and MNC R&D intensity. The knowledge value control is negative and statistically significant comparing born globals with single country family patents. (The odds ratios show that born global family patents relative to single country patent have a 0.76 times lower knowledge value than single country patents.) The controls also show that born global patents are more likely to originate from larger operations compared to single country patents, while foreign equivalent family patents are more likely to originate from smaller operations compared to single country patents. The MNC R&D intensity show that born global patents are also likely to originate from

MNCs with lower overall R&D intensities compared to single country patents while foreign equivalent patents are more likely to originate from MNCs with higher overall R&D intensities.

To examine the robustness of these results, Table Five reports the results from the ZINB models. Because this method models two separate processes for knowledge diffusion, including one for knowledge that does not diffuse at all and one that considers the count of countries to which firm knowledge diffuses, it provides some control for unobserved differences that might drive firms to diffuse some patents versus others. This table shows results that are mostly consistent with the MLOGIT results discussed above. Home rivals encourage knowledge diffusion through both foreign equivalent and born global family patents while foreign rivals positively and significantly encourage knowledge diffusion through born global family patents (and have a negative relationship with foreign equivalent family patents). There is a statistically significant difference across the foreign rival coefficients in the foreign equivalent versus born global family patents (comparing columns IV and VIII, $z = 2.6$, $p<0.01$). Regarding firm scope of activities, more extensive scope in foreign manufacturing activities encourages higher diffusion of firm knowledge through both foreign equivalents and born global family patents. However, the firm foreign R&D proportion is only significant in the foreign equivalent family patent results. Finally, the knowledge value control is also statistically and significantly across the foreign equivalent versus born global family patents (comparing columns IV and VIII, $z = 2.48$, $p<0.01$).

Discussion and Implications:

Although a basic premise within the field of international management is that MNCs exploit their knowledge assets throughout their worldwide operations, extant literature offers relatively little analysis of the actual knowledge diffusion that is done by these firms. Most

studies that analyze the global innovation and diffusion of firm knowledge consider patents from only one patent-granting authority. This is problematic because as this study shows, this underreports the actual global innovative activities of MNCs and lessens the theoretical and empirical lenses from which one can analyze the global innovation of MNCs. This paper overcomes these problems by merging together data on the worldwide operations of US MNCs from the BEA with family patent data from Thomson Innovation's DWPI. Using this database, this paper is the first study to provide a comprehensive look at the global knowledge diffusion of US MNCS, to offer three mutually exclusive categories of global family patents and to reveal how firm and competitor scope of activities influence the global knowledge diffusion of MNCs.

First, regarding my claim that studies using data from one patent generating authority are likely to be underreporting the actual knowledge generation and knowledge diffusion of MNCs, the raw data reveal that over one third of the foreign originating patents of US MNCs have not made their way to the USPTO (either through a patent equivalent or through the WIPO global patent process). While the raw data certainly reinforce prior findings regarding the importance of the home country for knowledge generation by US MNCs (Berry, 2014), with about two-thirds of all patents originating from the US, this information highlights that empirical research on the global innovation of US firms based on the patents from the USPTO are underreporting foreign generated innovations. This issue is almost certainly larger for studies that use the USPTO data while analyzing non-US firms. The other interesting fact that emerges from the raw data is that foreign originating patents of US MNCs have a higher rate of diffusion than US originating patents. This higher diffusion rate could have to do with regional strategies or firms pursuing global centers of excellence and future research could certainly explore in more detail why foreign generated knowledge has a higher diffusion rate than US generated knowledge.

Second, after reviewing the patent policies and procedures across countries, this paper offers three mutually exclusive types of "global" family patents based on when (or whether) firm knowledge is diffused, including: single-country patents, foreign equivalent patents and born global patents. Given that most papers on global innovation restrict themselves to one patent granting authority, these categories are intended to offer a way to highlight the intended focus and contribution of papers on global innovation. It is certainly not necessary for all research to examine the family patents of MNCs, but there is a need to be clear about the different types of patents that are included in the study and whether the inclusion of different categories might influence the results or implications of the study.

Third, this paper examines how firm and competitor scope of activities influences the knowledge diffusion of MNCs. Building on prior research that considers MNCs who come from the same home country to represent a distinct organizational population (Martin, Swaminathan and Mitchell, 1998), this paper separates the influence of home and foreign-based competitors. And building on studies in the multimarket competition literature that have shown the importance of internal coordination and integration (Golden and Ma, 2003; Yu, Subramaniam and Cannella, 2009), this paper argues that higher competition from home-country rivals will necessitate a broader role for using and protecting firm knowledge across foreign operations. Because MNCs from the same home country have access to same pool of knowledge and the majority of R&D is done in an MNC's home country (UNCTAD, 2004; Berry, 2014), it was argued that home country rivals encourages MNCs to diffuse their knowledge through foreign equivalents both to maintain competitive parity with these home country rivals and to preempt home country competitors from imitating this knowledge in foreign markets. The results confirm that higher competition from home country rivals abroad pushes firms to pursue foreign

equivalent family patents in comparison to single country patents. Although not offered as a hypothesis, the results also show that higher competition from home country rivals abroad is positively and significantly associated with born global family patents in comparison to single country patents. This may suggest that as the home county rivals of US MNCs have become more global in their R&D activities (Berry, 2014), it is becoming increasingly necessary for all MNCs to not only diffuse knowledge from the home market, but also generate global patents that are diffused more widely at inception. This suggests that home country rivalry not only encourages firms to exploit and protect home-country generated knowledge but also to tap into worldwide knowledge pools and generate and diffuse knowledge on a global basis to better compete with home-country rival MNCs.

This paper also explores the competitive impact of foreign rivals and argues that more extensive scope of knowledge activities by foreign firms in the home country of MNCs will encourage the quickest and most extensive type of global knowledge diffusion by MNCs due to the escalation of competition and a higher need for counterattack strategies across the multiple home markets of these foreign competitors (Chen, 1996; Young et al., 2000; Smith et al, 1992). The results confirm that more extensive knowledge activities by foreign rivals – and higher patenting by foreign rivals in the home market - is positively and significantly associated with born global family patents compared to both single country and foreign equivalent patents. Although not specifically hypothesized, the results also show that higher foreign patenting is negatively and significantly associated with foreign equivalent family patents (compared to both single country patents and born global patents). This suggests that when faced with foreign competition in a home market, MNCs are not only more likely to pursue born global family patents over either of the other categories, but they are also more likely to keep their knowledge

at home versus diffusing that knowledge through foreign equivalents. This may suggest a trade-off between exposing firm knowledge quickly and broadly versus keeping tight control over knowledge in the country in which the innovation was generated. Future research could certainly explore this further because this trade-off implies very different competitive dynamics with foreign rivals – especially when foreign rivals are patenting their knowledge in the home country market of the MNC.

The control for knowledge value also reveals interesting results, showing that the category with the quickest diffusion (born global family patent) are on average less valuable than single country patents. This suggests that the more valuable firm knowledge is, the less likely it is to be exposed quickly and widely across countries. This is likely due to the difficulties associated with transferring more complex technology (Teece, 1977; Szulanski, 1996; Berry, 2014) and spillover and appropriation risks more generally ((Blomstrom and Kokko, 1998; Javorcik, 2004). However, it is also interesting to note that the MNC R&D intensity variable shows that born global patents are likely to originate from MNCs with lower overall R&D intensities compared to single country patents. Taken together with the foreign competition finding, these results suggest that although increased competition from foreign rivals in a firm's home market may encourage quicker and wider diffusion of firm knowledge, either this competitive dynamic does not encourage these firms to send their most valuable knowledge or this competitive dynamic has more of an influence on less R&D intensive firms. Future research could certainly consider whether strategic groups within industry (and more or less knowledge intensive firms) are differentially affected by foreign rivals. At a minimum, the present study shows differences in the value of knowledge across family patent categories, suggesting that more valuable firm knowledge is less likely to be exposed quickly and widely across countries

and revealing that this knowledge is more likely to either remain within one single country or be diffused more slowly through foreign equivalent patents.

