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Transnational spatial dependencies in the geography of non-resident patent filings

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Abstract

This article provides new insights into how geography shapes spatiotemporal variations in the propensity of actors from particular countries to file for non-resident patents in specific foreign economies. Our major contribution is to show that, in addition to bilateral exports and outward foreign direct investment, the geography of non-resident patenting is shaped by transnational spatial dependencies: the cross-border patenting activity of residents from one country is influenced by the prior patenting activity of residents from third countries. We find that domestic actors from particular countries are more likely to file for patent protection in focal foreign economies where their regional peers and, to a lesser extent, competitors from economies with similar export product structures have filed for a larger number of patents.

Keywords: Patents, knowledge, imitation, economic linkages, spatial dependence
JEL classifications: F15, F23, D81, O33, O34
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1. Introduction

Within the context of economic globalization, the rise of emerging markets and the growing importance of knowledge as a source of competitive advantage, the number of non-resident patents has grown significantly over the past two decades (Archibugi and Michie, 1995; WIPO 2008). As a form of legally enforceable property right[1], patents allow actors to protect their intellectual assets, and more securely innovate or deploy technologies outside their home country. Yet, actors resident in certain countries apply for a greater number of patents abroad than their counterparts in other countries and, moreover, file for patent protection more in some foreign economies than others (Sun, 2003; Chan et al., 2004; van Pottelsberghe de la Potterie and van Zeebroeck, 2008; Yang and Kuo, 2008). This article seeks to provide new insights into how geography shapes spatiotemporal variations in the propensity of domestic actors (i.e. residents) from one country[2] to make non-resident patent filings (NRPFs) in specific foreign economies.

Previous quantitative studies have established that differences in the number of NRPFs can be explained by countries' level of exports and foreign direct investment

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1 More formally, a patent can be defined as an exclusive intellectual property right granted to a novel process and/or product innovation, which provides the owner with protection over a specified period of time.

2 Actors in this context refer to resident individuals, firms or other organizations.

(FDI) to recipient countries. They have also found some, but not always unambiguous, support for the idea that distance to potential recipients, intellectual property rights (IPR) protection and market attractiveness influence the numbers of NRPFs (Bosworth, 1984; Sun, 2003; O'Keeffe, 2005; Xu and Chiang, 2005; Hoti and McAleer, 2006; Yang and Kuo, 2008; Weinhold and Nair-Reichert, 2009). Our analysis advances on these studies in two important ways.

First, and most importantly, we explore a further set of explanations for differences in non-resident patenting by actors from individual countries. More specifically, we examine whether the decision by actors from one country to file for patents in another economy is influenced by the prior applications of actors in other 'reference' third countries, specified here as (a) states located in the same geographic macroregion and (b) states with a similar export product structure. There are a number of compelling reasons to expect transnational spatial dependence in the geography of cross-border patenting, but previous work has ignored this possibility outright.

A second advance is to use a sample of larger spatial and temporal dimensions. Past studies have either examined a medium-sized sample of countries over a small number of years (Falvey et al., 2006; Yang and Kuo, 2008), or examined a single country over a longer period of time (Bosworth, 1984; O'Keeffe 2005). The panel analysed in the present article not only includes a far larger number of countries than any equivalent study [up to 143 applicant and 108 recipient countries[3], compared to 30 countries in both categories for Yang and Kuo (2008), the study closest to our own], but also for a substantially longer period of time (10 years versus 3 in the case of Yang and Kuo). This larger sample means that we are able to produce more generalizable insights and examine whether previous findings are robust to the inclusion of countries outside the core of economies which account for the vast bulk of international non-resident patent activity.

The article informs wider debates in economic geography. By analysing unevenness in non-resident patenting, our study helps to advance understanding into the conditions under which (codified) knowledge is transferred across borders (Ivarsson, 2002; Gertler, 2003; Verspagen and Schoenmakers, 2004; Neumayer and Perkins, 2005; Faulconbridge, 2006). Our article also contributes to debates about relational economic geographies (Bunnell and Coe, 2001; Bathelt and Gluckler, 2003; Yeung, 2005). While work in relational geography distinguishes itself in its central recognition that agents' economic behaviour is strongly influenced by external economic networks, it has not gone far in examining how extralocal linkages with actors based in third countries may affect the spatiality of domestic actors' international business strategy. Through an examination of transnational spatial dependencies in non-resident patenting, this article sheds fresh light into one underexplored aspect of relational geography, and points towards the need for more complex accounts of the relational context.

2. Unevenness in patterns of internationalization

The number of patents filed in the majority of countries' patent offices has risen dramatically over the past two decades (Kortum and Lerner, 1999; van Pottelsberghe de la Potterie and van Zeebroeck, 2008). Accounting for a large share of this expansion are

3 Note, the sample falls to 128 applicant and 97 recipient economies with the inclusion of FDI and exports.

NRPFs, i.e. patents filed in offices outside the country of the owner/inventor of a technology, which have been growing faster than patents filed by a country's own domestic residents. Although indicative of a trend towards the international transfer and exploitation of technology, as with other manifestations of internationalization, large geographic variations exist in patenting activity. A handful of countries–USA, Japan, Germany and the Republic of Korea–accounted for the majority (59.5%) of NRPFs in 2006 (WIPO, 2008, p. 32). NRPFs received by individual countries also vary markedly. The USA receives by far the largest number of patent filings by non-residents, followed some distance behind by various European states covered by the European Patent Office[4], China, Japan, the Republic of Korea, Canada, Australia, Brazil and India.

Interesting as these disparities in the absolute number of patent filings and receipts are in their own right, they mask even more interesting differences in disaggregated inter-regional and inter-country patenting activity. As an illustration of these geographies, Table 1 provides an overview of the sum of non-resident patents taken by actors resident in specific macroregions in other specific macroregions.

This particular article focuses on variations in non-resident patenting at the national scale. We seek to explain why domestic actors from some countries demonstrate a greater propensity to file for patents in certain foreign economies than others. Our main concern is thus not with generic attributes of sending or receiving states which influence the total number of non-resident patent applications or receipts. For this reason, we relegate two sets of territorially bounded attributes identified in previous research to the status of control variables, namely: (i) the innovativeness of (potential) applicant countries or, more precisely, actors resident in these countries; and (ii) the market attractiveness of (potential) recipient countries (Scherer, 1983; Bosworth, 1984; Sun 2003; Xu and Chiang, 2005; Yang and Kuo, 2008). Rather, our central concern is with attributes which vary across dyads, comprising pairs of countries from which potential patent applications come from and recipient countries in which patent applications are filed. It is our contention that relational ties between potential applicant and recipient countries, as well as between third-party countries and potential applicant countries, have a significant influence on NRPF activity.

3. Motives for patenting

Applying for patents is costly (Sternitzke, 2009). A considerable amount of time, effort and money is required in order to prepare a patent application for consideration by a patent office, which itself typically charges various administrative fees to cover examination expenses. These costs will, if anything, be greater for applications from non-residents. An important corollary is that inventors and/or owners of a technology are unlikely to file for a patent in another country unless there are benefits from doing so which offset these costs (Bosworth, 1984; Inkmann et al., 2000; O'Keeffe, 2005).

