International Patenting and Knowledge Flows in Latin America.

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<recto><cn>9.<em><ct>International patenting and knowledge flows in Latin America[i]

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<a>1.<em>INTRODUCTION

One of the striking stylized facts of the last three decades is the ability of some developing countries to catch up with the advanced ones while others are lagging behind. A set of developed economies and a set of newly industrializing and emerging countries, in particular in East Asia, have shown the tendency to converge in terms of GDP per capita. At the same time most of the Latin American countries (LACs) failed to grow at the same speed and did not undertake a process of economic catch up. The question of why this is happening is complex and involves a rich set of institutional, technological and economic variables. However some consensus has been reached on the fact that technology and innovation play a very important role and the ability of a country to catch up depends upon its capacity to learn, to generate domestic technological capabilities and innovate (e.g. Fagerberg 1994; Lee and Lim 2001; Furman et al. 2002; Cimoli et al. 2009).

Also recent macroeconomic modelling has underlined that knowledge spillovers and externalities are major drivers of economic growth. The way knowledge diffuses affects the path of productivity growth and in particular these models emphasize that growth depends upon disembodied knowledge spillovers. As a consequence the possibility (and ability) to re-use existing knowledge generates increasing returns and long-run welfare effects. (e.g. Romer, 1990; Grossman and Helpman, 1991). Widespread differences across countries in the catch up process and the important role played by knowledge spillovers and international technological diffusion have stimulated interest in how knowledge and technology are transferred from developed to developing countries. Since technological knowledge is often tacit and embedded in people, many authors try to understand which conditions are conducive to effective technology transfer which depends upon costly processes of learning and the accumulation of specific capabilities that are required to absorb knowledge in different technological domains. Moreover market failures and problems related to asymmetric information – already relevant when knowledge is perceived as a public good – are particularly important when a large portion of knowledge is tacit.

On this premise this chapter studies the international technological activities of LACs and tries to analyse in depth their relative weakness vis à vis other emerging countries. This chapter is composed of two main sections. Section 2 describes LACs patenting activity at the USPTO. In particular it focuses on the actors involved (inventors and applicants) and on the processes of international technological specialization over time. It also asks how much growth we observe in international patenting and which are the technological absolute and relative advantages of a number of Latin American countries, compared with other areas in the world, in particular East Asian countries.

Section 3 addresses the issue of international knowledge diffusion. It studies whether the international patenting activity of LACs responds to international knowledge flows and analyses at national and sectoral level to what extent foreign R&D activity affects the innovative performance of LACs at industry level via different channels of international knowledge flows. In particular, it focuses on three mechanisms: foreign R&D, patent citation-related spillovers, and face-to-face contact spillovers based on co-inventorship relations. So knowledge flows are measured using patent citations and analysis of the network of co-inventors whose names are listed in the patent documents.

<a>2.<em>INTERNATIONAL TECHNOLOGICAL ACTIVITY IN LATIN AMERICA

Many papers have documented that LACs under-invest in business R&D and lag behind in terms of innovative output. Hall (2005) shows that there are dramatic differences in business R&D and patents per capita between four big LACs and Korea, Singapore, Taiwan, Hungary and Poland (see also Lall, 2003). In 1995 the total R&D to GDP ratio was on average 0.64 for LACs and 1.9 for East Asia, moreover in LACs only 20.4 % of total R&D comes from business R&D while the percentage is 67% for East Asia. Differences are even more striking if we consider other indicators like technological licenses per capita and high tech exports per capita.

Table 9.1 compares rates of growth of GDP per capita and R&D intensity in some LACs and East Asian countries. According to UNESCO, in Latin America Brazil reported the highest level of R&D intensity (1.0%), followed by Chile, Argentina and Mexico (0.7%, 0.5% and 0.5% respectively). Note that UNESCO data confirms that in LACs the share of the business sector in the funding and performance of R&D in 2007 was in most cases between 25% and 50%. On average, R&D intensity in Asia was around 1.6% in 2007, and the top investors in East Asia were: Japan (3.4%), the Republic of Korea (3.5%) and Singapore (2.6%). China reported spending 1.5% of GDP on R&D, while India and Malaysia invested between 0.6% and 0.8% of GDP. Larger differences between LACs and Asian countries are observed in terms of patents per million inhabitants. South Korea has the greater number of USPTO patents between 2000 and 2007 with around 733 patents per million inhabitants, followed by Malaysia with 24. