Transnational economic and strategic interdependencies in the geography of extra-territorial patent filings

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Abstract

This article provides new insights into how geography shapes spatio-temporal variations in the propensity of countries to file for non-resident patents in specific foreign economies. Our major contribution is to show that, in addition to bi-lateral exports and outward foreign direct investment, the geography of extra-territorial patenting is influenced by strategic interdependencies with third-countries. We therefore find that countries are more likely to file for patent protection in focal foreign economies where their regional peers and, to a lesser extent, competitors with similar export product structures have filed for a larger number of patents.

Keywords: patents, knowledge, imitation, economic linkages

Introduction

Within the context of economic globalisation, the rise of emerging markets, and the growing importance of knowledge as a source of competitive advantage, the number of extra-territorial 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 firms to protect their intellectual assets, and more securely innovate or deploy technologies outside their home country. Yet, individual countries differ in the number of patents that their nationals hold abroad and, moreover, demonstrate a greater propensity to file for patent protection in certain foreign economies than others (Chan et al. 2004; Sun 2003; van Pottelsberghe de la Potterie and van Zeebroeck 2008; Yang and Kuo 2007). This article seeks to provide new insights into how geography shapes spatio-temporal variations in the propensity of country nationals 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 (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; Hoti and McAleer 2006; O'Keeffe 2005; Sun 2003; Xu and Chiang 2005; Yang and Kuo 2007). Our analysis advances on these studies in two important ways.

[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.

First, and most importantly, we explore a further set of explanations for differences in extra-territorial patenting by citizens of individual countries. More specifically, we examine whether the decision by residents of one country to file for patents in another economy is influenced by the prior applications of other "reference" third-countries, specified here as (a) states located in the same geographic macro-region and (b) states with a similar export product structure. There are a number of compelling reasons to expect strategic interdependencies in the geography of extra-territorial 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 2007), 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[2], compared to 30 countries in both categories for Yang and Kuo (2007), the study closest to our own), but also for a substantial 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 generalisable 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 applications and receipts.

The article also contributes to wider debates in economic geography. By analysing unevenness in extra-territorial patenting, our study helps to advance understanding into the conditions under which (codified) knowledge is transferred across

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

borders (Faulconbridge 2006; Gertler 2003; Ivarsson 2002; Neumayer and Perkins 2005; Verspagen and Schoenmakers 2004). Our article also contributes to debates about relational economic geographies (Bathelt and Gluckler 2003; Bunnell and Coe 2001; Yeung 2005). While work in relational geography distinguishes itself in its central recognition that actors' economic behaviour is strongly influenced by external economic networks, it has not gone far in examining how extra-local linkages with firms based in third-countries may affect the spatiality of firms' international business strategy. Through an examination of cross-border strategic interdependence in extra-territorial patenting, this article sheds fresh light into one under-explored aspect of relational geography, and points towards the need for more complex accounts of the relational context.

Unevenness in patterns of internationalisation

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 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 domestic residents. Although indicative of a trend towards the international transfer and exploitation of technology, as with other manifestations of internationalisation, large geographic variations exist in patenting activity. A handful of countries – the United States, 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

varies markedly. The US 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[3], China, Japan, the Republic of Korea, Canada, Australia, Brazil and India.

Interesting as these disparities in the absolute number of patent filing and receipts are in their own right, they mask even more interesting differences in disaggregated bilateral patenting activity. Focusing on these latter variations, this article seeks to explain why some countries demonstrate a greater propensity to file for patents in certain 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: (a) the innovativeness of (potential) applicant countries and (b) the market attractiveness of (potential) recipient countries (Bosworth 1984; Scherer 1983; Sun 2003; Xu and Chiang 2005; Yang and Kuo 2007). Rather, our central concern is with attributes which vary across dyads, comprising pairs of potential applicant and recipient countries. It is our contention that relational ties between applicant and recipient countries, as well as between third-party countries and their residents involved in extra-territorial patenting, have a significant influence on NRPF activity.

Motives for patenting

[3] 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).

