The role of internationalization as a determinant of the innovation performance of countries[1]

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ABSTRACT

This paper analyses the impact of internationalization on the innovation performance – measured via patents – of 42 countries. Our results suggest that outward FDI and exports increase the scope of learning and the opportunities to innovate. We find evidence of a negative relationship between innovation and inward FDI and imports. We interpret our results to indicate that (a) the inward flow can be less innovation-intensive than a country's domestic activities which would be the case for more advanced and innovation-active countries, or (b) that a country may not have a sufficient absorptive capacity to benefit from inflows.

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INTRODUCTION

The aim of this study is to examine the relevance of internationalization in the innovation performance of countries. A positive impact of internationalization on innovation performance is found in several studies (Castellani & Zanfei, 2006; Frenz & Ietto-Gillies, 2007, 2009), including a study focusing on the financial services sector in the UK (Frenz, Ietto-Gillies & Girardone, 2005). However, all these works relate to specific countries. As far as we know, there are no studies of many countries together that support the existence of such a relationship. Filippetti, Frenz and Ietto-Gillies (2011) find strong correlations between innovation performance and several internationalization variables in a study of 32 European countries. On the basis of the theoretical analysis – which points to possible causal mechanisms – the study concludes that the association between internationalization and innovation is not spurious, but is very likely to be a sign of a causal relationship between internationalization and innovation performance. The current study builds on that work by expanding on the depth of analysis, the data and the empirical techniques as well as on the number of countries considered. Specifically we: (i) deepen the analysis by moving from association to explanation; (ii) extend the range of variables that capture the knowledge context, the innovation infrastructure and the sectoral context; (iii) extend the analysis to 42 countries (listed in Table 1); (iv) group the countries into two clusters according to their GDP per capita.

For these 42 countries we collected measures of innovation, internationalization and other relevant variables over a 19-year time period from 1990 to 2008. The key data sources are the United Nations' Conference on Trade and Development, the World Bank's World Development Indicators, and Main Science and Technology Indicators published by the Organization for Economic Cooperation and Development.

The measures used as a proxy for countries' innovation performance are the number of PCT applications and triadic patents that originate from a country. Patents are one of the key measures used in innovation research because of the good availability and reliability of long time-series data, and the comparability of data across countries, and these are the reason why our study relies on patents as a proxy for innovation. However, there are problems associated with the use of patent data. In particular, not all inventions are patented and an invention does not always lead to a successful commercialisation of a new good or service. Moreover, there may be sectoral biases because the use of patents is less pronounced in some industries, including many service industries.

Internationalization is measured by the following variables: stock of inward and outwards foreign direct invest (FDI), imports and exports and, in some models, the number of parent transnational corporations in the country. The models control for the following other time variant factors influencing countries' innovation performance: the number of journal publications; the number of Internet users; value added in services overvalue added in manufacturing; and a country's expenditure on R&D.

In terms of methodology, internationalization is linked to innovation using linear panel estimations. We introduce different time lags between the internationalization variables and innovation variables. In a further step the 42 countries are clustered into two groups depending on their GDP per capita, and we analyse, separately, the relationship between internationalization and innovation of countries for the two clusters

The overall contribution of the paper is in terms of support for the thesis that the internationalization of a country impacts positively on innovation. In this context, the paper contributes to the analysis of causal mechanisms between internationalization and innovation performance expressed in terms of patents. Specifically, the paper has the following contributive elements: (i) an assessment of the impact of internationalization on indicators of innovation performance in the context of a model that includes other relevant variables; (ii) the use of several internationalization variables to allow for the impact of the flow of capital, goods and services; (iii) analysis for 42 countries at different levels of development over a 19 year period; (iv) the separate assessment of the relationship between internationalization for different groups of countries clustered by their GDP per capita.

The paper proceeds as follows. The next section discusses theoretical and empirical findings on the relationship between innovation and internationalization. Section 3 considers the possible impact of the countries' contexts; Section 4 presents variables, data and methodology; Section 5 present and discuss the results; Section 6 summarises and concludes.

2. INTERNATIONALIZATION AND INNOVATION: THE BACKGROUND

The possible relationship between innovation performance and internationalization is complex and we here focus on two elements of such complexity.

Internationalization and innovation: a two-way process.

The first element of complexity is related to causation. There are strong theoretical arguments why causation could go both ways: from innovation to internationalization and/or from internationalization to innovation. It is indeed very likely that the two phenomena are linked by a cumulative causation mechanism. More innovative firms can better compete and thus become more internationalized. Moreover, internationalized firms are exposed to diverse cultures and innovation environments from which they can learn. Both these processes are likely to enhance their innovation performance.

The impact of innovation on internationalization has been explored in various studies. Posner (1961) and Hufbauer (1966) found that trade performance and, specifically, exports were related to the technological gap between countries. Posner's work formed the background to Vernon (1966) in which the innovation performance of firms and countries determines their exports performance, then – in a time sequence – their propensity to foreign direct investment and, eventually, both their exports and imports propensities. More recent works linking international variables to innovation include Amendola et al. (1993), Cantwell (1989, 1994), Cantwell and Sanna Randaccio (1993), Fageberger (1996), Krugman (1995) and Cassiman and Golovko (2011).

However, the impact of innovation on international performance is not the subject of this paper. We are interested in the possible impact of internationalization on innovation performance. How can such an impact come about?

As mentioned above, a high degree of internationalization – particularly in terms of the numbers of countries in which firms operate[1] – exposes them to diverse innovation environments and helps them to learn from these different contexts. Knowledge transmission at both national and international levels can take place via products and processes or via interaction between institutions and between people in institutions. Moreover, knowledge – the basis of innovation – can be tacit or codified. The former plays a key role in the development of innovation (Polanyi, 1966, 1967) and it can also assist in the acquisition and transmission of codified knowledge (Uzzi 1997). The transmission of tacit knowledge is facilitated by spatial proximity (Criscuolo et al 2005)[2]; by social embeddedness (Dhanaraj et al 2004; Uzzi, 1997); and by mobility of employees across firms and sectors as well as across units of the same firm.

Networks play a key role in the transmission of knowledge (Uzzi and Lancaster 2003). Spatially diversified companies develop a variety of networks some internal and some external to the company. Among the spatially diversified companies a special role in knowledge transmission is played by transnational companies (TNCs). Their activities span several countries, and they have, therefore, access to more diverse knowledge and innovation contexts compared to companies whose networks span a single country.

Theoretical underpinnings to the links between transnationalization and innovation can be found in the evolutionary theory of the firm (Nelson and Winter 1982; Nelson and Rosenberg 1993). This theory led to developments and applications to the TNCs in which the behaviour and performance of the latter is linked to their capability for the development, absorption and diffusion of innovation activities (Cantwell 1989; Kogut and Zander 1993, 2003[3]).

The role of TNCs' internal and external networks in knowledge transfer and innovation has been examined in several works (Castellani and Zanfei 2004, 2006; Hedlund and

Rolander, 1990; Frenz et al. 2005; Frenz and Ietto-Gillies, 2007, 2009; Zhara, Ireland and Hitt, 2000). Their internal network is constituted by headquarters and all the affiliates many of them scattered in various countries of the world characterized by diverse business and organizational cultures as well as by diverse technological environment. Each unit of the TNC can transmit and receive knowledge to/from other parts of the company via the internal network.

Moreover, each unit is part of various external networks within the environment in which it operates. These networks range from interactions between customers and suppliers (Crone and Roper 2001; Saliola and Zanfei 2009) or contractors and principals or partners in joint ventures (Lyles and Salk 1996) or industry and universities,[4] contacts with customers or suppliers or business partners or local universities and research centres. The range and extent of external networks the TNC is involved in vary according to the type of modality(ies) it uses to operate in foreign countries: from foreign direct investment (FDI) to trade to licensing or franchising to sub-contracting to joint ventures. TNCs are likely to use different modalities for different activities and/or host countries. Whichever the modality, the external networks it gives rise to can become channels for the acquisition of knowledge whose diffusion across the TNCs and countries will then be facilitated by the internal networks of the TNC.[5]

Thus, each unit of the TNC acquires knowledge from its environment and then transmits all or some of it to other parts of the company and thus to other countries. Moreover, knowledge from the unit – whether it is self-generated or acquired via the internal or external networks – spills over to the local environment via the same transmission mechanisms which lead to the acquisition of knowledge by the unit.

There are various issues connected to these mechanisms which have an impact on the degree of absorption and transmission of knowledge. First, the degree to which knowledge spills over from the unit of the TNC to the local environment depends on the strength of external networks, and, thus, on the degree of embeddedness[6] of the unit in the locality. On the latter point, Uzzi (1997) finds that, beyond a certain threshold, embeddedness can have negative effects on performance and knowledge transmission by insulating the business unit from information external to the local environment, and, therefore, making it more vulnerable to external shocks. This conclusion is consistent with that of works on the relevance of the internal organization structure of companies - and TNCs in particular – on the diffusion of knowledge. A more decentralized structure may facilitate the unit's interaction with its external environment, and, thus, facilitate acquisition of knowledge. A more centralized structure facilitates exchanges between units internal to the TNC including internal knowledge transfer (Bartlett and Ghoshal, 1989; Gupta and Govindarajan 1991, 2000; Hedlund, 1986).

Second, the extent of knowledge transfer from the unit to the locality depends also on the absorptive capacity of the locality. Similarly, the absorptive capacity of the TNC's unit affects the degree to which it can acquire knowledge from the environment. Third, the degree to which knowledge is transmitted across units of the TNC may partly depend on the internal organizational structure of the TNC.

The learning processes that TNCs' activities and organizations can be involved in, can come about via both their outward and inward FDI. However, in the case of inward FDI, the learning is also linked to the type of investment the country attracts. If the inward FDI is knowledge intensive relatively to the structure and development of the country, then the impact of inward FDI on innovation is likely to be positive. But, if it is less knowledge intensive, the impact is likely to be low. The absorptive capacity and capabilities of the host country are also strong elements in the positive contribution to innovation that inward flows of both FDI and importation of products are likely to make to a country[7].

The above points consider the role of TNCs' activities and structures in the potential effects of internationalization on innovation. However, there are many more international activities that take place independently of TNCs or via the operation of other actors as well as the TNCs. We refer particularly to trade, most of which, worldwide, originates with TNCs.[8]

Trade – whether it originates with a TNC or not – may contribute to the development of innovation capabilities by increasing the degree of competition as well as by exposing firms to new products and processes.

Exports encourage/force firms to innovate by exposing them to stronger competition as well as to the requirements and innovation environment of diverse markets and customers. Keller (2004) in his survey of diffusion of international technology reports evidence of learning-by-exporting in case studies though less conclusive evidence from econometric studies. Grossman and Helpman (1991) stress the benefits of exports in terms of access to large markets because it may encourage more investment in R&D.

Imports increase the firm's exposure to new products and possibly processes. New knowledge is often embedded in new machinery and products and their availability via importation facilitates learning in countries other than the one where they were produced. Moreover, the firm importing intermediate products may have to adjust its production processes to accommodate them. Thus, imports of innovative products[9] may contribute to innovation by: (a) increasing the absorptive capacity of the firm; and (b) by forcing the firm to innovate in order to accommodate the new product within its production processes.[10]

These possible positive effects rely on (a) the assumption that the imported products are innovation-based or – at any rate – more innovation-based than the corresponding domestic products. They also rely on (b) the assumption that the importing country has the adequate absorptive capacity to receive innovation. If these assumptions do not correspond to the real conditions in the country, then we would expect no effect or a negative effect of imports on the innovation performance of a country.

The impact of internationalization on innovation: country level effects.

The considerations above analyse the possible impact of internationalization on innovation mainly at the firm level. Putting firm – and in particular TNCs – centre stage is very important as they are the main vehicle for both products and processes innovation in any country. However, our analysis is at the country level and we must take account of the following. (a) Firms are the main contributors to innovation but not the only ones. Universities contribute via the education of highly skilled – most of whom are likely to work for firms – and via their own research activities and output. The knowledge and innovation contribute to the country's performance directly and also via the impact on the firms' own contribution. The movements of researchers from universities to firms is one avenue for this impact, but there are also often collaborative partnerships on research between universities and companies. In terms of contribution to the diffusion of knowledge, and innovation via internationalization, a key element is the cross-countries mobility of researchers and highly skilled personnel.

(b) Firms activities have a direct impact on a country's innovation performance through the generation of new products and processes; over and above that they add more indirectly – through spillovers of knowledge between firms and across sectors to the innovation outuputs in a country. The extent to which knowledge spills over can differ across countries and vary according to the absorptive capacity of receiving firms, sectors and whether – and to what extent – the original innovating firm or sector are basic to the rest of the economy or not. Thus, the extent of spillovers can depend on the absorptive capacity of the country as a whole as well as on its distribution across sectors. This is true of spillovers of knowledge and innovation in general as well as that which may be generated via the impact of international activities; of that generated within firms or within universities.