Orthodox, economic ('appropriation') accounts have largely conceptualized these benefits in terms of the protection of IPRs (Mazzoleni and Nelson, 1998). A patent creates a temporary monopoly, empowering inventors/owners with a legal right to stop

4 The European Patent Office (EPO) provides a route for inventors to apply for patent protection, using a single grant procedure, in one or more of 35 contracting states of the European Patent Convention (EPC).

Table 1. Sum of non-resident patent filings over the period 1995–2005

	Region of patent office																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Row sum
Region of patent applicant																	
1 Eastern Africa	207	0	0	0	44	4	1	19	0	0	6	0	24	14	3	0	322
2 Northern Africa	0	6263	0	0	76	4	6	10	0	0	0	1	3	9	3	0	6375
3 Southern Africa	66	63	5685	2	2483	129	317	832	80	278	656	30	176	656	146	9	11,608
4 Western and Middle Africa	0	2	0	18	13	0	0	2	0	0	1	0	1	11	0	0	48
5 North America	245	5430	2178	8	1,923,461	57,608	45,264	344,378	21,718	26,076	52,757	5927	28,080	82,899	32,335	848	2,629,212
6 Central America	0	35	1	0	2059	6189	443	431	23	20	51	18	103	163	68	3	9607
7 South America	2	23	15	0	3998	597	43,140	958	43	121	215	27	156	538	61	0	49,894
8 East Asia	13	433	145	2	690,789	5077	4592	5,540,976	15,482	7516	15,206	565	7994	74,286	3019	105	6,366,200
9 South-east Asia	0	5	0	0	4216	51	16	690	13,155	2	27	2	29	206	41	0	18,440
10 South Asia	15	44	8	0	6956	214	132	1393	146	35,627	372	115	397	653	133	15	46,220
11 Pacific	32	90	239	1	23,670	946	1073	8694	1714	1607	113,629	125	744	2706	1026	16	156,312
12 Balkan	1	16	1	1	1225	68	64	379	10	53	60	33,056	279	241	106	7	35,567
13 Eastern Europe	4	50	9	0	6135	190	95	1880	57	215	240	530	357,429	1408	370	322	368,934
14 Western Europe	247	5517	2987	43	512,450	32,545	39,988	324,679	17,307	27,765	33,220	11,455	67,197	1,208,679	26,538	751	2,311,368
15 Middle East	5	74	50	1	23,999	517	365	4540	260	647	907	222	924	1315	21,135	39	55,000
16 Central Asia	0	1	0	0	49	2	1	15	0	0	1	0	148	4	7	26,180	26,408
Column sum	837	18,046	11,318	76	3,201,623	104,141	135,497	6,229,876	69,995	99,927	217,348	52,073	463,684	1,373,788	84,991	28,295	12,091,515

Source: Own computations from WIPO (2008).

other parties from copying, manufacturing, selling or importing a technology, or to seek damages for infringement of intellectual property. By granting exclusive use, or the right to sell or licence a specific invention, patents allow inventors to appropriate rents from their innovative efforts (Inkmann et al., 2000). Another (related) payoff from patent protection identified in the literature derives from strategic deterrence (Gilbert and Newbery, 1982). Actors may pre-emptively acquire a portfolio of patents in a particular industrial field in order to raise the barriers to entry, potentially enabling them to establish or defend a dominant market position (Sankaran, 2000).

More recently, scholars have hypothesized that the returns from obtaining patents lie in their ability to facilitate coordination amongst actors involved in innovating and commercializing new technology (Kortum and Lerner, 1999). Penin (2005: 648–650) identifies a number of such benefits, including: (i) signalling that an actor possesses technological competencies and is therefore a valuable technological partner; (ii) creating a market for a new product by advertising its presence and providing assurance against free riding amongst potential buyers and (iii) providing a '"legal bargaining chip"...[that] will be traded when economic actors need to use technologies that are protected by patents held by other firms' (p. 649).

In the next section, we draw from and, moreover, extend these insights to develop a series of propositions about the attributes which are likely to influence the propensity of actors from one country to file for patents in another country.

3.1. Economic linkages via exports and FDI

The ownership of proprietary technology potentially provides economic actors wishing to export their products and services with a competitive advantage–vis-à-vis their rivals–in foreign markets. Precisely for this reason, we expect exporters to attempt to protect their technology in foreign markets, namely by filing for patent protection (O'Keeffe, 2005, 125). Without patent protection, domestic competitors (as well as third country competitors operating in the same market) could well engage in copy-cat engineering, eroding an economic actor's core competitive competencies and inflicting significant commercial damage (Vishwasrao, 1994).[5]

The literature on FDI has similarly made much of firm-specific technological assets. According to Dunning's (2001) influential eclectic framework, a transnational corporation (TNC) will make direct investments in other countries where it possesses ownership-specific advantages, including technology-based ones. As in the case of exports, these technological resources may allow a TNC to compete with foreign competitors. TNCs innovate, own and control a large share of the world's advanced technology, and evidence suggests that access to proprietary technologies plays an important role in many TNCs' competitive strategies (Globerman et al., 2000; Dicken, 2007). It follows that TNCs will possess strong incentives to protect their intellectual property, notably, by filing for patent protection in countries where they operate

5 Non-resident patent holders potentially face working requirements, which commit them to manufacture the patented technology locally within a specified period of time. Yet not all countries enforce this requirement and, even when they do, patents may provide temporary protection during which time non-working may be allowed or a patent holder locates a local licensee (Azmi and Rokiah, 2001; Bosworth, 1984).

(Sun, 2003).[6] As outlined in models of strategic blocking, FDI may additionally be accompanied by attempts to 'build walls' around foreign markets, with a view to deterring the entry of other competitors. TNCs may file for a large number of patents in particular technology fields, whether or not they intend to use or licence the technology, in countries where they operate. They may also file for patents in the host economy to facilitate interaction, transactions and cooperation with other firms.

Whether by exports or FDI, what is likely to determine the actual number of NRPFs is a country's absolute level of cross-border economic involvement in the recipient economy. A higher amount of exports to a particular country implies a greater number of transferred technologies, for which patent protection must be sought, and therefore a greater number of NRPFs. Moreover, higher exports imply a greater profit stream derived from the technological assets of domestic residents in the exporting country, suggesting that they should have more to gain economically by acquiring patents in these exports markets (Yang and Kuo, 2008). Similarly, higher inward stocks of FDI suggest greater and more profitable foreign involvement in the host economy, bringing with it a larger number of proprietary technologies, which again is likely to lead to more filings by non-resident actors.

These expectations are confirmed by recent empirical work. Previous statistical studies have all reached a broadly similar conclusion: countries' exports and the number of NRPFs in receiving countries are positively correlated (Schiffel and Kitti, 1978; Bosworth, 1984; Eto and Lee, 1993; Inkmann et al., 2000; Xu and Chiang 2005; Yang and Kuo 2008). A similar pattern emerges for FDI: levels of direct investment or numbers of TNCs located in host economies exhibit a positive relationship with NRPFs (Bosworth 1984; Eto and Lee 1993; Sun 2003; Yang and Kuo 2008).

Yet, before concluding that exports and FDI unambiguously drive NRPFs in recipient countries, several qualifications are in order. First, some of the above-cited studies are based on fairly rudimentary, bi-variate correlations, such that they potentially suffer from problems of omitted variable bias (Bosworth, 1984; Eto and Lee, 1993; Sun, 2003). Second, almost all of these studies have analysed exports and investment separately, instead of together. This is potentially problematic, in the sense that exports and inward FDI are not independent of one other, meaning that it is unclear from past studies whether one, the other or indeed both, are drivers of NRPF. And third, most previous studies are based on relatively small geographic samples, mainly comprising developed countries and a handful of more dynamic industrializing economies. On the recipient side, samples vary from one country for Sun (2003) to 50 for Bosworth (1984),[7] while on the applicant side, samples range from a single patenting country for Bosworth (1984) to 30 for Yang and Kuo (2008). Indeed, all that we can conclude from previous work is that exports and investment possibly have a positive influence on cross-border patenting in a subset of patent-intensive economies, predominantly from the developed world.

6 The eclectic paradigm also identifies location-specific advantages as a motive for FDI which, of note in the present context, are known to include technological capabilities not available in the TNC's home country (Dicken, 2007). Yet while these asset-seeking and asset-augmenting investments may give rise to new patents, we do not consider these in the present context because, as noted by Archibugi and Michie (1995), patented inventions are credited to the country of the inventor rather than the owner.

7 Moreover, this study does not employ a dyadic dataset, such that it merely suggests that countries with more inward FDI receive more NRPF filings, but not that they receive these filings from the major investors.

This article seeks to address some of these shortcomings, namely, by (i) using a multivariate research design in which exports and investment are analysed in the same estimation model, and (ii) analysing a substantially larger sample of years and applicant/recipient countries, including a large number of developing countries omitted in previous work.

3.2 Spatial dependence

Spatial dependence exists whenever the choices of actors from one particular spatial unit are affected by the decisions or behaviour of actors in other spatial units. There are good reasons to believe that the non-resident patenting activity of actors from one country might depend spatially on the non-resident patenting of actors from third countries. Most importantly, transnational spatial dependencies may arise because decision makers face considerable uncertainty over the need for, and payoffs from, patent protection (Vishwasrao 1994; Sternitzke 2009). Hence the decision to file for patent protection in another country may be relatively straightforward for actors transferring critical, high-value technology via exports and/or investment (Lanjouw et al., 1998). Yet, in many other situations, the choice to patent may be far from straightforward.

One source of uncertainty centres on an invention's medium- to long-term market returns (van Pottelsberghe de la Potterie and van Zeebroeck, 2008). Most inventions do not result in commercially viable technologies and, even when they do, it is likely to be difficult to predict a technology's future profitability in foreign markets. Indeed, these uncertainties are likely to be amplified where a domestic actor is unsure as to whether it is going to participate in a particular country, or to what degree. Another source of ambiguity is whether a particular patent system offers sufficient protection from imitation, so as to justify the financial or other costs of NRPF. Along similar lines, an economic actor may not know whether there is a genuine risk that its proprietary technology will be copied, applied or re-exported by firms operating in the (potential) recipient country. Adding to the difficulties of evaluating the financial payoffs from patents is uncertainty about the costs of acquiring protection through domestic patent systems.

Going further, even if an actor does decide that it wishes to defend its proprietary knowledge, it is by no means certain that patents will be used. In practice, there are a number of possible ways to lower the risks of imitation. Especially in R&D-intensive industries, evidence suggests that many actors rely just as much or more heavily on methods other than patents, especially secrecy (Levin et al., 1987; Inkmann et al., 2000; Arundel 2001).

Previous work on cross-border patenting has largely ignored these uncertainties. Instead, studies have implicitly or explicitly assumed that decision makers are rational, profit-maximizing agents, endowed with perfect information about the range of alternatives and the costs, benefits and returns associated with each of these options. They have also portrayed decision makers as atomistic agents, isolated from the influences of other actors (Bosworth, 1984; O'Keeffe, 2005; Xu and Chiang, 2005; Hoti and McAleer, 2006). However, we believe that these assumptions are highly questionable, and that the failure to properly acknowledge uncertainty and relational influences represents an important oversight.

Accepting that economic actors are not perfectly rational, knowledgeable and operate in uncertain, relational environments has far-reaching implications. In particular, it suggests that they may be influenced to file for non-resident patents not only by internal calculations regarding profitability or strategic value, but also by the actions of other actors. According to an established body of work, therefore, decision makers frequently resort to imitating significant reference groups when confronted with uncertainty (DiMaggio and Powell, 1983; Haveman, 1993; Henisz and Delios, 2001; Guler et al., 2002). Drawing from these ideas, we argue that the decision to file for patent protection in a particular country will be shaped by the choices of actors from third countries.

A number of causal mechanisms have been advanced to predict, or else explain, imitative dynamics (Lieberman and Asaba, 2006; Ordanini et al., 2008). One broad class focuses on information. For economic variants, decision makers may copy others, either assuming that they have better-quality information, or because doing so economizes on search, information and experimentation costs (Cyert and March 1963; Bikhchandani et al., 1992). Another related idea, which has its roots in the new-institutionalism in economic sociology, is that actors turn to other agents in their inter-organizational environments when making decisions, because doing so provides legitimacy for a particular course of action (DiMaggio and Powell, 1983; Fligstein 1985). Applied to non-resident patenting, decision makers lacking adequate information might plausibly look towards other actors' prior filings as a signal that patent protection is a necessary, profitable or otherwise worthy activity (Henisz and Delios, 2001). Similarly, from a new-institutionalist perspective, domestic actors could well follow the lead of foreign peers in order to align themselves with organizations whose choices are perceived as more legitimate, progressive or appropriate (Abrahamson, 1996; Neumayer and Perkins, 2005).

A second set of causal mechanisms conceptualize imitation 'as a response designed to mitigate competitive risk or rivalry' (Lieberman and Asaba, 2006, p. 374). According to theories of competitive diffusion, economic actors will emulate their (potential) rivals so as to minimize the risk of becoming competitively disadvantaged, resulting in 'follow-the-leader'-type behaviour (Haveman, 1993; Elkins et al., 2006). Again, these predications can be logically extended to patenting, where theories of competitive emulation would anticipate transnational spatial dependence in NRPF. An economic actor based in country i may be uncertain about whether to seek patent protection in country j. However, with a view to mitigating the risk that rivals will steal a competitive march by acquiring a position of technologically based leadership, actors from country i may copy the patenting activities of peers from 'competitor' economies k operating in focal country j. Indeed, competitive emulation of this sort may be important in view of strategic blocking, with actors hedging against market lock-out via non-resident patenting.

Although the possibility of transnational spatial dependence has been neglected in the literature on non-resident patenting, its existence is nevertheless beginning to be documented in other areas of business internationalization. Several large-N studies have shown that firms imitate their counterparts located in other countries, including in relation to foreign entry and exit decisions (Chan et al., 2006), and the adoption of management standards (Guler et al., 2002; Perkins and Neumayer, 2004, 2009; Albuquerque et al., 2007). This article extends the analysis of spatial dependence to non-resident patenting decisions.

