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Abstract

The recent resurgence of growth studies has clearly established that technological progress and knowledge accumulation are among the most important factors in determining the performance of regional and national economic systems. In particular, it is clear that the success of lagging poor countries is strongly influenced by the capacity to absorb knowledge and technologies from rich industrialised countries. Nonetheless, few empirical studies have tried to analyse directly knowledge flows between the group of advanced and the group of developing economies, mainly because of the lack of adequate indicators.

In this paper we propose original, exploratory evidence on the characteristics of knowledge flows of European Neighbouring Countries (ENC) based on a statistical databank, set up by CRENoS, on patenting and citations at the European Patent Office and at the Patent Cooperation Treaty according to the place of residence of either the inventors or the applicant. We consider the 16 European Neighbouring Countries and their relationships with European Union, with the United States, with Japan and with other ENC's. We also use data provided by WIPO, which distinguish patents at National Patent Offices according to the residence of applicant. We, therefore, use four proxies for knowledge flows across countries, the former three are based on patent at PCT and EPO whilst the latter refer to National Patent Offices.

a) in- and out-flows of patent citations
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The analysis is mainly descriptive and aims at unfolding the main characteristics of this phenomenon.

1. Introduction

The importance of technological and knowledge flows as a source of endogenous economic growth has been consolidated in the last twenty years. Romer (1990) is one of the first authors who highlights the role of technological change and human capital in explaining economic growth in an endogenous model, followed by Grossman and Helpman (1991) who emphasize the importance of knowledge flows across countries and the relevance of the effects on country's productivity that foreign innovations and knowledge can produce. Most importantly, the capacity to absorb knowledge and adopt technologies developed in other countries is essential for countries which lag behind the technological frontier. They can, as a matter of fact, stimulate a process of catching up through the diffusion of innovations created in richer countries, as suggested by the technology gap theory by Abramovitz (1986) and Verspagen (1991).

Knowledge flows occur when an idea generated by one particular economic agent is learned by other agents and such a learning process creates the availability of what is called 'accessible knowledge' (Griliches 1992). According to Coe and Helpman (1995) and Coe et al. (1997), international trade can provide easily accessible information on one of the main channel of those knowledge flows which travel with goods and services exchanged across countries. Krugman (1991), on the contrary, observes that knowledge flows are invisible and cannot be measured and tracked. Actually, trade statistics, even though rather rich and very detailed, provide only an indirect and somehow modest indicator[1]. They do not take into account, for example, the whole range of interactions which involve tacit knowledge. Johansson (2005) identifies knowledge flows which are either transaction based or pure. In the former case, there is an agreement between the sender and the receiver of the knowledge and knowledge can be transferred in two ways: through pure market transactions if the receiver pays the sender for the transfer, or through link transactions if two or more agents cooperate in the R&D process. In the latter case, when we refer to spillovers, we assume that knowledge is transferred between two or more agents, without any ex-ante agreement between the sender and the receiver, but through imitation and/or workers communication. Jaffe et al. (1993) contrasted Krugman's pessimism and suggested that such knowledge spillovers may leave a "paper trail" in the form of patent citations, which can be easily measured and therefore used to obtain information on several dimensions of the technological transmission mechanism.

As far as the main factors which facilitate these transmissions, economists and geographers have stressed the importance of geographical closeness to help the knowledge transfer between actors (Audretsch and Feldman, 1996 and Breschi and Lissoni, 2001). In particular in those

[1] For a critical assessment of this line of research see Keller (1998).

situations in which tacit knowledge is involved, proximity plays an important role enabling knowledge externalities. However, spatial proximity is not the only kind of proximity that may be necessary in the process of knowledge exchange. Boschma (2005) identifies five dimensions of proximity: cognitive, organisational, social, institutional and geographical. Marrocu et al. (2012), within this research project, provide an exploratory analysis which tries to operationalise these concepts in an application to European regions spillovers, moving along the traditional literature based on the estimation of knowledge production function (KPF), (Griliches, 1979). Spillovers are mainly measured through spatial econometric techniques (see the example of Moreno et al., 2005).

In this paper we try to complement this kind of analysis (see Usai et al., 2012 for an application to ENC) by investigating directly knowledge flows and networks by using some proxies based on patent activity. The starting point for a network analysis of knowledge flows is the micro-level of individual agents, that is individual inventors, firms and other organizations engaged in innovative activities. The relations among these agents may be either mapped through direct interviews or, more easily, deduced from patent documents or joint research programmes. By aggregating data at a given geographical level (usually regions but also countries), one may build a geography-based inventor network (see, among others, Ponds *et al.*, 2007 and Maggioni *et al.* 2007). This contribution finds a natural complement in the analysis developed within this research project by Autant-Bernard and Chalaye (2012). They analyse the dynamics of knowledge flows between EU countries and ENC countries and assess different channels through which this diffusion occurs, that is co-inventorships, as in this paper, and also co-autorships and research partnerships.