The arguments above referring to the contribution of universities and to that of spillovers, point to the relevance of labour mobility – at both national and international levels – as a mechanism for the diffusion of knowledge and innovation. Over and above the role of cross-country movements of capital (via the activities of TNCs), of goods and services (via imports and exports), the transmission of knowledge is facilitated by the movement of personnel and human resources (Salt, 1991, 1997; OECD, 2002). Some movements of highly skilled people take place internally to companies operating across countries. Other exchanges of tacit knowledge take place via international collaboration between researchers whether the exchanges are institutionalized or not. Filippetti et al. (2010) in an analysis of 32 countries used data on the mobility of employees, the mobility of students in tertiary education and the mobility of research students across countries as a proxy for possible exchanges of tacit knowledge via the movement of human resources. Unfortunately, we could not get the relevant data for the sample of countries in this study and therefore no variable on the international movement of human resources is used.[11]

INTERNATIONALIZATION AND INNOVATION IN THE CONTEXT OF COUNTRIES' INNOVATION ENVIRONMENTS

Though the main subject of our study is the impact of internationalization on innovation, we are aware that there are several other elements that affect the innovation performance of a country by their impact on the innovation environment. We single out, in particular, the following: the knowledge context which we proxy via a variable on the number of publications in scientific journals; the innovation infrastructure context which we proxy via a variable on the number of Internet users;[12] the sectoral structure context which we proxy via a variable on the ratio of value added in services over value added in manufacturing; and the overall country's commitment to innovation which we proxy via a variable on R&D expenditure. All these elements contribute to the absorptive capacity of the country.

The sectoral structure and the proxy used in this study need further clarification. Our study involves many countries at different stages of development and with different sectoral structures. In this context it is possible to see the service intensity of the countries representing a structural feature of development with implications for innovation. However, there may be several indicators for the sectoral structure. A possible one is related to the relative weight of employment in services and manufacturing. We discarded this type of indicator because it represented different economic structures and because it gives mixed signals in terms of innovation performance. This is because the service sector comprises very diverse activities characterized by different labour intensities: from domestic or hotels and restaurant services – which are labour intensive – to the less labour intensive activities of financial and software services. In terms of capturing the innovation context the latter are clearly more relevant. We felt that a variable focused on the value added of services versus manufacturing would better capture the innovation context we are interested in. In fact, a large services sector in terms of value added is a feature of the most highly developed countries, the ones most likely to have a record of large number of patents filed. Moreover, it can be argued that advanced services, like software development and generally those connected with IT developments, are needed for good innovation performance in both services and manufacturing (Alic, 1994).

However, it can also be argued that a relatively large service sector is less likely to highlight innovation particularly because, due to data availability for all the selected countries, we are measuring innovation performance via the number of patent applications. Patents are often used in innovation studies, though they are an inaccurate indicator of innovation as already pointed out. The traditional motive to patent is to protect inventions from imitations, but a much wider range of motives to patent is likely to play a role (e.g. patenting can be used within the firm as a measure of the performance of staff in R&D departments; it can also be used to assess the performance of collaborations agreement etc.). Moreover, a much wider range of strategies to protect innovation from imitations can be used such as lead-time advantages, complexity of design, secrecy (Blind, Edler, Frietsch & Schmoch, 2006; Nelson 1992; Cohen, Nelson & Walsh, 2000). Both motives for patenting, and strategies to protect innovation from imitation, differ by industry and sector, also because the propensity to patent is linked to the complexity of products, and to the technological field and technological intensity in a sector.

Service firms are comparatively less likely to rate the importance of patenting high (Cohen et al., 2000). From a legal point of view, computer software, unless it brings about an improvement in the functioning of hardware, cannot be patented outside the US (European Patent Office, 2012). In the US around 15% of all patents are software patents, with the caveat that only 5% of these patents are held by software developers (in the services sectors), while the remaining, larger share is held by manufacturing firms (Bessen and Hunt 2007).

VARIABLES, DATA AND METHODOLOGY

This section consists of two parts. In the first subsection we discuss the variables we are going to use and the related data. The second sub-section is devoted to a discussion of the methodology. Before delving into the main body of this section we would like to discuss briefly the selected 42 countries.

Table 1 here

The main criterion that led to the inclusion into our sample has been availability of data. Nonetheless, it should be noted that all continents, and most regions within them, are represented, though the sample is not representative of the world, either in terms of income per capita, or in terms of population. Over a third of the countries are from Europe. If Eastern Europe is included, this percentage rises to over 50. The countries represent a large spectrum in terms of GDP per capita, and this feature is further exploited in the separate treatment of high versus low income countries.

Variables and Data

Three types of variables were collected for the 42 countries and for the period 1990 to 2008: (i) dependent variables, i.e. patent applications, as proxy for countries' innovation performance; (ii) internationalization variables, namely FDI stocks, trade flows and the number of parent TNCs located in the country; and (iii) a set of control variables related to the following contexts. The knowledge context represented by the variable 'articles in scientific journals'; the innovation infrastructure context represented by the variable 'Internet users'; a country's level of investment in innovation measured by 'R&D as a proportion of GDP'; and the structural context represented by the variable 'value added of services over value added in manufacturing'. Table 2 provides an overview of the variables, their unit of measurement, and the data source. Descriptive statistics and correlations among the variables are provided in Appendix A (Tables A1 and A2).

Table 2 here

Dependent variables. Patent statistics are among the most frequently used measures in innovation research because of their good availability and reliability of long time-series data, and their comparability across countries. This is the reason why our study relies on patent statistics as a proxy for innovation. It should be noted that not all knowledge and innovations lead to patents; elements of tacit knowledge may not lead to patents; moreover not all patents lead to new products or processes.

There are three main types of patent statistics: patents filed with individual countries' patent offices; international patent applications, also referred to as Patent Cooperation Treaty (PCT) applications; and triadic patent families. Both PCT applications and triadic patents tend to be preferred over the use of data on the first type – i.e. data on patents filed with different patent offices – for two main reasons. Firstly, data published by different patent offices are not necessarily comparable across countries, and within countries over time, due to differences in legal and administrative practices as well as changes in government policies. For example, in China part of the recent patent surge can be explained through increasingly pro-patent policies (Hu & Jefferson, 2009). Secondly, because of a home bias in the filing of domestic applications. In other words, more patents are filed by residents of a country compared with non-residents (e.g. Organization for Economic Cooperation and Development, 2009). For these reasons we shall here use data from PCT and from triadic patent applications.