An important question concerns the identity of countries from which actors might plausibly exert imitative influence. A number of different possible country 'peer' groups

exist. Within the present study, however, we focus on two reference groups, namely: (i) countries which are located in the same geographic macro-region and (ii) economies with a similar export product structure. Guiding our choice of the first of these two groups is the idea that macro-regions comprise distinctive spaces of interaction, comparison and learning. Work in economic geography–as well as business studies–has identified a distinctive macro-regional configuration to cross-border trade, investment, R&D and production strategies (Yeung, 2001; Rugman and Verbeke, 2004; Dicken, 2007). An important consequence–and, to a greater or lesser extent, a cause–of these economic dependencies is that domestic actors are likely to communicate more frequently with their counterparts located in countries within the same geographic region, share information with them, observe their actions and take cues from their strategic choices (Albuquerque et al., 2007). Indeed, greater familiarity or sociocultural propinquity with actors located in the same region means that domestic actors located in one country are more likely to identify with their macro-regional peers, such that their actions carry greater weight (Bunnell and Coe, 2001; Gertler, 2003).

Inspiration for our second hypothesized peer group comes from theories of competitive emulation. If, as economic accounts emphasize, imitation is driven by the threat of competition, it follows that actors are more likely to mimic their counterparts in countries which are perceived as important competitors. According to previous work, one such set of actors are located in countries with an equivalent economic structure, competing internationally in similar export products (Cao and Prakash, 2010; Guler et al., 2002; Poon and Thompson, 2004; Elkins et al., 2006). As well as potential competitors, actors located in countries with similar export product structures might be perceived as providing more relevant signals of appropriate market behaviour, stemming from the fact that they are more likely to face similar economic circumstances.

Of course, our two hypothesized relational attributes are not mutually exclusive, and it is quite possible that the non-resident patenting behaviour of actors located in both sets of country reference groups may play a role in influencing the strategic choices of domestic actors to file for patent protection. However, to the extent that they capture contrasting aspects, our study provides a useful test case to examine whether spatial dependence is regionally based, structurally based or both.

4. Dependent and main explanatory variables

Our main dependent variable is a directed country dyadic variable, namely, the number of non-resident patents filed, regardless of whether these applications are successful, by nationals of country i in foreign country j. In a separate robustness test, we use an alternative dependent variable, namely the number of patents (successfully) granted to non-residents. Non-residents comprise individuals, firms and other public or private organisations. The data, obtained from the World Intellectual Property Organization (WIPO 2008), cover a 10-year period from 1995–2005.

We analyse four main explanatory variables–each corresponding to one of our hypotheses. Our export variable is measured by the value of bilateral exports–from patent applicant country i to recipient country j–using data obtained from UN (2007). Foreign investment dependence is measured using the value of outward bilateral FDI stock of country i in host economy j, with data taken from UNCTAD (2008). Values of exports and investment were converted to constant US$.

In order to model spatial dependencies, we use spatial lag variables. More precisely, we employ what Neumayer and Plümper (2010) call specific source contagion spatial lag variables, which can be defined formally as

$$y_{ijt} = \rho \sum_{k \neq i} \omega_{ikt-1} \, y_{kjt-1} + \cdots + \varepsilon_{ijt} \tag{1}$$

In words, the patenting activity of residents from country i in foreign country j depends spatially on the number of non-resident patents that actors from all other third-party countries k have filed in the same focal economy j in the previous year, weighted by a connectivity matrix capturing the degree of linkage between country i and countries k (ω_{ikt-1}). That is, the NRPF activity of domestic actors from country i is influenced by the cross-border patenting choices of domestic actors from other countries in the same focal economy j. However, they will be influenced more by actors in some third countries than others, as expressed by the connectivity matrix. We 'row-standardize' the weighting matrix, which is considered standard practice by some (Anselin, 2002),[8] and is convenient as it means that the spatial lags are in the same unit as the dependent variable. Note, the spatial lag refers to patenting activity in the previous year to mitigate endogeneity bias.[9]

In the case of our hypothesis of spatial dependence through export product equivalence, the connectivity variable entering the weighting matrix captures the similarity of export product shares. Actors in other countries k exporting a similar set of products as country i have a larger hypothesized influence on country i's non-resident patenting activity in focal economy j than actors in countries that export a more dissimilar set of products. Domestic actors are thus hypothesized as taking their cues from counterparts in countries which export similar goods. After Elkins et al. (2006), we calculate export product similarity as the correlation between two countries' export shares for 13 key product sectors among their total exports. If two countries exported exactly the same share of products in these sectors, the variable would be one, while it would be minus one if they exported entirely different products.

For our second hypothesis of spatial dependence via the macroregional location of countries, our connectivity variable is constructed using a simple dichotomous measure that is set to one if country i and country k are located in the same macro-region, and zero otherwise. Thus, as actors in country i's regional peers file for more patents in foreign recipient economy j, which itself may or may not be located in the same region, we expect residents of country i to file for more patents in country j. In this case, we assume domestic actors' decision to file for patent protection in a particular foreign focal economy to be influenced by (i.e. spatially depend on) prior patenting of actors from countries in the same geographic macro-region, e.g. because the latter are seen as providing relevant signals of profitable international business strategy. To identify regional location, we use the UNWTO's (2007) classification of countries into sixteen macro-regions. The appendix lists the UNWTO classification. In robustness tests,

8 Row-standardization would normally have to be justified on substantive grounds as well (Plümper and Neumayer, 2010). However, since our connectivity variable does not measure any level effects such as is the case for, e.g. trade or FDI, not row-standardizing makes little sense.

9 The potential endogeneity arises because, while countries k have an impact on country i, country i's activity also has a (small) reverse impact on countries k.

we use a separate macro-regional scheme, as given by the World Bank's country classification into eight regions.[10]

5. Control variables

We also include two sets of control variables. The first seeks to account for differences in the innovativeness of potential applicant countries and their residents. The underlying logic is that domestic actors in more innovative countries are likely to develop, commercialize and own a greater number of inventions which require patent protection in foreign markets (Sun, 2003). In order to capture the innovativeness of countries and their residents, we use three variables: gross domestic product (GDP), GDP per capita and the number of non-resident patents filed by residents of applicant countries in foreign economies other than the focal country j. Larger countries should, all else equal, have a greater number of actors involved in inventing, innovating and commercializing technologies and therefore have more inventions to patent. Likewise, actors in richer countries possess greater technological capabilities required to develop new technologies, together with the financial capabilities needed to finance innovation (Furman et al., 2002). Actors in richer economies should also be in a better position to afford the costs of acquiring patents (Chan et al., 2004). Finally, a higher total level of non-resident patenting activity would suggest that actors from these countries have a higher propensity to innovate and patent their innovations abroad, which should also lead to higher patenting activity in the focal country j. This variable can also capture differences in industrial structure across countries with firms of different sizes and different economic sectors exhibiting different propensities to seek patent protection (Patel and Pavitt, 1991), both domestically and abroad, as well as differences across countries in national systems of innovation.

A second set of variables seek to control for the real or perceived attractiveness of countries as a location for foreign actors to transfer technologies and file for patent protection. We use three controls. One is the degree of protection afforded by patent systems. We anticipate that domestic actors will be more willing to transfer their inventions to countries whose national patents systems offer greater protection. Although the relationship between IPR and technology transfer is complex, patent systems which offer greater protection should reduce the risk of appropriation, and increase the economic value of patent applications (Smith, 1999; Lerner, 2002; Xu and Chiang, 2005). We use Park's (2008) recently-constructed index of patent rights. The index scores national patent systems according to their: (i) coverage; (ii) a country's membership in international (IPR-related) treaties; (iii) enforcement mechanisms and (iv) restrictions on patent rights.

Additionally, we control for country market size (GDP) of (potential) recipients of NRPFs. As hypothesized elsewhere, owners/inventors are more likely to file for patent protection in larger markets, where greater demand for a more diverse set of innovations makes it more profitable for actors to deploy, exploit and protect their technology (Lanjouw et al., 1998; Sun, 2003; O'Keeffe, 2005). Previous empirical work

10 The World Bank classification is highly aggregated. To take one example: the World Bank places all countries in Central America, the Caribbean and South America into one large regional grouping. Yet the non-resident patenting decisions of actors in, say, Chile are somewhat unlikely to spatially depend on the choices made by actors in distant Guatemala.

supports these predictions (Bosworth, 1984; Inkmann et al., 2000; van Pottelsberghe de la Potterie and van Zeebroeck, 2008).

Neither IPR protection nor market size can fully capture the attractiveness of a foreign country *j* for NRPFs. We therefore additionally include the total number of NRPFs made by *any* foreigner in the previous year. A larger total number of NRPFs in country *j* in the previous year should, all other things equal, signal to potential patent applicants in country *i* that country *j* is an attractive market in which to file for patent protection. This variable can also capture the lower transaction costs and therefore greater attractiveness of filing patents in European states party to the European Patent Convention, which allows applicants to acquire a national patent in more than one country through a single application procedure.

Next, we seek to control for the likelihood that actors are more likely to patent their inventions in spatially proximate countries. Conceptually, this is typically explained in terms of the liabilities of foreignness, with potential applicants finding it more difficult, costly and risky to evaluate, make and manage investments in distant countries. Early empirical work provided support for these ideas, finding that neighbouring countries have high levels of inter-country patent flows (Sláma, 1981; Soete and Wyatt, 1983). More recently, Yang and Kuo (2008) show that physical distance is negatively correlated with non-resident patents, although Sun (2003) finds no such relationship with distance or geographic region. Still, to the extent that the literature suggests that spatial proximity continues to exert an influence over technology transfer, we seek to control for neighbourhood effects (van Pottelsberghe de la Potterie and Lichtenberg 2001; Keller, 2004; Rodríguez-Pose and Crescenzi, 2008; Won Sonn and Storper, 2008). In order to capture spatial proximity, we use two measures: (i) physical distance, in kilometres between the patent applicant country *i*'s and patent recipient country *j*'s capital cities, using data from Bennett and Stam (2005) and (ii) regional location, again using UNWTO (2007) to code whether the applicant country *i* and recipient country *j* are located in the same geographic macroregion. We additionally include the squared term of the distance variable, specifically to account for the fact that NRPF activity is likely to fall with distance, albeit at a decreasing rate.

Finally, we include year-specific time dummies to control for common shocks and trends which affect all dyads equally. A failure to control for common shocks and trends may lead to biased estimates for the spatial dependence variables (Plümper and Neumayer, 2010).

Most continuous variables enter the regressions in logged form to account for our expectation that the relationship between, say, measures of economic dependence and NRPF is non-linear: greater exports and FDI give rise to more non-resident patents, but diminishingly so as the value of these increase.[11] Based on the above, we estimate variants of the following model (leaving out the coefficients to be estimated):

$$\begin{aligned} y_{ijt} = & \sum_{k \neq i} \omega^1_{ikt-1} y_{kjt-1} + \sum_{k \neq i} \omega^2_{ik} y_{kjt-1} + \ln \exp_{ijt} + \ln FDI_{ijt} + \ln GDPpc_{it} \\ & + \ln GDP_{jt} + \sum_{m \neq i,j} y_{imt-1} + \ln GDP_{it} + \sum_{m \neq j} y_{mjt-1} + IPRP_{jt} \\ & + \ln dist_{ij} + (\ln dist_{ij})^2 + sameregion_{ij} + year_t + \varepsilon_{ijt}, \end{aligned} \tag{2}$$

11 This model also has a much better fit.

Table 2. Summary descriptive variable information

	Observations	Mean	Standard Deviation	Minimum	Maximum
y_{ijt} (patents filed)	10,572	280.38	2,065.76	1.00	71,994.00
$\sum_{k \neq i} \omega^1_{ikt-1} y_{kjt-1}$	10,571	283.79	669.07	0.00	4025.22
$\sum_{k \neq i} \omega^2_{ik} y_{kjt-1}$	10,572	593.98	4,035.98	0.00	104,069.50
$\ln exp_{ijt}$	10,572	6.40	2.12	0.00	12.62
$\ln FDI_{ijt}$	7,573	4.73	3.94	-2.30	12.60
$\ln GDP_{it}$	10,572	26.66	1.46	21.24	30.03
$\ln GDPpc_{it}$	10,572	9.57	1.03	5.68	10.87
$\sum_{m \neq i,j} y_{imt-1}$	10,572	11,475.22	20,853.65	0.00	117,378.00
$\ln GDP_{jt}$	10,572	25.92	1.96	18.73	30.03
$\sum_{m \neq j} y_{mjt-1}$	10,572	10,782.28	26,398.82	1.00	152,323.00
$IPRP_{jt}$	10,572	4.14	0.65	1.23	4.88
$\ln dist_{ij}$	10,572	7.24	2.31	0.00	9.42
$(\ln dist_{ij})^2$	10,572	57.72	22.16	0.00	88.76
$sameregion_{ij}$	10,572	0.19	0.39	0.00	1.00

where ω^1_{ikt-1} stands for export product structure similarity and ω^2_{ik} captures same macroregional location of countries i and k. Table 2 provides summary descriptive variable information and Table 3 provides a correlation matrix.

6. Estimation technique

The dependent variable is a strictly non-negative count variable (number of patents), so we cannot use ordinary least squares (OLS) because doing so would violate the estimation model's underlying assumptions. There are two main estimation models suitable for count data: poisson and negative binomial. The sample variance largely exceeds the sample mean and we therefore opt for the negative binomial model. Standard errors are adjusted for clustering of observations on country dyads.