Although competition has long been argued to play an influential role in foreign expansion (Knickerbocker, 1973; Flowers, 1973; Yu and Cannella, 2013), knowledge diffusion has not been examined in the multimarket competition literature. However, knowledge diffusion is a fundamental and strategic activity of MNCs that forms and influences the competitive advantages of these firms (Hymer, 1960; Kogut and Zander, 1992; Caves, 1996; Cantwell, 1989) and the competitive dynamics across countries. The exploitation and diffusion of knowledge allows firm to both maintain and upset the competitive balance within and across countries. By exploring the effects of home and foreign rivals on knowledge diffusion and how the actions of different types of competitors elicit different competitive responses by MNCs, this paper contributes to both the knowledge management and multimarket competition literatures.

Overall, this paper contributes to our understanding of knowledge management and knowledge diffusion by MNCS. It contributes to our understanding of the global diffusion of knowledge by offering a first look at the worldwide global knowledge diffusion of US MNCs. Based on the worldwide patenting of these firms, this paper offers three mutually exclusive categories of family patents that can shape future research on global innovation by providing boundary conditions on the scope of research regarding knowledge generation and diffusion by firms. And finally, this paper highlights how the actions of different types of multimarket competitors elicit different competitive responses by MNCs in terms of their management and diffusion of knowledge across markets.

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Figure One: Patent Families of US MNCs, 1989-2011

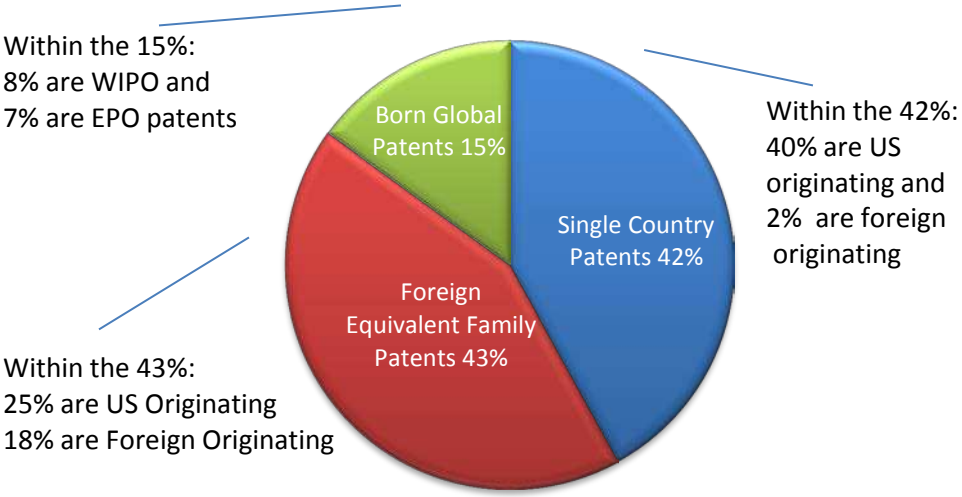

Table 1: Description of Variables (Sources)