PCT applications are patent applications filed with a patent office under the Patent Cooperation Treaty. A PCT application provides the option to file the same patent with the national office of the member states at a later stage (within 30 months).[13] Triadic patent families are patents filed by the same inventor for the same invention at the European, Japanese and US Patent Office. To be recorded as a triadic patent application, the invention it refers to has to be the subject of a granted patent with the United States Patent Office; however, it only requires being at the application stage with the European Patent Office and the Japan Patent Office.

In our dataset, the reference country for both triadic patents and PCT applications is the inventor's country of residence. There are on average 1,000 triadic patents and just over 2,000 PCT applications recorded in the 42 countries in our sample over the period 1990 to 2008.

Triadic patents and PCT applications have different strengths and weaknesses related to (a) quality/relevance and (b) the time that elapses between filing and the recording of the patent statistic. Point (a) is related to the value distribution of patents which tends to be very skewed. Only very few patents have a high economic value, and there is a tail of many patents that are never used. This degree of skewness tends to be higher for PCT applications, compared to triadic patents. This is because, compared with the parallel application of triadic patents, the initial costs of filing PCT applications are much lower. Triadic patents, with the higher costs incurred due to the parallel applications to three patent offices, tend to capture higher value inventions aimed at international markets (Organization for Economic Cooperation and Development, 2009). Referring to point (b), PCT applications record the information on the invention nearer the actual time of invention, compared with triadic patents. Specifically, and as it is the case for our data, the PCT statistics are recorded with reference to the first filing with the first receiving office.[14] The first filings of a patent application are published 18 months after filing. Thus, the time lag between invention (filing) and our PCT data is 18 months. Triadic patents, on the other hand, have, on average, a 35months, and a maximum of 44 months, time-lag caused by the time that elapses between filing and the United States Patent and Trademark Office granting the patent (Organization for Economic Cooperation and Development, 2009). Because the strengths and weaknesses of triadic patents and PCT applications are quite different, we report results on both types of data.

The empirical literature tends to normalize country level patent data by either using population or GDP values. For example, Castellacci (2011) uses US patents per million people and Schneider (2005) uses US patent applications per residents. We use triadic patents and PCT applications per million people.

Independent variables. We use FDI stocks and trade flows to capture countries' internationalization. We also use a variable related to number of parent TNCs in a country. The reason for the inclusion of the latter variables is the following. We are aware that the outward FDI variable already represents direct business activities of TNCs from their home country. However, for any given country home to TNCs, the distribution of FDI in terms of origin from the investing TNC may be different from the distribution of patent filing by the same set of TNCs. In other words, with this additional variable we aim to capture the possibility that not all companies that substantially contribute to filing patents, substantially contribute to outward FDI (and vice versa). Take the example of country X (for example, the UK) with a large (financial) services sector relative to its manufacturing sector. Most financial service companies are large, tend to operate transnationally, and invest heavily abroad. However, compared to manufacturing companies, the financial services ones contribute relatively little to patenting. So, we could have a situation of large outward FDI from a relatively small number of large TNCs who contribute little to patenting.[15]

FDI and trade are broadly available in a comparable form across countries and over time. In the case of outward and inward FDI, we use stock data which are less volatile from year to year compared with flow data. The trade variables are annual flows. We normalize these internationalization variables by GDP (see Appendix A.1 for average values). The reference years are 1990 to 2006. The data series used compared with the data series on patent statistics are different because of time lags introduced to the regression analyses.

The number of TNCs in a country, taken from United Nations' World Investment Reports (WIR), is normalized by population size of a country and is expressed as the number of TNCs per million people. We could find data for only three relevant reference periods: early 1990 (for most countries one of the years 1988 to 1991 as reported in WIR 1992; the year 1998 as reported in WIR 2000; and the year 2005 as reported in WIR 2006).

Control variables. We employ the following set of control variables in the regressions: (i) the number of scientific articles per million people as a proxy for the knowledge context; (ii) the number of Internet users per thousand people as a proxy for the technological infrastructure context; and (iii) the share of value added in services over the share of value added in manufacturing as a proxy for the sectoral structure context. In addition, in some models, we also use the variable R&D as a proportion of GDP as a proxy for the country's commitment to innovation. The estimations with R&D as a control variable are based on fewer observations because of (a) missing values and (b) colinearity issues. We comment on these results but do not present the models.[16]

Methodology

We use linear regressions to examine the relationship between countries' innovation and internationalisation indicators. The model can be described as follows:

$$Y_{i,t+k} = ß_0 + ß_1 W_{i,t} + ß_2 X_{i,t} + f_i + a_t + \varepsilon_{i,t}$$

$Y_{i,t+k}$ is the number of PCT applications or triadic patents filed by country i in year t. The values of our dependent variables lead by k years, with k taking values of 2, 3, 4, and 5 in the case of PCT applications, and 3, 4, 5 and 6 in the case of triadic patents. For example, if k=2 then the dependent variable might be measured in 2008 and this is associated with values of our independent and control variables in 2006. The leads in the dependent variables are introduced for two reasons. Firstly, PCT applications are recorded 18 months after the invention is filed and triadic patents are recorded on average 35 months after the invention is filed. Thus, to match invention and the degree of internationalization at approximately the same point in time, we use the two-year lead in the PCT applications and the three-year lead in the triadic patents. Secondly, we have mentioned in Section 2 the possible effect of innovation on internationalization: firms that are highly innovative are better equipped to internationalise compared with firms that are less innovative. This two-way causality renders our models open to endogeneity problems. To try and address this issue we extend the lead in the values of our dependent variables to up to five years in the case of PCT applications and six years in the case of triadic patents.

In the model $W_{i,t}$ is a vector that combines our independent variables related to internationalization. It includes countries' FDI outward stocks, inward stocks, exports and imports. We estimate further additional models, where FDI outward stocks are replaced with the number of TNCs relative to the total number of companies in a country. For this estimation the number of observations is much lower, because, and, as mentioned above, we have data for only three years on TNCs. We comment on these regressions but do not present the coefficients.[17]

$X_{i,t}$ is a vector of exogenous independent variables that are linked with increased patenting activities in a country. These include: the share of value added within the services sectors in each country; the number of scientific articles published in a country and the number of Internet users as an indicator of the general IT infrastructure in the country. In some regression models we also use the R&D expenditures relative to GDP as an independent variable.

f_i are country specific fixed effects that account for any unobserved and time invariant country factors; a_t are year dummies included to account for any shocks; and $\varepsilon_{i,t}$ the usual error terms.