7. Results

Table 4 shows our estimation results. We start with a model that does not include any of the four main explanatory variables of interest (column 1). With the exception of the same-region variable, all of the control variables are statistically significant with the expected coefficient sign. As previously hypothesized in the literature, we thus find that actors in larger and wealthier countries, as well as ones resident in countries with a greater number of patents filed abroad, account for a larger number of NRPFs in country j. The same goes for spatial proximity (Furman et al., 2002; Sun, 2003; Chan et al., 2004), although the negative effect of distance on NRPF activity becomes smaller with increasing distance as revealed by the positive and statistically significant

Table 3. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 y_{ijt} (patents filed)	1												
2 $\sum_{k \neq i} \omega^1_{ikt-1} y_{kjt-1}$	0.2426	1											
3 $\sum_{k \neq i} \omega^2_{ik} y_{kjt-1}$	0.1513	0.3363	1										
4 $\ln exp_{ijt}$	0.2370	0.2985	0.2243	1									
5 $\ln FDI_{ijt}$	0.1914	0.1131	0.1027	0.6705	1								
6 $\ln GDP_{it}$	0.1732	−0.1139	0.0093	0.3279	0.324	1							
7 $\ln GDPpc_{it}$	0.0861	−0.1339	−0.0560	0.0386	0.4123	0.2345	1						
8 $\sum_{m \neq i,j} y_{imt-1}$	0.1543	−0.1240	−0.0361	0.1622	0.2274	0.7348	0.3575	1					
9 $\ln GDP_{jt}$	0.1919	0.6370	0.2192	0.5815	0.3287	−0.1849	−0.1263	−0.1624	1				
10 $\sum_{m \neq j} y_{mjt-1}$	0.2836	0.7656	0.2480	0.2727	0.1268	−0.1587	−0.1500	−0.1318	0.6008	1			
11 $IPRP_{jt}$	0.0870	−0.1096	−0.0453	0.1226	0.4019	0.3616	0.7545	0.3700	−0.1531	−0.1364	1		
12 $(\ln dist_{ij})^2$	0.0329	0.1460	−0.0737	−0.3465	−0.2245	0.1065	0.0331	0.1245	0.0774	0.1394	0.0081	1	
13 $sameregion_{ij}$	−0.0146	−0.1297	0.1319	0.3779	0.3146	−0.0800	0.0892	−0.1121	0.0701	−0.1532	0.0661	−0.5514	1

$N = 7{,}573$.

Table 4. Estimation results

	(1) Base model	(2) Exports and FDI added	(3) SL (export product similarity) added	(4) SL (same region) added	(5) Both SL variables added
$\sum_{k \neq i} \omega^1_{ikt-1} y_{kjt-1}$			0.000414***		0.000211***
			(0.000143)		(0.0000767)
$\sum_{k \neq i} \omega^2_{ik} y_{kjt-1}$				0.0000538***	0.0000481**
				(0.0000197)	(0.0000218)
$\ln exp_{ijt}$		0.283***	0.298***	0.292***	0.297***
		(0.0611)	(0.0624)	(0.0634)	(0.0637)
$\ln FDI_{ijt}$		0.0572***	0.0652***	0.0673***	0.0694***
		(0.0159)	(0.0158)	(0.0153)	(0.0156)
$\ln GDP_{it}$	0.603***	0.294***	0.253***	0.261***	0.248***
	(0.0438)	(0.0724)	(0.0695)	(0.0706)	(0.0706)
$\ln GDPpc_{it}$	0.464***	0.366***	0.364***	0.376***	0.372***
	(0.0598)	(0.0689)	(0.0704)	(0.0697)	(0.0703)
$\sum_{m \neq i,j} y_{imt-1}$	0.00000895**	0.0000117***	0.0000129***	0.0000110***	0.0000115***
	(0.00000399)	(0.00000451)	(0.00000441)	(0.00000398)	(0.00000397)
$\ln GDP_{jt}$	0.507***	0.233***	0.162***	0.190***	0.161***
	(0.0257)	(0.0514)	(0.0433)	(0.0438)	(0.0443)
$\sum_{m \neq j} y_{mjt-1}$	0.0000182***	0.0000181***	0.0000118***	0.0000163***	0.0000132***
	(0.00000220)	(0.00000238)	(0.00000344)	(0.00000221)	(0.00000252)
$IPRP_{jt}$	0.314***	0.192*	0.178*	0.183*	0.178*
	(0.0854)	(0.102)	(0.103)	(0.103)	(0.104)
$\ln dist_{ij}$	−0.185**	−0.235***	−0.275***	−0.320***	−0.319***
	(0.0720)	(0.0820)	(0.0716)	(0.0689)	(0.0690)
$(\ln dist_{ij})^2$	0.00809	0.0283***	0.0328***	0.0370***	0.0371***
	(0.00717)	(0.00863)	(0.00752)	(0.00726)	(0.00727)
$sameregion_{ij}$	−0.0575	−0.323*	−0.385**	−0.587***	−0.561***
	(0.173)	(0.190)	(0.168)	(0.162)	(0.162)
Constant	−30.60***	−16.73***	−13.92***	−14.77***	−13.73***
	(1.477)	(2.702)	(2.370)	(2.393)	(2.404)
Observations	10572	7573	7573	7573	7573

Notes: ω^1_{ikt-1} is an export product similarity, ω^2_{ik} is a same region weighting matrix.
***Significant at 1% level, **Significant at 5% level and *Significant at 10% level. Negative binomial regression with observations clustered on country dyads. Standard errors in brackets. Year-specific time dummies included, but coefficients not reported.

coefficient of the squared distance variable in all other models but the first one.[12] In other words, NRPF activity declines with distance between the country pair, but at a decreasing rate. Turning to recipient countries, confirming the findings of previous work, we estimate a positive relationship between NRPs filed by residents of country *i*, on the one hand, and economic size of the recipient country, the total number of patents filed by non-residents in the recipient country (as a general measure of a country's attractiveness for foreign patenting) and the strength of patent system protection in recipient economies, on the other.

[12] Computations show that, as one would expect, the total effect of distance never becomes positive within the relevant range of distances.

In column 2, we add the dyadic export and FDI stock variables. All of the control variables remain largely similar. The same is true for the remaining estimation models, which is why we no longer report control variable results below. The only exception is that the previously insignificant *same-region* variable becomes statistically significant, but with an unexpected negative coefficient sign. Once we account for the effect of exports and FDI, actors in countries from the same region take out fewer rather than more NRPs. A possible explanation for this change is that countries typically trade and invest more with spatially proximate/same region economies, such that our economic linkage and locational variables are correlated with one another.

Turning to the first of our two main explanatory variables, we estimate a positive and statistically significant relationship between the measure of bilateral exports and NRPFs, indicating that domestic actors apply for more non-resident patents in countries to which they export more. Also supporting the idea that non-resident patenting is mapped onto cross-border economic linkages, our coefficient for outward FDI stock is positive and statistically significant. Simply put: our results suggest that a greater stock of foreign investment in a particular economy is likely to be accompanied by more NRPFs from the country of the investors. We thus find evidence supporting our first two hypotheses. The substantive effect of both variables is strong, but it is stronger for exports than for FDI. Holding all other variables at their mean values, we calculate that a one standard deviation increase in bilateral exports raises the expected non-resident patent count by almost 85%, while a one standard deviation increase in the bilateral FDI stock raises the expected non-resident patent count by roughly 25%.

Of even greater interest to us is whether there is evidence of spatial dependence in the decision to file for non-resident patents. Entered separately, coefficients for each of the two spatial lag variables capturing trait-based country categories are positive and statistically significant (see columns 3 and 4, respectively). As anticipated, our results suggest that domestic actors are more likely to file for non-resident patents in a particular economy where their counterparts in other countries exhibiting a similar export product structure have made a higher number of NRPFs (column 3). The substantive effect of this spatial dependence is somewhat larger compared to the one relating to FDI: a one standard deviation increase in the export product similarity weighted spatial lag variable increases the expected non-resident patent count by slightly more than 33%, holding all other variables at their mean values. Also in line with expectations, domestic actors' propensity to file for patent protection in recipient economies rises as actors in their macroregional peers account for a larger number of non-resident patents in these economies (column 4). The substantive importance of this second spatial lag variable is roughly the same as that of the other spatial lag: a one standard deviation increase raises the expected patent count by approximately 28%.