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 extra-territorial applications. 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 conceptualised 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 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 patents protection identified in the literature derives from strategic deterrence (Gilbert and Newbery 1982). A firm, or group of firms, may pre-emptively acquire a portfolio of patents in a particular industrial field in order to raise the barriers to entry, potentially enabling firms to establish or defend a dominant market position (Sankaran 2000).

More recently, scholars have hypothesised that the returns from obtaining patents lie in their ability to facilitate co-ordination amongst firms involved in innovating and commercialising new technology (Kortum and Lerner 1999). Penin (2005: 648-650) identifies a number of such benefits, including: (a) signalling that a firm possesses technological competencies and is therefore a valuable technological partner; (b) creating

a market for a new product by advertising its presence and providing assurance against free-riding among potential buyers; and (c) providing a '"legal bargaining chip"…[that] will be traded when firms need to use technologies that are protected by patents held by other firms' (pg.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 residents from one country to file for patents in another country.

Economic links via exports and FDI

The ownership of proprietary technology potentially provides firms 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, pg.125). Without patent protection, domestic competitors (as well as third-country ones operating in the same market) could well engage in copy-cat engineering, eroding a firm's core competitive competencies and inflicting significant commercial damage (Vishwasrao 1994).[4]

The literature on FDI has similarly made much of firm-specific technological assets. According to Dunning's (2001) influential eclectic framework, a company will make direct investments in other countries where it possesses ownership-specific advantages, including technology-based ones. As in the case of exports, these

[4] 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 Alavi 2001; Bosworth 1984).

technological resources may allow a transnational corporation (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 firms' competitive strategies (Dicken 2007; Globerman et al. 2000). It follows that TNCs will possess strong incentives to protect their intellectual property, notably, by filing for patent protection in countries where they operate (Sun 2003).[5] 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 co-operation 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 (Yang and Kuo 2007). A higher amount of exports to a particular country implies a greater diversity of transferred technologies, for which patent protection must be sought, and therefore a greater number of NRPFs. Similarly, higher inward stocks of FDI suggest greater 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-residents.

[5] The eclectic paradigm also identifies location-specific advantages as a motive for FDI which, of note in the present context, is 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.

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 (Bosworth 1984; Eto and Lee 1993; Inkmann et al. 2000; Schiffel and Kitti 1978; Xu and Chiang 2005; Yang and Kuo 2007). 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 2007).

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 industrialising economies. On the recipient side, samples vary from one country for Sun (2003) to 50 for Bosworth (1984),[6] while on the applicant side, samples range from a single patenting country for Bosworth (1984) to 30 for Yang and Kuo (2007). Indeed, all that we can conclude from previous work is that exports and investment possibly have a positive influence on extra-territorial patenting in a sub-set of patent-intensive developed economies.

[6] 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 (a) using a multivariate research design in which exports and investment are analysed in the same estimation model, and (b) analysing a substantially larger sample of years and applicant/recipient countries, including a large number of developing countries omitted in previous work.

Strategic interdependencies

The decision to file for patent protection in another country may be relatively straightforward for firms 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. These difficulties arise because, as in other business contexts, corporate decision-makers face considerable uncertainty over the need for and payoffs from patent protection (Sternitzke 2009; Vishwasrao 1994).

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 firm 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, a company 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 a firm 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 ways in which economic actors can attempt to prevent imitation. Especially in R&D-intensive industries, evidence suggests that many firms rely just as much or more heavily on methods other than patents, especially secrecy (Arundel 2001; Inkmann et al. 2000; Levin et al. 1987).

Previous work on extra-territorial patenting has largely ignored these uncertainties. Instead, studies have implicitly or explicitly assumed that decision-makers are rational, profit-maximising 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 firms (Bosworth 1984; Hoti and McAleer 2006; O'Keeffe 2005; Xu and Chiang 2005). 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 firms may be influenced to file for patents not only by internal calculations regarding profitability or strategic value, but also by the actions of other firms. 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; Guler et al. 2002; Haveman 1993; Henisz and Delios 2001). 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 firms 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, managers may copy others, either assuming that they have better quality information, or because doing so economises on search, information and experimentation costs (Bikhchandani et al. 1992; Cyert and March 1963). Another related idea, which has its roots in the new-institutionalism in economic sociology, is that managers 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 extra-territorial patenting, corporate decision-makers lacking adequate information might plausibly look towards other firms' 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 firms 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 conceptualise imitation 'as a response designed to mitigate competitive risk or rivalry' (Lieberman and Asaba 2006, pg.374). According to theories of competitive diffusion, firms will emulate their (potential) rivals

so as to minimise the risk of becoming competitively disadvantaged, resulting in "follow-the-leader"-type behaviour (Elkins et al. 2006; Haveman 1993). Again, these predications can be logically extended to patenting, where theories of competitive emulation would anticipate cross-country interdependence in NRPF. A firm based in country A may be uncertain about whether to seek patent protection in country B. However, with a view to mitigating the risk that rivals will steal a competitive march by acquiring a position of technologically-based leadership, firms from country A may copy the patenting activities of peers from "competitor" economy C operating in focal country B. Indeed, competitive emulation of this sort may be important in view of strategic blocking, with firms hedging against market lock-out via extra-territorial patenting.

Although the possibility of strategic interdependence has been neglected in the literature on extra-territorial patenting, its existence is nevertheless beginning to be documented in other areas of business internationalisation. Several large-N studies have shown that firms imitate their domestic rivals in making choices about foreign market entry (Delios et al. 2008; Guillén 2002; Henisz and Delios 2001). Going further, studies have found evidence that firms may also imitate their counterparts located in other countries, including in relation to foreign entry/exit decisions (Chan et al. 2006), and the adoption of management standards (Albuquerque et al. 2007; Guler et al. 2002). This article extends the analysis of cross-border strategic interdependencies to extra-territorial patenting decisions.

An important question concerns the identity of countries which 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: (a)

countries which are located in the same geographic macro-region; and (b) 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 (Dicken 2007; Rugman and Verbeke 2004; Yeung 2001). An important consequence – and, to a greater or lesser extent, a cause – of these economic dependencies is that firms are likely to communicate more frequently with their counterparts located in 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 socio-cultural propinquity with actors located in the same region means that economic actors are more likely to identify with their 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 emphasise, imitation is driven by the threat of competition, it follows that firms are more likely to mimic their counterparts in countries which are perceived as important competitors. According to previous work, one such set of firms are located in countries with an equivalent economic structure, competing internationally in similar export products (Elkins et al. 2006; Guler et al. 2002; Poon and Thompson 2004). As well as potential competitors, firms located in countries with similar export product structures might be perceived as providing more relevant signals of appropriate market behavior, stemming from the fact that they are more likely to face similar economic circumstances.

Of course, our two hypothesised relational attributes are not mutually exclusive, and it is quite possible that the extra-territorial patenting behaviour of firms located in both sets of country reference groups may play a role in influencing the strategic choices of firms to file for patent protection. However, to the extent that they capture contrasting aspects, our study provides a useful test case to examine whether strategic interdependence is locational, structural or both.

Dependent and main explanatory variables

Our dependent variable is a directed country dyadic variable, namely, the number of non-resident patents filed by nationals of country *i* in foreign country *j*. The data, obtained from the World International Property Organization (WIPO 2008), cover a 10-year period from 1995-2005.

We analyse four main explanatory variables – each corresponding to a hypothesis regarding the influence of economic or strategic dependence. 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 capture strategic interdependence, we use spatial lag variables. More precisely, we employ what Neumayer and Plümper (2009) call specific source contagion spatial lag variables, which can be defined formally as:

$$y_{ijt} = \rho \sum_{k \neq i} \omega_{ikt-1} y_{kjt-1} + ... + \varepsilon_{ijt} \quad (1)$$