We assume a linear relationship between indicators of internationalization and innovation. Analysing panel data using linear models we estimated, and selected between, three different techniques: (i) OLS regressions on pooled data, (ii) fixed effects regressions, and (iii) random effects regressions. In most cases the results presented in the paper are those of the random effects estimations.[18]

Following the fixed effects model, we rejected that the countries' individual effects are identical, thus, the results of pooled OLS regressions are biased. Using a Hausman test we found our random effects estimators to be consistent, resulting in (a) the fixed effects and random effects estimates being highly similar and (b) the random effects model the most appropriate among the three estimators (e.g. Greene, 2003). The random effect models explaining triadic patents with a five and six-year lead are not consistent, and, in the case of these two exceptions, we report the fixed effects estimators.[19]

We further grouped the countries into comparatively higher and lower income countries and repeated the full set of regressions. We did this to further investigate if the relationship between countries' internationalization variables and patenting differs across these two groups of countries. The grouping is informed by the data itself. We performed a two-step cluster analysis of our data, using GDP per capita as the clustering variable. The results of the grouping and the regression estimates are reported in Appendix B.

RESULTS

Two sets of regression results are presented in Table 3. In interpreting the results it is worth keeping in mind the following. Our study relates to the country as a whole, not to specific industries or case studies of firms. Due to data limitations we represent innovation by patent application intensity. This is a departure from a previous study (Filippetti et al., 2011) where several variables are used to represent innovation performance. This work uses composite indices, based on the European Innovation Scoreboard: a range of measures feed into the indices including the share of product and process innovators in a country and the average turnover from innovation generated by the firms within a country. Such data, however, is only available for a few points in time.

Table 3 here

From Table 3 we take the following observations. Firstly, we find positive correlations between outward measures of internationalization (FDI and exports) and innovation performance of countries, while we find negative correlations between inward FDI stock, imports and PCT applications. The positive correlations of patent applications with outwards FDI stocks and exports are in line with our expectations discussed in Section 2. In Section 2 we also discussed the role of home-based TNCs for the patenting activities in countries. We tested for this relationship, but on a much smaller dataset (observations range between 57 and 82). We found the number of TNCs being positively correlated with PCT applications.

The negative correlations with inward FDI stocks and imports can be explained with the discussion we presented in Section 2 that relates to (a) the degree of innovation intensity of products and investments that a country attracts, and (b) a country's absorption capacity.

A country that is involved in innovation-based outward investment and exports is likely to be an advanced, innovative country that might import and attract inward investment of a less innovative nature, compared to what it exports and the investment it attracts. Our sample includes also countries at lower levels of development. They may be the ones with low absorption capacity, and, thus, may be the ones that find it difficult to learn from inward FDI and from imported products. We ran the same regressions for two clusters to which countries were allocated on the basis of their GDP per capita. The results (presented in Appendix B) on the whole are not very impressive, nor are they strongly pointing towards explanation (a) or (b) above. The models presented in Table B.2 suggest that it is the low income countries that exhibit negative associations between inward FDI, imports and innovation, pointing towards explanation (b) above, i.e. the role of countries' ability to assimilate and benefit from the inflow of potentially more innovative, compared with local, products and investments.

We find that the number of scientific articles and Internet users are positively correlated with PCT applications. Service intensity – measured as value added in services over value added in manufacturing – is not correlated with patent applications. In relation to this there are two possible alternative mechanisms already highlighted in Section 3: (a) manufacturing firms are more likely to patent compared with services (pointing towards a negative relationship); (b) service economies tend to be more advanced, and firms located in more advanced countries are more likely to patent (pointing towards a positive relationship). The results, on average, appear to point more strongly towards the second explanation.

We observe a very similar pattern for both PCT applications and triadic patents: positive correlations for outward FDI and exports, and negative correlations for inward FDI and imports. Finding the same pattern is within expectations; both dependent variables are used to proxy countries' innovation performance. The triadic patents lean towards recording higher value patents compared with PCT applications, but they are recorded with a much greater delay. The recording may take up to 44 months and, moreover, the delay may be quite variable. For the triadic patents we find that the two trade variables remain significant, albeit with a smaller coefficient size, but the FDI variables do not.

One possible explanation for this is the fact that triadic patents data relate to the most innovative patenting activities with high value attached to them. Thus, the companies, and countries involved in them, do so independently of any learning and relationship through FDI and trade pattern of the country. In other words, the patenting activities is a sign of strong innovation drive that takes place independently of possible learning from investing abroad or exportation activities.

Our results are mirrored by those in other studies. Chang et al. (2010) use annual FDI flows as a percentage of GDP – inward and outward – as well as exports, but not imports, for 37 countries for the years 1994 to 2005. They find that outward FDI and exports are positively associated with triadic patents, and that inward FDI is negatively correlated. Schneider (2005) uses per capita flow data for 47 countries on imports and FDI and averages the data over four five-year periods. She finds that high-tech imports from developed countries positively correlate with US patents, and finds a negative coefficient close to zero and not significant with FDI inflows.

We computed the same regressions, but with an additional control variable: R&D over GDP. In the relevant regressions the number of observations is much smaller ranging between 204 and 354 observations based on between 5 to 9 years. This is compared to between 432 to 593 observations reported in Table 3. We find, in the case of PCT applications the same pattern and significant associations as reported in Table 3. One interesting pattern emerges from this exercise: when we control for R&D, the control variable service intensity becomes positively and significantly related to patenting. This seems to indicate that those advanced countries – the ones with high services to manufacturing ratios – that have a high commitment to innovation – expressed by the expenditure on R&D – will have also a high innovation performance.

DISCUSSION, LIMITATIONS AND PLAN FOR FURTHER WORK

The main purpose of the paper is to test whether internationalization has a positive impact on the innovation performance of countries. Innovation performance is proxied by two sets of data on patents: PCT applications and triadic patents. The independent variables related to internationalization include: outward and inward direct investment; exports and imports. The control variables relate to a variety of country-context elements and indicators of the country's absorptive capacity elements and specifically: number of papers in scientific journals as proxy for the country's knowledge context; number of Internet users as proxy for the country's technological infrastructure context; the ratio of value added in services and manufacturing as proxy for the industrial structure; and – in some estimates – expenditure on R&D as proxy for the country's commitment to innovation. The estimates are carried out for 42 countries all together and for two separate country groups selected on the basis of countries' GDP per capita.