How do these results change when both spatial lag variables are entered into the estimation model simultaneously (column 5)? Although remaining statistically significant, the coefficient of the spatial lag capturing export product similarity decreases to half its previous size, whereas the coefficient of the spatial lag with the connectivity matrix linking countries from the same macro-region decreases only slightly. In substantive terms, whilst a one standard deviation increase in the same region weighted spatial lag variable increases the expected non-resident patent count by 25% (down only three percentage points), a corresponding one standard deviation increase in the export product similarity weighted spatial lag variable raises the expected patent count by only 16%. The latter is substantially lower than the estimated 33%

when only the export product weighted spatial lag variable is included in the estimations. Caution must be exercised when interpreting these findings, but they do tentatively suggest that the NRPF decisions of domestic actors in one country depend spatially more on the patent activity of their peers in other countries within the same macroregion rather than of other countries with a similar export product structure.

8. Robustness tests

In Table 5, we report results from some robustness tests on the basis of an estimation model that contains both spatial lags. It is impossible to know the correct temporal lag length for the spatial lag variables. Hence, in column 1 of Table 5, we enter the spatial lag in its contemporaneous form, i.e. not lagged by one period as throughout Table 4. In column 2, we lag both variables by two periods. In both cases, the spatial lag variables remain statistically significant, and with approximately the same coefficients. The same holds true for lagging the spatial lag variables by three or four periods (results not reported).

In column 3, we include the temporally lagged dependent variable. Although this variable might capture many different dynamics, of particular significance in the present context, it can control for the possibility that a potential patent applicant from country *i* may look towards the NRPFs made by other residents of the same country in focal economy *j*. Interestingly, we find that the lagged-dependent variable is only weakly statistically significant at the 10% level. Despite the fact that the temporally lagged dependent variable absorbs some of the variation in the variable to be explained, all of the explanatory variables remain statistically significant with the same coefficient sign as before, with two exceptions: First, the same region weighted spatial lag variable becomes (marginally) insignificant and, second, the variable measuring the number of non-resident patent filings by actors from country *i* in foreign countries other than in focal country *j* becomes clearly insignificant.

In the main estimations, we used the UNWTO's classification of countries into regions, rather than the courser-grained World Bank classification. In column 4, we check whether our results are robust to using the World Bank country scheme, which turns out to be the case. In column 5, we exclude patent applicants from OECD countries to check whether our results are entirely driven by the presence of high income, developed countries in the sample. We find that the spatial lag variable working via export product structure becomes statistically insignificant, whereas the other spatial lag variable remains significant. Our results would seem to suggest that export product structure only matters for non-resident patent filings from developed country nationals. Note also that the FDI variable becomes insignificant. This is not surprising given that there is comparatively little FDI from non-OECD countries. In columns 6 and 7, we take the number of patents granted rather than patents filed as the dependent variable, using UNWTO and World Bank regional classifications, respectively. In both columns, the export product structure weighted spatial lag variable is statistically insignificant, whereas the same region weighted spatial lag variable remains significant.[13] Overall, we

13 The spatial lag and two of the control variables also refer to patents granted, rather than patents filed, for these two estimations.

Table 5. Robustness tests

	(1) Both SL variables not lagged	(2) Both SL variables lagged by two periods	(3) Temporally lagged dependent variable included	(4) World Bank regional classification	(5) Excluding OECD patent applicants	(6) Patents granted UNWTO regional classification	(7) Patents granted World Bank regional classification
y_{ijt-1}			0.000410*				
			(0.000225)				
$\sum_{k\neq i}\omega^1_{ikt-1}\,y_{kjt-1}$	0.000167**	0.000178**	0.000171**	0.000220***	0.0000805	0.000139	0.000227
	(0.0000728)	(0.0000803)	(0.0000703)	(0.0000741)	(0.000124)	(0.000243)	(0.000234)
$\sum_{k\neq i}\omega^2_{ik}\,y_{kjt-1}$	0.0000441**	0.0000475**	0.0000224	0.000231***	0.0000202*	0.000118*	0.000359*
	(0.0000180)	(0.0000214)	(0.0000144)	(0.0000768)	(0.0000122)	(0.0000693)	(0.000198)
$\ln exp_{ijt}$	0.296***	0.284***	0.269***	0.302***	0.197***	0.432***	0.430***
	(0.0637)	(0.0648)	(0.0572)	(0.0639)	(0.0542)	(0.0538)	(0.0535)
$\ln FDI_{ijt}$	0.0689***	0.0688***	0.0701***	0.0670***	−0.0290	0.0685***	0.0670***
	(0.0154)	(0.0159)	(0.0146)	(0.0154)	(0.0233)	(0.0161)	(0.0160)
$\ln GDP_{it}$	0.250***	0.254***	0.227***	0.243***	0.325***	0.0724	0.0759
	(0.0706)	(0.0730)	(0.0636)	(0.0707)	(0.0846)	(0.0611)	(0.0605)
$\ln GDPpc_{it}$	0.373***	0.367***	0.351***	0.344***	0.214**	0.387***	0.367***
	(0.0701)	(0.0714)	(0.0666)	(0.0671)	(0.0855)	(0.0846)	(0.0821)
$\sum_{m\neq i,j} y_{imt-1}$	0.0000116***	0.0000119***	0.00000183	0.0000130***	0.000103***	0.0000239***	0.0000256***
	(0.00000395)	(0.00000406)	(0.00000354)	(0.00000400)	(0.0000240)	(0.00000647)	(0.00000669)
$\ln GDP_{jt}$	0.167***	0.170***	0.163***	0.135***	0.206***	0.0134	0.00169
	(0.0443)	(0.0455)	(0.0415)	(0.0452)	(0.0546)	(0.0467)	(0.0458)
$\sum_{m\neq j} y_{mjt-1}$	0.0000141***	0.0000142***	0.00000555**	0.0000131***	0.0000183***	0.0000303***	0.0000296***
	(0.00000257)	(0.00000254)	(0.00000234)	(0.00000262)	(0.00000385)	(0.00000550)	(0.00000578)
$IPRP_{jt}$	0.178*	0.184*	0.174*	0.184*	0.262***	0.358***	0.357***
	(0.103)	(0.108)	(0.0975)	(0.0985)	(0.0911)	(0.117)	(0.112)
$\ln dist_{ij}$	−0.313***	−0.313***	−0.313***	−0.317***	−0.135	−0.342***	−0.338***
	(0.0694)	(0.0727)	(0.0633)	(0.0678)	(0.107)	(0.0620)	(0.0618)
$(\ln dist_{ij})^2$	0.0364***	0.0360***	0.0361***	0.0386***	0.0133	0.0460***	0.0466***
	(0.00732)	(0.00763)	(0.00684)	(0.00729)	(0.0125)	(0.00708)	(0.00706)
$sameregion_{ij}$	−0.551***	−0.560***	−0.656***	−0.483***	0.765***	−0.459***	−0.333***
	(0.162)	(0.167)	(0.146)	(0.146)	(0.258)	(0.128)	(0.120)
Constant	−13.89***	−13.98***	−12.71***	−12.85***	−15.68***	−7.901***	−7.579***
	(2.404)	(2.487)	(2.251)	(2.455)	(3.163)	(2.222)	(2.203)
Observations	7573	6850	7573	7573	2020	7405	7405

Notes: ω^1_{ikt-1} is an export product similarity, ω^2_{ik} is a same region weighting matrix.
***Significant at 1% level, **Significant at 5% level and *Significant at 10% level. Negative binomial regression with observations clustered on country dyads. Standard errors in brackets. Year-specific time dummies included, but coefficients not reported.

conclude that our results are robust to some plausible changes to the specification of our estimation model.