Dependent Variables	For MLOGIT: Three categories of Family Patents (Derwent): 1 – Single Country Patents (Base Category) 2 – Foreign Equivalent Family Patents 3 – Born Global Family Patents For ZINB: Count of countries in which a patent family has been granted a patent outside of the originating country (Derwent)
Independent Variables:	
Home MNCs Abroad $_{t-1}$	Herfindahl index of sales by US firms outside the US, by industry (BEA)
Foreign Rivals in US $_{t-1}$	Stock of industry-relevant patents with non-US inventors as a proportion of total industry relevant patent stock (NBER USPTO)
MNC Foreign Man Prop $_{t-1}$	Proportion of an MNC's assets for foreign country operations that report manufacturing sales to the assets of all foreign country operations (BEA)
MNC Foreign R&D Prop $_{t-1}$	Proportion of an MNC's foreign R&D expenditures to total R&D Expenditures (BEA)
Knowledge Value	Technology class and year weighted count of forward citations of the family patent (Derwent)
Multi-Country Patent	Dummy = 1 if family patent has inventors from more than one country (Derwent)
Unit Product Integration $_{t-1}$	Lagged exports and imports divided by total sales for the country operations in which the family patent was generated (BEA)
Unit R&D/Sales $_{t-1}$	Lagged R&D expenditures divided by total sales for the country operations in which the family patent was generated (BEA)
Unit Size $_{t-1}$	Lagged log of total sales of the country operations in which the family patent was generated (BEA)
MNC Size $_{t-1}$	Lagged log of a MNC's total US and foreign assets (BEA)
MNC R&D/Sales $_{t-1}$	Lagged MNC total R&D expenditures divided by MNC total sales (BEA)
Offshore Outsourcing $_{t-1}$	Lagged third party sourcing percent of total sourcing to US for the parent operations of the MNC (BEA).
MNC Debt to Equity $_{t-1}$	Lagged parent debt divided by the difference between parent total assets minus parent debt (BEA)

Country GDP/Cap $_{t-1}$	Lagged GDP per capita for unit country (WDI)
Country GDPGrowth	Lagged first difference in GDP per capita for unit country (WDI)
Country FDI Inflows	Lagged FDI as a percent of country GDP (WDI)

Table 2: Summary Statistics

Knowledge Diffusion (# Countries)	21.38 (40.42)
Home MNCs Abroad	0.37 (0.14)
Foreign Rivals in US	0.49 (0.04)
MNC Foreign Man Proportion	0.58 (.41)
MNC Foreign R&D Proportion	0.11 (0.14)
Knowledge Value	1.01 (0.76)
Multicountry Family Patent	0.09 (0.11)
Unit Product Integration	0.19 (0.18)
Unit Log Size	15.30 (2.05)
MNC R&D Intensity	0.04 (0.03)
MNC Size	16.50 (2.34)
Parent Offshore Outsourcing	0.26 (0.15)
Parent Debt to Equity	2.06 (1.90)
Country Log GDP/Cap	10.50 (0.29)
Country GDPGrowth	0.02 (0.02)
Country Openness	0.02 (0.02)

Table 3: Correlations

	1	2	3	4	5	6	7	8	9
1. PatentMultCtrv	1.0								
2. KnowledgeValue	0.01	1.0							
3. HomeMNCsAbroad	- 0.01	-0.02	1.0						
4. ForeignRivals	-0.01	0.06	0.08	1.0					
5. UnitProdIntegration	-0.01	-0.02	0.13	-0.09	1.0				
6. PropForRD	0.03	-0.01	0.12	-0.17	0.08	1.0			
7. PropForMan	0.01	-0.02	0.14	0.03	0.10	0.01	1.0		
8 .UnitRDbySales	0.01	0.02	-0.20	0.09	0.10	-0.11	-0.22	1.0	
9. UnitLogSales	0.05	0.01	0.28	0.18	0.12	-0.01	-0.36	0.08	1.0
10 MNCLogAssets	0.06	-0.05	0.30	0.01	0.07	0.09	-0.39	-0.05	0.40
11 MNCRDbysales	0.01	0.03	-0.19	0.05	0.04	-0.10	-0.02	0.31	-0.7
12 OffshoreOutsourcing	-0.01	-0.03	-0.01	0.01	0.24	-0.12	0.21	-0.18	-0.01
13 ParentDebt	-0.01	0.09	-0.07	-0.01	-0.09	-0.15	0.41	0.01	-0.29
14 CtrySize	0.08	0.05	0.12	0.14	-0.10	-0.08	-0.26	0.31	0.35
15 CtryGrowth	-0.01	0.01	-0.08	0.03	-0.00	-0.04	0.12	-0.01	-0.5
16 CtryOpenness	0.01	-0.01	0.01	-0.06	-0.06	0.01	-0.01	-0.01	-0.05