The paper finds support for a positive impact of internationalization on countries' innovation performance, specifically with respect to outward looking international linkages. In Section 2 we discussed the possible ambiguous relationship between inward flows of investment and products (via FDI and imports respectively) on innovation. One possible scenario we expected was that these inward flows would only impact positively on innovation, provided the following conditions are satisfied: (a) that the type of investment or imports is innovation intensive compared to the domestic activities; and/or (b) that the receiving country – whose innovation performance via patenting activities is being explained – has enough capabilities and absorptive capacity to benefit from innovation-intensive inward FDI and/or imports. Were these conditions not to be satisfied, one would expect no impact or a negative impact from these inward flows on innovation.

Our hypotheses are supported; outward FDI and exports are found to impact on patenting activity. For inward FDI and imports the results are negative. We interpret this to mean that one (or both) of the two conditions above is not satisfied. This may be taken to mean: either that (a) the inward inflow of investment or products is less innovation-intensive than the country's domestic activities which would be the case for more advanced and innovation active-countries; or (b) that the country does not have a sufficient absorptive capacity to benefit from inflows. However, there may be a different explanation: it is worth remembering that patenting is only one aspect of innovation and there may be a variety of innovations, particularly in services or business methods, that are not captured by our dependent variable.

The results based on low- and high-income country groups on the whole are not very significant. They point towards the role of explanation (b) above driving our overall results. With regards to the signs on the FDI variables – positive for outward and negative for inward – there may be an additional reason for them. Our dependent variable is patent applications, and TNCs are more likely to file patents in the home country, and, indeed, to carry out the research – leading to patenting – in the home country where research laboratories tend to be located (Patel & Pavitt, 1991). Empirically we find some support for this relationship with respect to PCT applications.

The patterns reported with respect to PCT applications and triadic patents are similar, but the effect sizes are greater in the case of PCT applications. The two proxies differ, in that triadic patents tend to refer to higher value innovations, because the costs of filing in three countries are greater, compared with the minimum requirement of PCT applications. If triadic patents are the most innovative patents, than our results suggest that companies and countries involved in these activities do so with a lesser dependence on any learning effects that come through investing abroad or exporting abroad, and with a greater dependence on internal capabilities.

There are limitations in a study of this sort. First, there are limitations on the side of the dependent variables. They derive from the measuring of innovation performance via patenting activity as has been pointed out throughout the paper. Our proxy for innovation performance – number of patent applications – while readily available, only partially captures innovation performance (see our discussion in Section 2). If an independent variable – such as imports or inward FDI – appears to have a low contribution, the interpretation should not necessarily be that it does not contribute to innovation, rather, that it does not contribute to patenting. Further work is needed that expands on the range of innovation performance variables as well as on countries and time periods. Second, there are also limitations deriving from the independent variables specifically from their internationalization component. Data availability has constrained our analysis to a consideration of inflows and outflows of investment and products. Other major elements of internationalization such as the movements of human resources could not be used for lack of data. Yet these components are bound to be very important.[20] Third, there are limitations also on the side of the control variables. The expenditure on R&D variable is only available for all the countries in our sample for a limited number of years.

Pasinetti argues that: "…the primary source of international gains is not mobility of goods, but mobility of knowledge….International learning must therefore remain, for any country, the major and primary aim." (1981: 271). In international relations he therefore advocates "…a shift of focus in our attention from the narrow subject of international trade to the basic problem of lack of international mobility of technical knowledge". (1981: 274). Pasinetti's focus is trade not FDI and the activities of TNCs. However, his overall conclusion is consistent with our results on the impact of internationalization – whichever the type of exchange it involves – on innovation. There are policy implications from his conclusions and our findings. If the primary element of gain in international relation is knowledge and innovation, then mobility of knowledge must take priority in policy, whatever its channel, be it trade or FDI or mobility of labour. These conclusions may also have implications for the restriction of knowledge flows. Legal or policy frameworks that inhibit the dissemination of knowledge may be a hindrance to advancement in both developed and developing economies.

[1] An index of internationalization based on the number of countries in which TNCs have direct business activities is developed in Ietto-Gillies (1998 and 2009).
[2] Narula and Santangelo (2009) find that spatial proximity affects the choice of partners in R&D alliances.
[3] Cantwell's and Kogut and Zander's works are summarized and commented on in Ietto-Gillies (2012: Ch. 11)
[4] See Boradman (2009) as well as various articles in the Special Section on University-Industry Linkages in *Research Policy (*2008).
[5] Alvarez et al (2009) stress the relevance of internal and external networks also for the competitiveness of the firm.
[6] On the concept of embeddedness see Granovetter (1985).
[7] A positive contribution to knowledge, innovation and capabilities in the host country is, of course, made by inward FDI in R&D on which see the evidence and analysis in European Commission (2013).
[8] UNCTAD (1999, 2002) estimate that two-thirds of world trade originates with TNCs. Moreover, estimates give at one-third the share of world trade which is intra-firm, i.e. trade that takes place between units of the same TNC located in different countries.
[9] Coe and Helpman (1995) find positive effects on productivity of imports weighted by R&D expenditure in the country where the imports originate from.
[10] Cohen and Levinthal (1989 and 1990) develop these arguments in relation to increased R&D capacity while Filippetti et al. (2011) extend them to increased capacity via the importation of innovative products.
[11] The variable on foreign research students as percentage of total research students did show strong association with innovation variables in Filippetti et al. (2011).
[12] Both variables are frequently used in studies that examine the innovation capabilities of countries (see Archibugi & Coco, 1994).
[13] The filing can be done with a national office or the WIPO, and can be done immediately or within a 12-months priority period from an initial filing of a domestic patent. PCT applications undergo an international search, while domestic patents undergo a national search only.
[14] The PCT procedure to file a patent is divided into two phases: The first phase is filing at a national level (in other words, the filing with the receiving office), while phase two refers to filing at the international level (with a second or more patent offices). Stage two might or might not take place. Once a PCT application is filed, applicants have up to thirty months to file patents with additional patent offices.
[15] This work is in progress and the results are not presented here.
[16] The corresponding results can be made available upon request from the authors.
[17] Full regression results with the TNC variable included are made available on request.
[18] Results of all estimations are made available on request.
[19] Schneider (2005) in her analysis based on panel data of countries' innovation and internationalization performance reports on pooled OLS and fixed effects models, while Chang et al. (2010) report on the fixed effects and random effect models. Neither of these report on the Hausman test or the bias of the pooled regressions.
[20] In a study, that uses a much shorter time period, fewer countries as well as a different methodology, it was found that human resources variables are strongly correlated with countries' innovation performance (Filippetti et al., 2011).