9. Conclusion

Our goal in the present article has been to advance understanding into the factors which explain variations in the propensity of domestic actors from particular countries to file for patent protection in specific foreign economies. As in previous work, we demonstrate a major role for economic linkages, although our findings are based on a significantly larger sample of developed and developing countries. Higher levels of exports and outward foreign investment are therefore found to be associated with more non-resident patenting activity in recipient countries.

A plausible explanation for these findings is that the economic value of patents is greater in major foreign markets where, presumably, inventors and/or owners have more to lose from failing to protect their proprietary technology (Lanjouw et al., 1998). Another possible reason why exports and foreign investment matter is that domestic actors may pre-emptively acquire patents in particular foreign countries–whether or not they intend to actually deploy, work or sell the technology locally–in order to 'block' competitors from entering their major markets (Gilbert and Newbery, 1982). Especially in the case of FDI, it is also possible that acquiring patents facilitates co-ordination, better allowing foreign transnationals to transact, co-operate and manage disputes with other economic actors in host economies (Penin, 2005).

As well as providing more generalizable evidence about the role of exports and investment, a major contribution of the present article is to demonstrate the existence of spatial dependencies in the decision by non-residents to apply for patent protection in particular economies. The idea of spatially dependent decision making has been documented in other areas of international business activity (Guler et al., 2002; Perkins and Neumayer, 2004; Albuquerque et al., 2007). Yet, to the best of our knowledge, it has remained unexplored in the field of non-resident patenting.

Filling an important gap in current understanding, we thus find statistically robust evidence that the decision by domestic actors to file for patent protection in particular foreign markets is influenced by the prior non-resident patenting activity of actors from trait-based groups of other countries. The number of patents filed in a specific foreign economy by residents from one country increase with a higher number of prior non-resident filings by actors from macroregional peers in this same economy. A similar relationship exists where the peer group comprises countries which are structurally equivalent in terms of their export product shares, albeit only for non-resident patent filings from developed country nationals.

According to the literature, imitative behaviour has its roots in uncertainty and ambiguity (Lieberman and Asaba, 2006), conditions which are likely to confront decision makers in relation to many non-resident patenting decisions (Vishwasrao 1994; Sternitzke, 2009). Thus, it is possible that uncertainty about the costs, benefits and overall business value of holding patents in particular markets prompts domestic actors to turn to their foreign peers for information, guidance and strategic cues. Understood as a form of imitative behaviour, the influence of macroregional location could plausibly arise from a number of geographically bounded attributes, including: the greater propensity of actors to communicate, share information and observe regional

peers; social, political or cultural similarities which render the choices of regional peers more relevant, appropriate and legitimate; and economic actors located in the same macroregion being seen as competitors, such that their choices prompt competitive emulation (Bunnell and Coe, 2001). Similar factors might explain the imitative influence of structurally equivalent exporters, with actors based in these countries more likely to be seen as rivals, whose decisions have competitive implications. Unfortunately, our aggregate, statistical study cannot tell us the true reasons for observed patterns of imitative behaviour, suggesting that an important task for future research should be to investigate the underlying microdynamics of individual decision-making processes.

These insights have wider implications for understanding in economic geography. Our results therefore contribute to debates about the pathways through which (codified) knowledge diffuses across borders (Gertler, 2003; Verspagen and Schoenmakers, 2004; Faulconbridge, 2006; Poon et al., 2006). Although a share of non-resident patents will be filed in countries for strategic blocking purposes, we nevertheless provide large-*N*, statistical confirmation of work which has suggested that exports and outward FDI are major vehicles for international knowledge transfer (Globerman et al., 2000; Ivarsson, 2002; Keller, 2004; Perkins and Neumayer, 2005; Dicken, 2007).

Our findings also speak to debates about relational economic geographies. Recent work within this paradigm has drawn attention to the influence of the external context within which actors operate, transact and make strategic decisions (Bathelt and Gluckler, 2003; Yeung, 2005). An important contribution of the present article is to expand the boundaries of this relational context to include complex, extra-local interactions and dynamics. The finding that non-resident patent filing by domestic actors in particular recipient economies is positively correlated with prior non-resident patent filing by actors in other countries which are regional peers and structurally equivalent exporters suggest that economic decision making is shaped by agents based in third countries. That is, relational influences are not only governed by direct contact, but also through distanciated forms of learning, comparison and emulation.

Finally, our study is instructive in relation to debates about the ongoing importance of regional location. We find that region matters, but not in the way commonly hypothesized. On the one hand, we find no statistically significant positive relationship between the macroregional location of potential applicants of non-resident patents and the macroregional location of recipient countries in which non-resident patents are filed. This would appear to contradict recent work which suggests that patterns of economic internationalization, knowledge diffusion and exploitation have a regional dimension (Globerman et al., 2000; Keller, 2004; Rugman and Verbeke, 2004; Dicken, 2007). On the other hand, we show that regional location matters in the sense that non-resident patent filing in a particular focal economy by actors in countries from the same macroregion would appear to exert imitative influence over non-resident patenting activity by a country's own residents in the same focal economy. Actors from one country would also appear to pay attention to the actions of actors from other countries with whom they compete internationally in export products in making decisions about non-resident patenting. However, even though more tentative than our other findings, the fact that the same region weighted spatial lag variable appears to be a more robust and, if included together, also substantively more important predictor of non-resident patent filings, would suggest that (if anything) regional location trumps economic structure in underpinning spatial dependence.

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Appendix
Regional classification of countries in the sample

North America: Canada, United States.
Central America: Dominica, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago.
South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela.
Western Europe: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.
Eastern Europe: Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Russian Federation, Slovak Republic, Ukraine.
Balkan: Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Macedonia, Romania, Slovenia, Yugoslavia, FR (Serbia/Montenegro).
Northern Africa: Algeria, Egypt, Morocco, Tunisia.
Eastern Africa: Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Zambia.
Western and Middle Africa: Congo, Rep., Liberia, Sierra Leone.
Southern Africa: Lesotho, South Africa, Zimbabwe.
Middle East: Iran, Israel, Saudi Arabia, Turkey.
Central Asia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan.
South Asia: Bangladesh, India, Nepal, Pakistan, Sri Lanka.
East Asia: China, Japan, Mongolia, South Korea.
South-East Asia: Indonesia, Malaysia, Singapore, Thailand, Vietnam.
Pacific: Australia, New Zealand