There are by now many empirical studies on citations, which have followed the seminal contribution developed at NBER by Jaffe et al. (1993), based on data provided by the United States Patent Office (USPTO). The wide availability of this source has given rise to several studies on knowledge flows based on USPTO dataset (see Jaffe and Trajtenberg, 1999, 2002 and Hall et al., 2001 among others). Other contributions have tried to combine this dataset with the one provided by the European Patent Office (EPO), like Lukatch and Plasmans (2003) or Criscuolo and Verspagen (2006). Finally, there are some contributions, principally based on EPO data, such as Maurseth and Verspagen (2002), Le Sage et al. (2007) and Paci and Usai (2009) that attempt to measure knowledge flows across regions in Europe. More recently some contribution (Picci, 2010 and Maggioni et al., 2011) have gone beyond citation indexes and exploited two other relational features contained in patent data: the information on inventor partnerships across countries and regions and on the relationship between inventors and applicants, that is the creators of the invention and the actual owner and potential used of the patent.

The structure of the paper is as follows. In the next section we introduce some properties of the indicators used in this paper to proxy knowledge flows across countries. In the following section we comment and interpret the descriptive statistics on knowledge flows associated to citations, co-

inventorships, applicant-inventor relationships and non-resident national patents respectively. The final section concludes.

2. Treating patents as relational data

The early use of patent statistics as economic indicators (Griliches, 1990), treat such data as mainly attributional, that is a measure of the output of the inventive activity (both at the firm and at more aggregated – region, nation, industry – levels) and, therefore, to measure innovative activity and performance (see Breschi and Lissoni, 2006, for a updated review).

However, patents can be treated also as relational data as it has been done by Jaffe et al. (1993) who suggest that knowledge flows leave a "paper trail", contrary to Krugman's (1991) opinion, in the form of patent citations. Citations can be therefore used to obtain information on several dimensions of the innovation spillovers phenomenon: industrial and geographical, among others. As a matter of fact, citations of previous patents are collected for legal reasons, since they limit the property right (and therefore the monopoly power) awarded to proponents of new patents. More specifically, the cited patent is acknowledged as a previous piece of existing knowledge upon which the new invention is built. The linkage between cited and citing patents may therefore be a reasonable way to detect knowledge flows. If such knowledge flows are expressed as a measure of geographical space (for example using inventors' place of residence) then one may have an adequate proxy for interregional or international flows of knowledge and technologies. The same may apply to industries where citations of patents across sectors can provide a measure of intersectoral knowledge flows. Since the first contribution by Jaffe et al. (1993), other papers have used patent citations to measure knowledge flows across countries and regions and to assess the role of several factors affecting their dynamics (see, among others, Jaffe and Trajtenberg, 1999, 2002; Hall et al., 2001; Maurseth and Verspagen, 2002; Le Sage et al., 2007; Paci and Usai, 2009).

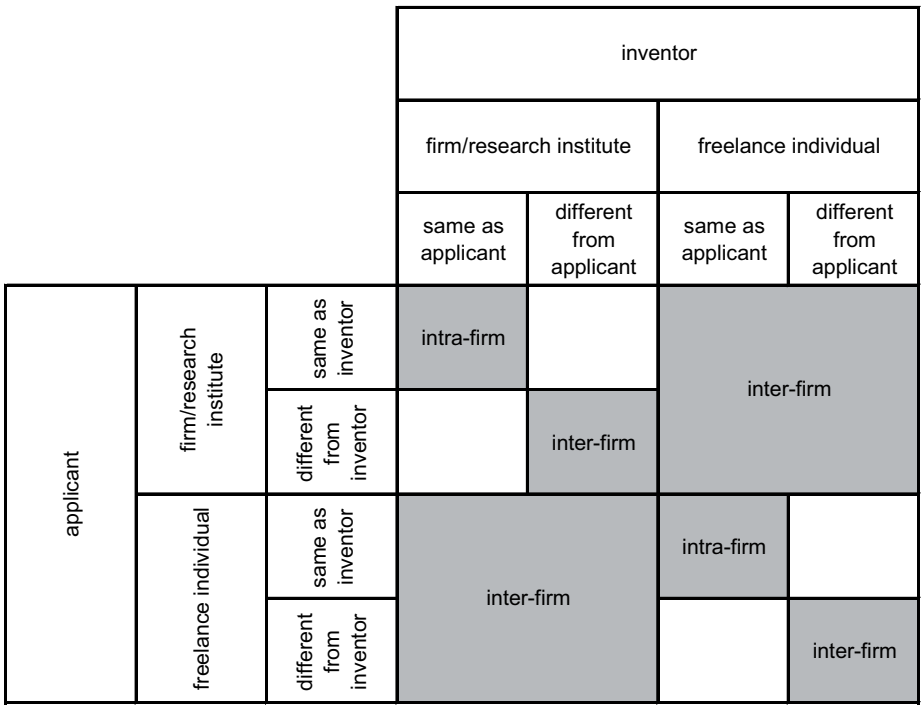
The relational content of patents has been further exploited with a different approach by other studies, such as Ejermo and Karlsson (2006), Cantner and Graf (2006), Maggioni and Uberti (2006 and 2009), Scherngell and Barber (2009), Hoekman et al. (2009) and Autant-Bernard and Chalaye (2012 within this research line). These authors use the information about multiple inventors of the same patent in order to map networks of intentional knowledge exchange between scientists (or, by appropriately aggregating the data, between research institutions, firms, regions and countries). In this case, this indicator can be a interesting direct indication of the presence of cooperative relationships among economic agents across countries. Obviously these cooperative links may work either within or across firms with different implications from an economic perspective. However, the data do not offer the possibility to discriminate among different kinds of links. A