	10	11	12	13	14	15	16
11 MNCRDbySales	-0.13	1.0					
12 OffshoreOutsourcing	-0.07	-0.04	1.0				
13 ParentDebt	-0.23	0.05	0.04	1.0			
14 CtrySize	0.16	0.08	-0.15	0.11	1.0		
15 CtryGrowth	-0.09	-0.01	0.04	-0.12	-0.20	1.0	
16 CtryOpenness	0.05	-0.01	-0.03	0.02	- 0.12	0.20	1.0

Table 4: MLOGIT Results for Family Patent Type Comparison

Dep Var:1= Single Country Patent; 2 =Foreign Equivalent Family Patent; 3 =Born Global Family Patent					
Model Comparison:	Coefficients, Comparing		Marginal Effects, Comparing		
	2 with 1	3 with 1	2 with 1	3 with 1	2 with3
H1: Home Rivals Abroad $_{t-1}$	0.14**	0.12**	[1.15]**	[1.23]**	[0.99]
	(0.06)	(0.03)			
H2: Foreign Rivals in US $_{t-1}$	-0.31*	0.22**	[0.46]*	[1.39]**	[0.21]**
	(0.13)	(0.03)			
H3: MNC ForManProp	0.84**	0.13**	[1.61]**	[1.49]**	[1.08]
	(0.25)	(0.03)			
H3: MNC ForeignR&DProp	0.14**	0.13*	[1.92]**	[1.89]**	[1.05]
	(0.06)	(0.05)			
Knowledge Value	0.01	-0.31**	[1.01]	[0.73]**	[1.06]**
	(0.03)	(0.08)			
Multi-country Patent	0.57**	0.47**	[1.77]*	[1.62]**	[1.02]
	(0.06)	(0.05)			
Unit Product Integration $_{t-1}$	0.71	0.42	[1.31]	[1.13]	[1.24]*
	(0.41)	(0.36)			
Unit R&D Intensity$_{t-1}$	0.83**	0.08	[1.76]**	[1.09]	[1.64]**
	(0.13)	(0.06)			
Unit Log Sales $_{t-1}$	-0.24	0.19*	[0.90]	[1.21]*	[0.88]
	(0.06)	(0.08)			
MNC R&D Intensity $_{t-1}$	0.19**	-0.21*	[1.86]**	[0.36]*	[2.24]**
	(0.07)	(0.05)			
MNC Size $_{t-1}$	0.22	-0.32	[1.17]	[0.92]	[1.37]
	(0.19)	(0.18)			
Parent Debt to Equity	-0.01	0.01	[0.99]	[1.01]	[0.99]
	(0.02)	(0.01)			
Parent Offshore Outsourcing	0.27	0.08	[1.31]	[1.08]	[1.20]
	(0.16)	(0.17)			
Country Log GDP$_{t-1}$	-0.01**	-0.01**	[0.99]**	[0.99]**	[0.99]
	(0.00)	(0.00)			
Country Openness $_{t-1}$	0.01	0.13**	[1.01]	[1.14]**	[0.87]**
	(0.02)	(0.03)			
Country GDP/Cap Growth $_{t-1}$	-0.02	0.07	[0.99]	[1.07]	[0.90]
	(0.02)	(0.04)			
Constant	0.67**	0.97**			
	(0.09)	(0.12)			
Log Likelihood	-34067.26**				
Industry and Year Dummies	Yes				
Clustered by Firm-Country	Yes				
Number of Observations	429,129				

(robust standard errors) [marginal effects]
Significance level (two-sided): *<5%, **<1%,