In words, the patenting activity of nationals from country *i* in foreign country *j* depends spatially on the number of patents that nationals from all other third-party countries *k* have filed in the same focal economy *j* in the previous year, weighted by some connectivity matrix capturing the degree of linkage between country *i* and countries *k* (ω_{ikt-1}). We thus assume that residents of any one country are influenced in their patenting activity in recipient country *j* by the number of patents filed by nationals of other countries in the same focal economy *j*, but they are influenced more by some third-countries than others, as given by the connectivity matrix. As is standard practice, we "row-standardize" the weighting matrix (Anselin 2002). Note, the spatial lag refers to patenting activity in the previous year to mitigate endogeneity bias.[7]

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. Other countries *k* exporting a similar set of products as country *i* have a larger hypothesized influence on its patenting activity in focal economy *j* than countries that export a more dissimilar set of products. 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.

[7] 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*. Fully accounting for potential endogeneity would require a negative binomial spatial maximum likelihood estimator which, to our knowledge, does not currently exist.

For our second hypothesis of spatial dependence via the regional 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 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*. To identify regional location, we use the UNWTO's (2007) classification of countries into sixteen macro-regions, rather than the World Bank's eight macro-region classification. The latter is too highly aggregated. To take one example: the World Bank places all countries in Central America, the Caribbean and South America into one large regional group, but actors in, say, Chile are unlikely to strategically depend on the choices made by actors in distant Guatemala. The appendix lists the UNWTO classification.

Control variables

We also include two sets of control variable. The first seeks to account for differences in the innovativeness of potential applicant countries. The underlying logic is that more innovative countries are likely to develop, commercialise and own a greater number of inventions which require patent protection in foreign markets (Sun 2003). In order to capture the innovativeness of countries, we use two variables: gross domestic product (GDP) and GDP per capita. Larger countries should, all else equal, have a larger number of actors involved in inventing, innovating and commercialising technologies and therefore have more inventions to patent. Likewise, actors in wealthier countries possess

greater technological capabilities required to develop new technologies, together with the financial capabilities needed to finance technological development (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).

A second set of variables seek to control for the real and/or perceived attractiveness of countries as a location for foreign firms 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 foreigners 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 (Lerner 2002; Smith 1999; 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.[8]

Additionally, we control for country market size (GDP) of (potential) recipients of NRPFs. As hypothesised 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 firms to deploy, exploit and protect their technology (Lanjouw et al. 1998; O'Keeffe 2005; Sun 2003). Previous empirical work supports these predictions (Bosworth 1984; Inkmann et al. 2000; van Pottelsberghe de la Potterie and van Zeebroeck 2008).

[8] Park provides data for 1995, 2000 and 2005. We linearly interpolate for the missing in-between years.

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 taken out 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 foreign patent applicants in country *i* that country *j* is an attractive market in which to file for patent proection. This variable can also capture the lower transactions 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 (2007) show that physical distance is negatively correlated with non-resident patents, although Sun (2003) finds no such relationship with distance and/or same 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 (Keller 2004; van Pottelsberghe de la Potterie and Lichtenberg 2001; Won Sonn and Storper 2008). In order to capture spatial proximity, we use two measures: (a) 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 (b) regional location, again using UNWTO (2007) to code whether the applicant country *i* and recipient country *j* are located in the same geographic macro-region.

Finally, we include year-specific time dummies to control for common shocks and trends which affect all countries equally. A failure to control for common shocks and trends may lead to biased estimates for the spatial dependence variables (Plümper and Neumayer 2009).

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 extra-territorial patents, but diminishingly so as the value of these increase.[9] Based on the above, we estimate variants of the following model (leaving out the coefficients to be estimated):

$$y_{ijt} = \sum_{k \neq i} \omega^{1}{}_{ikt-1} y_{kjt-1} + \sum_{k \neq i} \omega^{2}{}_{ik} y_{kjt-1} + \ln exp_{ijt} + \ln FDI_{ijt} + \ln GDP_{it} + \ln GDPpc_{it} + \ln GDP_{jt} + \ldots$$

$$+ IPRP_{jt} + \sum_{i} y_{ijt-1} + \ln dist_{ij} + sameregion_{ij} + year_{t} + \varepsilon_{ijt} \quad , \qquad (2)$$

where $\omega^{1}{}_{ikt-1}$ stands for export product structure similarity and $\omega^{2}{}_{ik}$ captures same regional location of countries *i* and *k*.