problem which is also present with the use of the indicator described below which uses information on applicants and inventors.

Maggioni et al. (2011) and Picci (2010), as a matter of fact, deepen the analysis by distinguishing those links which appear when inventor and applicant of the same patent reside in different regions or countries, respectively. This relationship is particularly relevant since it refers to a somewhat hierarchical link between the economic agent who is responsible for the creation of new knowledge and the economic agent or institution (a firm or a research centre) which is going to exploit the economic results of the invention once it has been transformed in a innovation. Following Picci (2010), in this paper we exploit the grid of voluntary and presumably market-led exchanges between inventors and applicants at the country level.

The main advantages of examining the innovation process described by patents from the perspective of attributional and relational aspects lie in the possibility of discriminating the process of producing an invention from the process of implementing the invention into the marketplace. The former phenomenon is based on inventors, whilst the latter is centred on applicants or assignees. Moreover, thanks to this double perspective we can identify those international spillovers which are mediated between economic agents involved in the process of technological change, that is inventors and applicants, who reside in different areas. In particular, if economic agents are either firms/research institutes or freelance individuals, the following table, provided by Maggioni et al. (2011), can help us to classify different types of spillovers across countries according to different couplets of agents involved.

Figure 1: Classification of inventors–applicants relations



Source: Maggioni et al. (2011)

From figure 1 it is clear that flows can happen either within the borders of countries or across countries and either within the same economic body or not. More specifically, we are mainly interested in spillovers across countries independently of their being intra or inter-firm[2]. It is interesting to note that the former happen mainly in multi-plant firms and more rarely thanks to commuting employees and that without multi-locations and commuters, the utilisation and the production of new knowledge would be discriminated only by inter-firm links.

Obviously and unfortunately it is not possible, due to data limitation, to discriminate among all the possible cases, but it is important to keep them in mind. The main limitation derives from the formal procedures of patent application: all relevant information come mainly from the applicants[3]. Therefore, on the applicant side, one may wonder whether, in case of large companies with multiple locations, the patent is assigned to the branch/subsidiary/division where the innovation has been produced (or will be applied), or just left to the parent company headquarter. On the inventor side, one may doubt (at least this may be a problem for some countries) whether the legal address of the inventor coincides with the actual place where the inventor lives.

[2] It is worth noting that the great majority of patents are applied either by firms or individuals and only a small fraction by research institute, either public or private.

[3] Information can also be provided by professional representatives, a compulsory element when applicants do not have either their residence or their principal place of business in a contracting state.

However, the two examples above are nevertheless interesting because they illustrate different channels through which technical knowledge and information may flow from one country to another, and can be captured by patent data. One channel is the intra-firm flow which goes from one subsidiary to a headquarter where the economic effects (if any) of the innovation are appropriated. Another channel is active when the inventor works at the headquarter while he/she has kept the formal residence in another place. We emphasise that this can also prove to be a case of interest since the channel of transfer is actually embodied in the employee who is still attached to the place of residence.

3. Knowledge networks

In this paper we propose original, exploratory evidence on the characteristics of knowledge flows of European Neighbouring Countries (ENC) based on a statistical databank, set up by CRENoS, on patenting and citations at the European Patent Office and at the Patent Cooperation Treaty (OECD, 2009, and Webb et al., 2005) according to the place of residence of either the inventors or the applicant. We consider the 16 European Neighbouring Countries and their relationships with European Union, with the United States, with Japan and with other ENC's. We also use data provided by WIPO, which distinguish patents at National Patent Offices according to the residence of applicant. We, therefore, use four proxies for knowledge flows across countries, the former three are based on patent at PCT and EPO whilst the latter refer to National Patent Offices.