Table 5: ZINB Results for Family Patent Knowledge Diffusion

	Foreign Equivalent Family Patents (with Single Country Patents in Zero Equation)				Born Global Family Patents (with Single Country Patents in Zero Equation)			
DV:	**Count of Countries in Which Patent Family is Granted (beyond originating country)**							
Model Number	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**	**VII.**	**VIII.**
H1: Home Rivals Abroad	0.24** (0.12) [1.19]			0.23** (0.11) [1.19]	0.17** (0.08) [1.15]			0.17** (0.08) [1.15]
H2: Foreign Rivals in US		-1.13 (0.86) [0.91]		-1.16 (0.84) [0.91]		2.85** (1.31) [1.57]		2.86** (1.33) [1.58]
H3: MNC ForManProp			0.53** (0.21) [1.42]	0.54** (0.21) [1.42]			0.44** (0.16) [1.35]	0.45** (0.18) [1.37]
H3: MNC ForR&DProp			0.12* (0.07) [1.05]	0.12* (0.07) [1.06]			0.19 (0.31) [1.04]	0.19 (0.34) [1.04]
Knowledge Value	0.01 (0.01) [1.01]	0.01 (0.01) [1.01]	0.01 (0.01) [1.01]	0.01 (0.01) [1.01]	-0.04** (0.02) [0.89]	-0.04* (0.02) [0.88]	-0.04* (0.02) [0.88]	-0.04* (0.02) [0.89]
MultiCountry Patent	0.23** (0.04) [1.26]	0.23** (0.04) [1.26]	0.23** (0.04) [1.26]	0.23** (0.04) [1.26]	0.60** (0.22) [1.42]	0.60** (0.21) [1.42]	0.60** (0.22) [1.43]	0.61** (0.21) [1.45]
Unit Log Sales	0.07** (0.02) [1.07]	0.07** (0.02) [1.07]	0.07** (0.02) [1.07]	0.07** (0.02) [1.07]	0.04** (0.02) [1.05]	0.04** (0.02) [1.05]	0.04** (0.02) [1.05]	0.04** (0.02) [1.05]
Unit R&D Intensity	0.31** (0.17) [1.34]	0.31** (0.17) [1.34]	0.31** (0.17) [1.34]	0.31** (0.17) [1.34]	0.22** (0.11) [1.46]	0.22** (0.11) [1.46]	0.22** (0.11) [1.46]	0.22** (0.11) [1.46]
MNC Log Assets	0.01 (0.02) [1.01]	0.01 (0.02) [1.01]	0.01 (0.02) [1.01]	0.01 (0.02) [1.01]	-0.02 (0.02) [0.97]	-0.02 (0.02) [0.97]	-0.02 (0.02) [0.97]	-0.02 (0.02) [0.97]
MNC R&D/Sales	0.39* (0.20) [1.19]	0.39* (0.19) [1.19]	0.39* (0.19) [1.19]	0.39* (0.19) [1.19]	-0.13 (0.59) [0.91]	-0.13 (0.09) [0.91]	-0.13 (0.09) [-0.91]	-0.13 (0.09) [0.91]
Parent Debt to Equity	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]	-0.01 (0.01) [0.99]
Parent Offshore Outsourcing	-0.18 (0.16) [0.93]	-0.18 (0.16) [0.93]	-0.17 (0.16) [0.93]	-0.17 (0.16) [0.93]	0.06 (0.05) [1.05]	0.06 (0.05) [1.05]	0.06 (0.05) [1.05]	0.06 (0.05) [1.05]
Country Log GDP	0.02* (0.01) [1.06]	0.02* (0.01) [1.06]	0.02* (0.01) [1.06]	0.02* (0.01) [1.06]	0.02 (0.06) [1.03]	0.02 (0.06) [1.03]	0.02 (0.06) [1.03]	0.02 (0.06) [1.03]
Country Openness	0.03** (0.01) [1.04]	0.03** (0.01) [1.04]	0.03** (0.01) [1.04]	0.03** (0.01) [1.04]	0.01 (0.01) [1.02]	0.01 (0.01) [1.02]	0.01 (0.01) [1.02]	0.01 (0.01) [1.02]
Country GDP/Cap Growth	-0.02 (0.02) [0.98]	-0.02 (0.02) [0.98]	-0.02 (0.02) [0.98]	-0.02 (0.02) [0.98]	0.07** (0.02) [1.08]	0.07** (0.02) [1.08]	0.07** (0.02) [1.08]	0.07** (0.02) [1.08]
Intercept	0.21** (0.05)	0.20** (0.05)	0.21** (0.06)	0.21** (0.05)	0.14** (0.04)	0.11** (0.03)	0.14** (0.04)	0.13** (0.04)
Zero Equation:								