Estimation technique

[9] This model also has a much better fit than an alternative one with these variables entered linearly.

The dependent variable is a strictly non-negative count variable (number of patents) meaning that 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.

Results

Table 1 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 sameregion variable, all of the control variables are statistically significant with the expected coefficient sign. As previously hypothesised in the literature, we thus find that larger and wealthier countries account for a larger number of NRPFs, as do countries which are physically closer (Chan et al. 2004; Furman et al. 2002; Sun 2003). Turning to recipient countries, confirming the findings of previous work, we estimate that larger markets attract more non-resident filings (Bosworth 1984; Inkmann et al. 2000; van Pottelsberghe de la Potterie and van Zeebroeck 2008). Also consistent with expectations, we estimate a positive relationship between NRPFs filed by citizens of country *i* on the one hand and the strength of patent system protection in recipient economies as well as our general measure of a country's attractiveness for foreign patenting on the other.

In column 2, we add the dyadic export and FDI stock variables. The previously insignificant sameregion variable now becomes statistically significant, but with an

unexpected negative coefficient sign, while the previously significant distance variable now becomes statistically insignificant. A possible explanation for these changes is that countries typically trade and invest more with spatially proximate/same region economies, such that our economic dependence and locational variables are likely to be correlated with one another. All of the other 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.

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 countries make a greater number of patent filings in countries to which they export more. Also supporting the idea that extra-territorial patenting is mapped onto cross-border economic linkages, our coefficient for outward FDI stock and NRPFs is positive and statistically significant. Simply put: our results suggest that greater stocks 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.

Of even greater interest to us is whether there is evidence of strategic interdependence in the decision to file for 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 a country is more likely to file for patents in a particular recipient economy where other countries exhibiting a similar export product structure have taken out a higher number of NRPFs. Also in line with expectations, countries' propensity to

file for patent protection in recipient economies rises as their regional peers account for a larger number of extra-territorial patents in these countries.

How do these results change when both variables of strategic interdependence are entered into the estimation model simultaneously (column 5)? The spatial lag capturing export product structure becomes statistically insignificant. Yet the spatial lag linking countries from the same macro-region remains statistically significant. Caution must be exercised when interpreting these findings, but they do tentatively suggest that there is more robust evidence that the NRPF decisions of countries depend spatially on the patent activity of other countries in the same region rather than of other countries with a similar export product structure.

Conclusion

Our goal in the present article has been to advance understanding into the factors which explain variations in the propensity of individual countries to file for patent protection in specific foreign countries. As in previous work, we demonstrate a major role for economic links, 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 NRPF in destination 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 firms may pre-

emptively acquire patents in particular 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 firms in host economies (Penin 2005).

As well as providing more generalisable evidence about the role of exports and investment, a major contribution of the present article is to demonstrate the existence of strategic interdependence in the decision by non-residents to apply for patent protection in particular markets. The idea of strategically interdependent decision-making has been documented in other areas of international business activity (Albuquerque et al. 2007; Guillén 2002; Guler et al. 2002). Yet, to the best of our knowledge, it has remained unexplored in the field of patenting.

Filling an important gap in current understanding, we thus find statistically robust evidence that the decision to file for patent protection in particular markets is influenced by the prior actions of actors from specific 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 regional peers in this same economy. A similar relationship exists where the peer group comprises countries which are structurally equivalent in terms of their export products, although the relationship is not statistically significant when both sets of strategic interdependence are accounted for in the regression equation.

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 extra-territorial patenting decisions (Sternitzke 2009; Vishwasrao 1994). Thus, it is possible that uncertainty about the costs, benefits and overall business value of holding patents in particular markets prompts firms to turn to their foreign peers for information, guidance and strategic cues. Understood as a form of imitative behaviour, the influence of regional 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 and/or cultural similarities which render the choices of regional peers more relevant, appropriate and legitimate; and firms located in the same macro-region 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.