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Table 1 Countries included in the study

Argentina	Denmark	Ireland	Norway	Spain
Australia	Estonia	Israel	Poland	Sweden
Austria	Finland	Italy	Portugal	Switzerland
Belgium	France	Japan	Romania	Turkey
Brazil	Germany	Korea	Russian Federation	United Kingdom
Bulgaria	Greece	Lithuania	Singapore	United States
Canada	Hungary	Mexico	Slovakia	
China	Iceland	Netherlands	Slovenia	
Czech Republic	India	New Zealand	South Africa	

Table 2 Overview of the variables, their unit of measurement and original source

Variable	*Unit of measurement*	*Source*
Dependent variable: Innovation		
PCT applications	Number of patents filed under the patent cooperation treaty per million people in t+2, t+3, t+4, t+5	World Intellectual Property Organization: Statistics on the PCT system
Triadic patents	Number of triadic patents per million people in t+3, t+4, t+5, t+6	Organisation for Economic Cooperation and Development: Main Science and Technology Indicators
Independent variables: Internationalization		
FDI outward stock	FDI outward stock as a percentage of GDP in t	The World Bank's World Development Indicator
TNCs	TNCs in a country per million people in t	United Nations' World Investment Report
FDI inward stock	FDI inward stock as a percentage of GDP in t	The World Bank's World Development Indicator
Exports	Exports as a percentage of GDP in t	The World Bank's World Development Indicator
Imports	Imports as a percentage of GDP in t	The World Bank's World Development Indicator
Control variables		
Scientific articles	Number of scientific articles per million people in t	The World Bank's World Development Indicator
Internet users	Number of Internet users per thousand people in t	The World Bank's World Development Indicator
R&D	R&D expenditure as a percentage of GDP in t	The World Bank's World Development Indicator
Services intensity	Value added in services over value added in manufacturing in t	The World Bank's World Development Indicator

* GDP is measured at current prices and using current exchange rates.

Table 3 The impact on countries' innovation activity of internationalization estimating a random effects model on panel data

Variables	*PCT applications*				*Triadic patents*			
	2 years lead	3 years lead	4 years lead	5 years lead	3 years lead	4 years lead	5 years lead[a]	6 years lead[a]
Outward FDI	66.00**	67.00**	63.06*	54.70	-9.28	-6.20	-7.78	-6.43
	(32.22)	(32.60)	(33.03)	(33.42)	(10.05)	(10.14)	(9.57)	(8.74)
Inward FDI	-50.33**	-46.84**	-38.58**	-26.89	-1.18	-0.39	1.03	-0.86
	(20.56)	(19.55)	(19.43)	(17.74)	(4.83)	(4.54)	(4.50)	(5.60)
Exports	68.80**	67.13**	56.22**	52.65**	16.30**	11.84	11.52	10.00
	(27.37)	(27.11)	(24.59)	(24.60)	(7.28)	(8.04)	(12.83)	(15.66)
Imports	-80.92***	-82.63***	-79.78***	-86.15***	-20.56***	-14.39*	-16.44	-13.29
	(22.67)	(22.40)	(21.65)	(20.57)	(7.71)	(8.32)	(11.78)	(12.52)
Scientific articles	0.11***	0.12***	0.14***	0.15***	0.02***	0.02**	-0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Internet users	0.14***	0.12***	0.11***	0.09***	0.02*	0.01	0.01	0.01
	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)
Services intensity	1.38	2.91	1.54	1.72	2.43	2.49	1.35	1.36
	(7.54)	(7.44)	(7.31)	(7.15)	(2.26)	(2.26)	(2.32)	(2.07)
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included
Constant	-20.24	-24.77*	-19.43	-16.25	4.58	7.33	18.54***	19.84***
	(13.01)	(13.38)	(12.70)	(12.08)	(4.69)	(4.66)	(5.61)	(5.37)
Observations	593	554	514	473	554	514	473	432
R-squared	0.814	0.809	0.801	0.789	0.467	0.464	0.134	0.083
Number of id	41	41	41	41	41	41	41	40
Chi-squared (d.f.)	563.3(22)***	547.7(21)***	678.3(20)***	567.1(19)***	162.4(21)***	157.2(20)***		
F-statistic							6.56***	3.42***

Robust standard errors are reported in parentheses. Observations are based on yearly data from 1990 to 2008.
[a] Estimates based on the fixed effects regressions, because the related Hausman test indicates that the random effects models are biased.
*** p<0.01, ** p<0.05, * p<0.1

Appendix A Descriptive and correlation statistics

Table A.1 Descriptive statistics of the variables

Variables	Observations	Mean	SD	Min	Max
PCT applications	756	54.21	72.59	0.00	347.36
Triadic patents	756	21.10	28.69	0.00	120.00
FDI outward stock	768	0.20	0.26	0.00	1.58
FDI inward stock	770	0.27	0.29	0.00	1.90
Exports	743	0.38	0.26	0.07	2.43
Imports	737	0.31	0.23	0.03	1.67
Scientific articles	698	397.71	320.59	1.33	1181.11
Internet users	732	205.37	244.14	0.00	887.71
R&D intensity	485	1.55	0.97	0.31	4.86
Services intensity	730	2.09	0.62	0.53	3.83

Table A.2 Correlations among the variables

Variables		1	2	3	4	5	6	7	8	9
1	PCT applications	1.00								
2	Triadic patents	0.81	1.00							
3	FDI outward stock	0.62	0.52	1.00						
4	FDI inward stock	0.22	0.05	0.70	1.00					
5	Exports	0.15	0.03	0.45	0.74	1.00				
6	Imports	0.01	-0.06	0.35	0.70	0.94	1.00			
7	Scientific articles	0.81	0.73	0.60	0.22	0.17	0.04	1.00		
8	Internet users	0.67	0.40	0.61	0.46	0.29	0.18	0.48	1.00	
9	R&D intensity	0.87	0.83	0.41	0.04	0.05	-0.04	0.80	0.52	1.00
10	Services intensity	0.39	0.35	0.42	0.17	-0.07	-0.06	0.49	0.36	0.29