Home Rivals Abroad	0.82 (0.86)	0.82 (0.86)	0.82 (0.86)	0.82 (0.86)	0.91 (0.72)	0.92 (0.71)	0.93 (0.74)	0.92 (0.72)
Foreign Rivals in US	0.76 (0.91)	0.76 (0.91)	0.76 (0.91)	0.76 (0.91)	0.22 (0.56)	0.23 (0.54)	0.22 (0.57)	0.22 (0.55)
MNC ForManProp	-0.86** (0.38)	-0.86** (0.38)	-0.86** (0.38)	-0.86** (0.38)	-0.70** (0.32)	-0.72** (0.31)	-0.72** (0.31)	-0.71** (0.32)
MNC ForRDProp	-1.18** (0.47)	-1.18** (0.47)	-1.18** (0.47)	-1.18** (0.47)	-1.04** (0.55)	-1.03** (0.53)	-1.02** (0.55)	-1.05** (0.55)
Knowledge Value	0.02 (0.03)	0.02 (0.03)	0.02 (0.03)	0.02 (0.03)	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)
Multi-Country Patent	-0.19** (0.07)	-0.19** (0.07)	-0.19** (0.07)	-0.19** (0.07)	-0.14** (0.06)	-0.14** (0.05)	-0.13** (0.05)	-0.14** (0.05)
Unit Log Sales	0.03 (0.04)	0.03 (0.04)	0.03 (0.04)	0.03 (0.04)	0.04 (0.06)	0.04 (0.06)	0.04 (0.05)	0.04 (0.06)
Unit R&D Intensity	0.32 (0.17)	0.31 (0.17)	0.31 (0.18)	0.33 (0.18)	0.18 (0.11)	0.18 (0.11)	0.18 (0.11)	0.18 (0.11)
MNC Log Assets	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)
MNC R&D/Sales	0.45 (0.38)	0.45 (0.38)	0.45 (0.38)	0.45 (0.38)	0.41 (0.32)	0.41 (0.32)	0.41 (0.32)	0.41 (0.32)
MNC Debt to Equity	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Parent Offshore Outsourcing	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Country Log GDP	1.13** (0.36)	1.13** (0.36)	1.13** (0.36)	1.13** (0.36)	1.37** (0.49)	1.37** (0.49)	1.36** (0.49)	1.37** (0.48)
Country GPD/Cap Growth	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.03 (0.02)	-0.03 (0.02)	-0.03 (0.02)	-0.03 (0.02)
Country Openness	0.09** (0.04)	0.09** (0.04)	0.09** (0.04)	0.09** (0.04)	0.06** (0.03)	0.06** (0.03)	0.06** (0.03)	0.06** (0.03)
Intercept	1.41* (0.51)	1.44* (0.52)	1.43* (0.51)	1.44* (0.53)	1.29* (0.65)	1.24* (0.65)	1.23* (0.61)	1.32* (0.65)
Alpha	1.91**	1.91**	1.92**	1.92**	1.49**	1.46**	1.46**	1.47**
Wald Chi Squared	293.21**	284.23**	296.56**	298.82**	316.45**	320.15**	312.51**	356.35**
Observations	364,759	364,759	364,759	364,759	244604	244604	244604	244604
NonZero	184,525	184,525	184,525	184,525	64,370	64,370	64,370	64,370
Zero Obs	180,234	180,234	180,234	180,234	180,234	180,234	180,234	180,234
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm-Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

All models include an exposure term, which is the total number of countries in which the firm has operations. Lags included and all models have robust standard errors; Sig: † <10%, *<5%, **<1%