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 (Faulconbridge 2006; Gertler 2003; Verspagen and Schoenmakers 2004). Although a share of 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 (Dicken 2007; Globerman et al. 2000; Ivarsson 2002; Keller 2004; Perkins and Neumayer 2005).

Our findings also speak to debates about relational economic geographies. Recent work within this paradigm has usefully drawn attention to the influence of the external context within which firms 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 patent filings by regional peers and structurally equivalent exporters are correlated with own country residents' patent filings in particular target markets suggest that corporate decision-making is shaped by actors 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 hypothesised. On the one hand, we find that same regional location of the potential patenter and the country in which the patent is taken fails to exert a positive influence on the geography of NRPFs. Of note, this would appear to contradict recent work which suggests that patterns of economic internalisation, knowledge diffusion and exploitation have a regional dimension (Dicken 2007; Globerman et al. 2000; Keller 2004; Rugman and Verbeke 2004). On the other hand, we show that location matters in the sense that patenting activity by regional peers in focal economies exerts imitative influence over the decision by own country residents to file for patent protection. Indeed, although more tentative than our other findings, the fact that same region patenting would appear to be a more robust predictor than patenting by countries with a similar export composition suggests that (if anything) location trumps structure. That is, despite

evidence suggesting that countries file for patents in an increasing number and diversity of economies worldwide, countries would appear to pay more attention to the actions of actors from the same region than those with whom they compete internationally in export products.

Table 1. Estimation results.

	(1) base model	(2) exports & FDI added	(3) SL (export product similarity) added	(4) SL (same region) added	(5) Both SL variables added
$\sum_{k \neq i} \omega^{1}{}_{ikt-1} y_{kjt-1}$			0.001		0.001
			(2.08)**		(1.16)
$\sum_{k \neq i} \omega^{2}{}_{ik} y_{kjt-1}$				0.001	0.001
				(2.27)**	(2.02)**
$\ln exp_{ijt}$		0.246	0.250	0.245	0.247
		(5.78)***	(5.84)***	(5.64)***	(5.69)***
$\ln FDI_{ijt}$		0.072	0.076	0.079	0.080
		(4.48)***	(4.67)***	(5.01)***	(5.01)***
$\ln GDP_{it}$	0.681	0.412	0.402	0.392	0.390
	(27.18)***	(8.82)***	(8.64)***	(8.59)***	(8.55)***
$\ln GDPpc_{it}$	0.462	0.334	0.335	0.331	0.331
	(8.89)***	(5.39)***	(5.33)***	(5.35)***	(5.34)***
$\ln GDP_{jt}$	0.517	0.254	0.224	0.236	0.226
	(25.08)***	(7.39)***	(6.96)***	(7.31)***	(6.90)***
$\sum_{i} y_{ijt-1}$	0.001	0.001	0.001	0.001	0.001
	(8.77)***	(8.05)***	(5.00)***	(7.89)***	(6.25)***
$IPRP_{jt}$	0.411	0.280	0.268	0.280	0.274
	(4.90)***	(2.66)***	(2.52)**	(2.64)***	(2.58)***
$sameregion_{ij}$	-0.058	-0.414	-0.457	-0.639	-0.629
	(0.35)	(2.16)**	(2.58)***	(4.18)***	(4.11)***
$\ln dist_{ij}$	-0.144	-0.025	-0.028	-0.037	-0.036
	(6.21)***	(0.87)	(0.96)	(1.25)	(1.23)
Constant	-33.171	-20.038	-18.981	-18.905	-18.595
	(38.33)***	(11.67)***	(11.61)***	(11.80)***	(11.56)***
Observations	15754	10691	10689	10691	10689

Notes: $\omega^{1}{}_{ikt-1}$ is an export product similarity, $\omega^{2}{}_{ik}$ is a same region weighting matrix. *, **, *** significant at 10, 5 and 1 percent, respectively. Negative binomial regression with observations clustered on country dyads. Absolute z-statistics in brackets. Year-specific time dummies included, but coefficients not reported.

Appendix. Regional classification of countries in 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.

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