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a. Citations

The first indicator which is going to be analysed is based on citations. Table 1a and Table 2a list the number of citations made and received during the whole period of existence of the EPO by the neighbouring countries and their regions as origin and destination of the citation, respectively. Data are reported for the group of the so called old Europe, that is EU15, the New Member States which have entered the EU in the latest years (NMS12), for the USA and for JAPAN. Table 1b and Table 2b provide similar information as a percentage of total citations, but for those countries where the number of citations is inferior to five and the citation distribution does not provide any relevant information.

It is immediately evident that the phenomenon under examinations is quite modest with the important exception of Israel, clearly an outlier among the ENC's. From 1978 to 2010, Israel made

sightly more than 2700 citations towards one of EU15 countries, 2939 to patents invented in USA, 1408 to ENCs, that is mostly towards Israel itself, and more than 1000 to Japanese patents (see table1a). Quite similar numbers are found in table 2a where we assess the capacity to attract citations by patents granted to applicant resident in ENC'S. Israel, as a matter of fact, was the destination of citations more than 6500 patents from all over the world.

Other countries which emerge with some relevant knowledge flows are Ukraine, with around 200 citations made and only slightly more than 100 received and Egypt which, on the contrary, has almost the same amount of patents made and received. This result is quite different from the average behavior of ENC's where the number of citations received (see table 1a) is much lower than the number of citations made (see table 2a). Egypt therefore has an apparently more valuable technological production. Other countries worth of notice are: Belarus among the eastern ENC's, with 42 citations made and 13 received, and Jordan with 79 citations made and just 19 received. Another final interesting case is that of Morocco which cite 24 patents and receives 30 citations, even though most of them are self-citations, that is made to Jordanian patents.

The geographical flows of citations for countries like Armenia, Azerbaijan, Georgia, Moldova, Algeria and Lybia are very feeble.

Table 1a. EPO patent citations made by ENCs by area of destination, 1978-2010

country	EU15	NMS12	USA	Japan	ENC	others	Total
Armenia	1	0	1	1	0	0	3
Azerbaijan	3	0	3	0	0	1	8
Belarus	16	0	8	11	4	2	42
Georgia	1	0	0	0	0	0	2
Moldova	2	0	2	0	1	2	7
Ukraine	89	0	60	24	6	29	207
ENC-East	112	0	75	36	11	35	269
Algeria	3	0	4		0	0	7
Egypt	22	3	22	4	1	5	58
Israel	2,706	24	2,939	1,119	1,408	468	8664
Jordan	30	1	13	20	11	3	79
Lebanon	6	1	3	2	0	0	12
Libya	0	0	1	0	0	0	1
Morocco	11	0	6	6	1	1	24
Syria	5	0	6	1	7	0	19
Tunisia	16	0	2	2	0	1	21
ENC-South	2,799	28	2,996	1,155	1,428	479	8886

Source: CRENoS calculation on OECD-REGPAT Database (January 2012)

Table 1b. EPO patent citations made by ENCs by area of destination, 1978-2010 (% of total citations)

country	EU15	NMS12	USA	Japan	ENC	Others
Azerbaijan	43%	0%	43%	1%	0%	13%
Belarus	39%	0%	20%	25%	10%	5%
Moldova	23%	0%	31%	0%	15%	31%
Ukraine	43%	0%	29%	12%	3%	14%
ENC-East	42%	0%	28%	13%	4%	13%
Algeria	38%	0%	57%	0%	0%	5%
Egypt	39%	5%	37%	8%	2%	9%
Israel	31%	0%	34%	13%	16%	5%
Jordan	38%	1%	17%	26%	15%	4%
Lebanon	55%	4%	26%	15%	0%	0%
Morocco	45%	0%	25%	25%	3%	2%
Syria	24%	0%	34%	8%	34%	0%
Tunisia	75%	0%	10%	9%	0%	6%
ENC-South	32%	0%	34%	13%	16%	5%

Source: CRENoS calculation on OECD-REGPAT Database (January 2012)

If one analyzes the distribution of patent citations across groups of countries the first thing to notice is that Israel is no longer an exception. Its distribution is very similar to the average ENC: around 35% citations are made and received with respect to EU15 countries, whilst the second largest knowledge partner is the USA with a quota which is around 30%. Knowledge flows with Japan are on average quite modest but there are some countries which show significant quota, as, for example, for Belarus, Jordan, Morocco (for the citations made) and for Azerbaijan, Egypt, Jordan and Morocco for the citations received.

As for the flows which go towards the New Europe made of new entrant countries, they are extremely modest. Finally, there are some flows within ENC's but they are quite limited as well. However, we can see that Syria shows an high quota of knowledge flow (34%) and other countries as Moldova, Israel and Jordan show a quota of around 15-16%.

Another interesting observation refers to the last columns of table 1b and 2b which refers to other countries. The quota of citations received and made by eastern ENC's is slightly higher than the quota which refer to southern ENC's. One hypothesis is that this is a legacy of the linkages with the former Soviet block to which these countries used to pertain. However this hypothesis is not confirmed by a closer look to the matrices of flows country by country show that these links are mainly with another European country, that is Switzerland, and another North American one, that is Canada. Links with Russia are almost non existent.

The analysis of the country by country matrix is also interesting in order to notice that there is a clear geographical distribution of these links. Germany is relatively more involved in the knowledge network with Eastern countries, while France and Italy, also for historical reasons, are relatively more involved with North African countries.

Table 2a. EPO patent citations received by ENCs by area of origin, 1978-2010

country	EU15	EU12	USA	Japan	ENC	Others	Total
Armenia	1	0	0	0	1	1	2
Azerbaijan	0	0	0	0	0	0	0
Belarus	4	2	3	1	3	1	13
Georgia	1	0	0	1	0	0	2
Moldova	2	0	0	0	0	1	3
Ukraine	42	3	44	13	4	10	116
ENC-East	50	5	46	15	8	14	138
Algeria	3	0	2	0	0	0	6
Egypt	27	0	12	13	1	2	54
Israel	2080	19	1613	950	1413	495	6570
Jordan	3	0	0	5	9	2	19
Lebanon	7	0	3	0	0	1	10
Libya	1	0	1	0	0	0	2
Morocco	14	1	3	7	1	3	30
Syria	7	0	1	2	7	1	18
Tunisia	6	0	2	0	0	0	8
ENC-South	2146	20	1638	977	1430	504	6715

Source: CRENoS calculation on OECD-REGPAT Database (January 2012)

Table 2b. EPO patent citations received by ENCs by area of destination, 1978-2010 (% of total citations)

country	EU15	NMS12	USA	Japan	ENC	Others
Azerbaijan	50%	0%	0%	50%	0%	0%
Belarus	28%	15%	19%	4%	25%	10%
Ukraine	36%	3%	38%	11%	4%	9%
ENC-East	36%	4%	34%	11%	6%	10%
Algeria	52%	0%	37%	5%	3%	3%
Egypt	49%	0%	22%	23%	1%	4%
Israel	32%	0%	25%	14%	22%	8%
Jordan	14%	0%	1%	27%	49%	10%
Lebanon	66%	0%	25%	0%	0%	9%
Morocco	47%	3%	12%	22%	5%	11%
Syria	41%	0%	8%	11%	37%	3%
Tunisia	70%	0%	26%	2%	0%	2%
ENC-South	32%	0%	24%	15%	21%	8%

b. Co-inventorships

In this section we study knowledge and research co-operation networks by means of the patent-based indicators of co-inventorship. In the tables below we observe the patenting relation of the neighbouring countries with respect to the rest of the world for two types of patents (those requested to the European Patent Office, EPO and those to the Patent Cooperation Treaty, PCT). For EPO patents data can be disaggregated with respect to the geographical location of inventors

abroad and we can distinguish flows with respect to the 27 European Member States, the United States, Japan and the other ENC's. We focus on patents in the latest period from 2000 to 2008.

Due to the increasing importance of international networks, we can find strong cooperation among scientists in both East and South ENC as indicated by the share of patents with foreign co-inventors. Table 3a allows to have a detailed idea of the quota of patents with foreign co-inventors for each of the ENC and to compare this indicator with the one available also for some group of countries, such as EU27, EU15 and NMS12.

The first relevant result is that ENC are very much involved in cooperation inventive networks, probably due to their scarce experience both in innovative activity and in patenting. In other words they need to be involved in a partnership to invent a new patentable product or process and to apply for a patent. As usual Israel is a case apart with an index which is very similar to, actually even smaller than, the one of the countries in EU15. The average ENC country, on the contrary is much more similar to European new Member states (NMS12).

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Table 3a. PCT and EPO patents with foreign co-inventor(s) (% of total patents), 2000-2008

country	PCT	EPO
Armenia	34,2	82,6
Azerbaijan		-
Belarus	36,2	54,9
Georgia	44,4	75,0
Moldova	46,4	62,5
Ukraine	39,3	64,8
ENC-East	39,2	64,6
Algeria	19,4	61,5
Egypt	28,5	59,8
Israel	14,8	16,2
Jordan	55,9	42,1
Lebanon	55,4	49,1
Libya		-
Morocco	38,4	69,2
Syria		-
Tunisia	51,3	61,1
ENC-South	16,7	17,8
EU27	19,9	17,5
EU15	19,7	17,2
NMS12	32,2	37,8

It is also worth noticing that results are quite different if we refer to EPO or to PCT. The quota of collaboration being higher in the latter case probably due to the fact that in this case the presence of an European inventor may have a facilitating role in the transmission of knowledge concerning this patent system.

If we look at the first column, referring to PCT, we find that the countries with the highest quota of co-inventorship are Jordan and Lebanon with around 55% of patents with foreign co-inventors. On the other hand, the smallest quota, excluding Israel, refers to Algeria with about 20% of co-inventorship. Data and quota are different in the second column referring to EPO. As a matter of fact in this case the country with the highest quota is Armenia with more than 80% of patents due to a collaboration with foreign inventors and the smallest to Jordan with about 42% of foreign co-inventorships

Table 3b. EPO patents with foreign co-inventor(s) by partner country (% of total patents), average 2000-2008

country	world	EU27	USA	Japan	ENC
Armenia	82.6	65.2	13.0	0.0	0.0
Azerbaijan	-	-	-	-	-
Belarus	54.9	30.8	8.8	0.0	11.0
Georgia	75.0	15.0	50.0	2.5	5.0
Moldova	62.5	33.3	4.2	0.0	33.3
Ukraine	64.8	25.1	26.4	0.5	5.1
ENC-East	64.6	27.3	23.7	0.5	7.1
Algeria	61.5	61.5	0.0	0.0	0.0
Egypt	59.8	35.6	18.9	3.8	1.5
Israel	16.2	4.8	10.1	0.2	0.1
Jordan	42.1	21.1	27.2	4.4	0.9
Lebanon	49.1	43.4	3.8	0.0	0.0
Libya	-	-	-	-	-
Morocco	69.2	63.7	2.2	0.0	0.0
Syria	-	-	-	-	-
Tunisia	61.1	51.9	9.3	0.0	0.0
ENC-South	17.8	6.3	10.3	0.2	0.1

Source: CRENoS calculation on OECD Data

Table 3b allows to distinguish foreign inventors involved in research activities with ENC residents with respect to EU27, USA, Japan and other ENC. It is interesting to note that there is a dual picture: some countries are more oriented towards Europe, whilst some others are more involved with inventors in the USA. On the one hand, the largest part of foreign inventors for Algeria, Morocco, Lebanon and Tunisia are from the European Union, whilst Georgia and Jordan show a stronger innovative relationship with American scientists. It's interesting to note that the co-inventorship with other ENCs is relevant just for Moldova, due to its relation mainly with Israeli scientists. Finally, the collaboration with Japan is generally weak or totally absent. Israel has a more limited international co-operation: 16 out of 100 patents are co-invented with foreigners and most of them, 10 out of 16, with an American scientist as a partner.

c. Applicant-inventor relationships

In the next set of tables we investigate the extent to which foreign firms own domestic inventions in neighbouring countries and ENC domestic firms own foreign inventions by using the data on applicants and inventors of the same patent when they reside in different countries. Table 4a and 4b shows the share of patents with a domestic inventor and at least a foreign applicant in the country's total domestic inventions by nationality of the applicant firms. In Table 5a and 5b, on the contrary, we report the share of patents with a domestic applicant and at least a foreign inventor in the country's total domestic applications.

Table 4a shows the distribution of foreign ownership of domestic invention between the two patent offices: EPO and PCT. In general, we find that the presence of a foreign firm which owns, uses and exploits a domestic is higher in ENC with respect to EU27. As usual, Israel is an exception with a quota which is almost equal to the EU15 share. At the same time, ENC have a performance which is very similar to NMS12. Finally we record an average value which is higher for EPO rather than with PCT, as it was the case for the co-inventor relationships.

In table 4b ENC inventions which have produced an EPO patent with foreign ownerships are distinguished with respect to the usual set of countries in order to analyse their geographical distribution.

Table 4a. PCT and EPO patents: foreign ownership of domestic inventions (% of total patents), average 2000-2008

country	PCT	EPO
Armenia	36.8	95.5
Azerbaijan	-	-
Belarus	41.7	62.6
Georgia	54.5	85.0
Moldova	51.8	70.8
Ukraine	45.2	77.6
ENC-East	45.1	76.1
Algeria	25.4	61.5
Egypt	33.3	69.7
Israel	25.6	28.9
Jordan	86.0	44.2
Lebanon	80.0	80.8
Libya	-	-
Morocco	43.2	76.9
Syria	-	-
Tunisia	64.1	77.8
ENC-South	26.6	30.4
EU27	25.0	23.3
EU15	24.7	23.0
NMS12	41.2	48.7

We find that there is a very high degree of foreign control in several countries, such as Armenia, Georgia and Lebanon (96, 85 and 81 points, respectively), followed by Tunisia, Ukraine and Morocco (around 77 points). The lowest quota refers to Jordan with only 44% of inventions owned by foreigners. This country is a special case for another reason: more than half of these inventions are patented by US firms (27%), while only one out of four (8%) is owned by a EU firm. Moreover, Jordan is the only country where it is registered a relevant presence of Japanese ownership, with 5% of Jordanian inventions.

As for the other countries, the owner firm is usually located in Europe in the case of Southern Mediterranean countries (especially for Algerian, Moroccan and Tunisian patents), and also for some Eastern countries such as Moldova and Belarus. By contrast, a high level of American control is shown in the case of Georgia and Ukraine. Israel is as usual an exception with a low level of foreign control (29 points) with a predominance of US firms.