Appendix B Additional regressions for two clusters of countries grouped by GDP per capita

Table B.1 Grouping of countries by GDP per capita for the years 1990 to 2007

Countries with a comparatively lower GDP/capita between 1990 and 2007		*Countries with a comparatively higher GDP/capita between 1990 and 2007*	
Argentina	6,247	Australia	23,088
Brazil	3,987	Austria	28,510
Bulgaria	2,135	Belgium	27,566
China	988	Canada	24,987
Czech Republic	7,150	Denmark	35,163
Estonia	5,679	Finland	28,041
Greece	14,618	France	27,320
Hungary	6,261	Germany	27,828
India	501	Iceland	34,060
Korea, Rep.	11,731	Ireland	28,118
Lithuania	4,220	Israel	17,197
Mexico	5,606	Italy	23,244
Poland	4,797	Japan	33,469
Portugal	12,588	Netherlands	28,699
Romania	2,437	Norway	42,435
Russian Federation	3,434	Singapore	22,622
Slovak Republic	6,424	Sweden	31,833
Slovenia	11,778	Switzerland	41,199
South Africa	3,725	United Kingdom	26,575
Spain	17,786	United States	32,623
Turkey	4,081		
Average	*6,484*	*Average*	*29,229*

* This table reports GDP per capita for each country and averaged in each of the two clusters over the period 1990 to 2007. GDP is reported in US$ measured at current prices and using current exchange rates.

Table B.2 The impact on countries' innovation activity of internationalization estimating random effects model on panel data. Regressions for lower income countries

Variables	*PCT applications*				*Triadic patents*			
	2 years lead	3 years lead	4 years lead	5 years lead	3 years lead	4 years lead	5 years lead	6 years lead
Outward FDI	-14.78	-11.89	-12.52	-6.09	-9.28	-7.20	-3.35	-10.22
	(29.69)	(28.79)	(30.79)	(29.94)	(10.92)	(11.43)	(10.65)	(10.68)
Inward FDI	-37.47**	-39.40*	-34.23	-31.44	-17.40**	-15.06*	-14.41*	-12.70*
	(18.65)	(20.63)	(20.85)	(20.03)	(8.73)	(8.59)	(8.46)	(7.60)
Exports	24.07	25.62	22.77	31.79	10.94	12.07	16.52	19.42
	(19.63)	(21.41)	(21.61)	(23.30)	(7.80)	(9.62)	(12.57)	(14.03)
Imports	-26.15	-27.50	-30.68	-41.06*	-12.59*	-14.21	-17.11	-19.39
	(19.42)	(18.46)	(18.87)	(24.53)	(6.76)	(8.93)	(12.47)	(14.12)
Scientific articles	0.04*	0.04*	0.04*	0.03*	0.00	0.00	-0.00	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)
Internet users	0.11***	0.13***	0.14***	0.16***	0.05**	0.05**	0.06***	0.06***
	(0.04)	(0.05)	(0.05)	(0.05)	(0.02)	(0.02)	(0.02)	(0.01)
Services intensity	-0.92	-1.13	-2.28	-2.76	-0.39	-0.73	-0.89	-1.05
	(1.77)	(1.94)	(2.26)	(2.67)	(0.73)	(0.81)	(0.93)	(1.23)
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included
Constant	0.39	1.03	3.81	5.20	1.72	2.05	2.06	2.08
	(3.89)	(4.33)	(5.14)	(5.35)	(1.78)	(1.87)	(1.72)	(1.85)
Observations	299	278	258	237	278	258	237	216
R-squared	0.671	0.682	0.684	0.663	0.598	0.571	0.512	0.457
Number of id	21	21	21	21	21	21	21	21
Chi-squared (d.f.)	.	.	2,297(20)***	2,0571(19)***	.	930(2)***	4,125(19)***	3,804(18)***

Robust standard errors are reported in parentheses. Observations are based on yearly data from 1990 to 2008. Results from the fixed effects model are almost identical.
*** p<0.01, ** p<0.05, * p<0.1

Table B.3 The impact on countries' innovation activity of internationalization estimating random effects model on panel data. Regressions for higher income countries

Variables	*PCT applications*				*Triadic patents*			
	2 years lead	3 years lead	4 years lead	5 years lead	3 years lead	4 years lead	5 years lead	6 years lead
Outward FDI	24.41	33.45	37.50	30.64	-8.80	-3.46	-2.19	-2.31
	(52.10)	(57.76)	(61.07)	(61.36)	(11.88)	(11.68)	(12.32)	(12.82)
Inward FDI	-24.86	-23.92	-21.97	-8.31	6.04	4.62	5.03	5.06
	(32.37)	(33.51)	(34.01)	(29.18)	(8.72)	(8.77)	(8.50)	(10.39)
Exports	37.95	30.36	0.41	-16.62	2.44	-7.67	-6.96	-18.33
	(64.48)	(66.20)	(68.81)	(75.09)	(16.33)	(16.27)	(20.53)	(30.23)
Imports	-40.85	-33.84	-6.48	-11.52	-0.20	11.77	-5.60	3.43
	(73.24)	(76.04)	(79.70)	(78.05)	(25.18)	(28.56)	(30.33)	(34.68)
Scientific articles	0.13***	0.14***	0.13***	0.13***	-0.00	-0.01	-0.02	-0.01
	(0.04)	(0.04)	(0.04)	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)
Internet users	0.11***	0.08**	0.04	0.02	-0.00	-0.01	-0.02	-0.02*
	(0.04)	(0.04)	(0.05)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)
Services intensity	9.89	14.67	11.23	12.10	4.30	3.05	2.84	2.02
	(20.35)	(19.25)	(19.98)	(21.12)	(5.37)	(5.33)	(5.66)	(5.90)
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included
Constant	-57.39	-65.09	-40.83	-24.59	24.30**	34.66***	45.59***	48.29***
	(46.04)	(42.04)	(45.53)	(46.52)	(10.60)	(11.15)	(13.68)	(14.57)
Observations	280	262	243	224	262	243	224	205
R-squared	0.663	0.624	0.580	0.523	0.00725	0.0477	0.0771	0.0190
Number of id	19	19	19	19	19	19	19	18
Chi-squared (d.f.)	.	.	.	.	.	.	.	.

Robust standard errors are reported in parentheses. Observations are based on yearly data from 1990 to 2008. Results from the fixed effects model are almost identical.
*** p<0.01, ** p<0.05, * p<0.1