Table 4b. EPO patents: foreign ownership of domestic inventions by partner country (% of total patents), average 2000-2008

country	world	EU27	USA	Japan	ENC
Armenia	95.5	63.6	22.7	4.5	0.0
Azerbaijan	-	-	-	-	-
Belarus	62.6	40.7	7.7	1.1	1.1
Georgia	85.0	15.0	52.5	2.5	2.5
Moldova	70.8	50.0	4.2	0.0	12.5
Ukraine	77.6	32.0	28.5	0.0	2.1
ENC-East	76.1	34.2	25.5	0.5	2.4
Algeria	61.5	61.5	0.0	0.0	0.0
Egypt	69.7	30.3	25.0	4.5	0.8
Israel	28.9	6.5	19.3	0.2	0.0
Jordan	44.2	8.0	27.4	5.3	0.0
Lebanon	80.8	59.6	11.5	1.9	0.0
Libya	-	-	-	-	-
Morocco	76.9	65.9	2.2	0.0	0.0
Syria	-	-	-	-	-
Tunisia	77.8	63.0	9.3	0.0	0.0
ENC-South	30.4	7.8	19.2	0.3	0.0

Source: CRENoS calculation on OECD Data

The last indicator of internationalization of technology that we present is the domestic control of foreign inventions, calculated as the share of patents with a domestic applicant and at least one foreign inventor in the country's total domestic applications. Table 5a show the distribution between EPO and PCT patents and table 5b provides the distribution of EPO patents across group of countries.

Table 5a shows a more heterogeneous scenario with respect to previous tables. It is important to notice for example that Eastern ENC have a higher share of domestic ownerships of foreign inventions with respect to Southern countries (even if one exclude Israel). In other words in these countries, probably for the presence of big firms inherited by the previously planned economy, it is possible to have inventions which are made abroad and owned and applied domestically. This is particularly true for the case of EPO patents, where 30% of patents owned by ENC countries have involved at least one scientist who reside abroad, whilst the same quota is at 20% for EU15 countries and 22.5% for NMS12 countries.

Table 5a. PCT and EPO patents: domestic ownership of inventions made abroad (% of total patents), average 2000-2008

country	PCT	EPO
Armenia	18.6	60.0
Azerbaijan		-
Belarus	12.8	20.0
Georgia	17.9	28.6
Moldova	25.0	36.4
Ukraine	23.9	31.2
ENC-East	21.7	29.8
Algeria	1.9	20.0
Egypt	5.0	17.4
Israel	10.2	10.9
Jordan	15.6	11.4
Lebanon	30.0	13.3
Libya		-
Morocco	10.9	31.0
Syria		-
Tunisia	41.1	38.7
ENC-South	11.4	11.2
EU27	23.3	19.8
EU15	23.4	19.8
NMS12	20.1	22.5

Source: CRENoS calculation on OECD Data

Table 5b confirms the high variability across countries. It is worth noting that Armenia has the highest value (60%) with a prevalence of European inventors involved in domestic firms. The other eastern ENC have very different distributions. Most inventors of the patents owned by Georgia and Moldova comes from other ENC, that is from mainly Ukraine and Israel respectively, whilst in Belarus and Ukraine inventors comes both from EU and USA. It is also worth noting that some patents which are owned by these ENC's have been invented by Russian residents. A likely legacy of the previous USSR national innovation system.

In the case of the Southern ENC's, on the contrary, the scenario is more homogenous and the presence of European inventors is always very significant, but for the case of Israel where there is a prevalence of American rather than European inventors. It does not come as a surprise that for countries such as Algeria, Morocco and Tunisia most inventors reside in France, with which historical and cultural links are very strong and where the immigration flows from all these countries have been and still are significant.

Table 5b. EPO patents: domestic ownership of inventions made abroad by partner country (% of total patents), average 2000-2008

country	world	EU27	USA	Japan	ENC
Armenia	60.0	40.0	0.0	0.0	0.0
Azerbaijan	-	-	-	-	-
Belarus	20.0	7.5	5.0	0.0	0.0
Georgia	28.6	0.0	0.0	0.0	14.3
Moldova	36.4	0.0	9.1	0.0	18.2
Ukraine	31.2	8.8	8.0	0.8	1.6
ENC-East	29.8	8.5	6.9	0.5	2.7
Algeria	20.0	20.0	0.0	0.0	0.0
Egypt	17.4	8.7	2.2	2.2	0.0
Israel	10.9	3.6	5.2	0.2	0.1
Jordan	11.4	10.0	1.4	0.0	0.0
Lebanon	13.3	13.3	0.0	0.0	0.0
Libya	-	-	-	-	-
Morocco	31.0	27.6	0.0	0.0	0.0
Syria	-	-	-	-	-
Tunisia	38.7	35.5	0.0	0.0	0.0
ENC-South	11.2	3.9	5.1	0.2	0.1

Source: CRENoS calculation on OECD Data

d. Non resident national patents

In these final paragraphs we propose patent statistics taken from the WIPO Statistics Database, which is based on information supplied to WIPO by patent offices in annual surveys. In this case, the reference date is the filing year in the considered national patent office, while the geographical location of the patent is made on the basis of the country of residence of the first-named applicant. As already said, for this reason these data are not perfectly comparable with the EPO ones. In the last decades there has been a significant increase in the level of internationalization of patent activity. We observe the degree of internationalization in applications in national patent offices for ENCs by distinguishing between resident and non-resident filing[4].

[4] Resident filing refers to an application filed at an office of or acting for the State in which the first-named applicant in the application concerned has residence. Likewise, non-resident filing refers to an application filed at an office of or acting for the State in which the first-named applicant in the application concerned does not have residence (WIPO).

From Table 6 it is clear that the level of internationalization varies across countries/economies with a clear dual picture concerning neighbouring countries in the East and countries in the South. The share of non-resident patent filings in the former countries is on average very low with the smallest shares regarding Azerbaijan, Armenia and Moldova, where the average share does not reach 5 points. On the contrary, in the patent offices of the southern ENC's non resident patenting is prevalent with respect to resident patents. In particular in some countries such as Algeria, Jordan, Israel, Morocco and Tunisia, more than 80 per cent of total filings are accounted for by non-resident firms.

This indicator can be interpreted as a measure of the interest of foreign firms in the consumer market of these countries, and an indication of the degree of actual or potential completion from domestic and/or foreign firms.

Table 6. Patent applications at national patent offices by residence of the first-named applicant, average 2000-2010

country	Resident	Non resident	Total	Resident *(%)*	Non resident *(%)*
Armenia	162	7	169	96.1	3.9
Azerbaijan	252	6	257	97.9	2.1
Belarus	1,250	250	1,500	83.3	16.7
Georgia	211	198	409	51.5	48.5
Moldova	293	13	306	95.7	4.3
Ukraine	3,493	2,063	5,556	62.9	37.1
ENC-East	5,659	2,537	8,196	69.1	30.9
Algeria	55	412	467	11.7	88.3
Egypt	502	1,105	1,607	31.2	68.8
Israel	1,226	5,842	7,068	17.3	82.7
Jordan	50	291	341	14.6	85.4
Lebanon	-	-	-		
Libya	-	-	-		
Morocco	143	633	775	18.4	81.6
Syria	181	54	235	77.1	22.9
Tunisia	42	175	217	19.3	80.7
ENC-South	2,198	8,512	10,710	20.5	79.5

Source: CRENoS calculation on WIPO Data

4. Discussion

Products and services are nowadays the result of some exchange, voluntary or involuntary, among firms and economic agents in different countries all over the world. More and more this

process of internationalization applies to innovative activity too. In this paper we have tried to assess the internationalization of technological activity among countries pertaining to the European Union and the European neighbouring countries by looking at knowledge flows. We measure these flows by means of patent data which is an indicator of technological relationships as much as of technological activity. As a matter of fact, patents can provide information on the relationship among patents due to citations made and received, on the relationship among multiple inventors of the same patent and on the relationship between the inventors and the applicant, that is the owner, of the same patent. All such information has been rarely used in the literature. The most notable recent exceptions being Picci (2010) and Maggioni et al. (2011).

In this paper, we discuss the extent, and tentatively try to shed some light on the potential causes, of internationalization of innovative activities with European Neighbouring Countries. We found that the degree of internationalization of innovative activities has increased over time but it is extremely limited and diversified among countries which have a very different economic background and level of development.

Nonetheless, it is clear that some countries, especially the biggest ones in terms of population, are getting more and more important for European countries as much as for the United States. Moreover, knowledge flows are clearly influenced by several dimensions of proximities across countries. Geographical distance and proximity clearly still plays a role, but also cultural and historical linkages may impact on the probability to have an exchange, either market mediated or as a result of an externality. Finally, it is also clear that technological proximity may have an impact on knowledge flows both in quantitative and qualitative terms across countries. This is particularly evident for those countries which have major natural resources which attract multinational corporations which, sometime, try to complement their production with some innovative activity. The presence of such a high level of heterogeneity suggest that policy interventions have to be differentiated with respect to the different contexts in terms of both internal aspects and external links (see Tödtling and Trippl, 2005).

The analysis presented in this paper is mainly descriptive and therefore clearly preliminary but provides an original empirical scenario on which further analyses (starting from Ondos and Bergman, 2012, Autant-Bernard and Chalaye, 2012 and Sebastyen and Varga, 2012 within this research project), can find important basic information and inspiring research hypotheses.

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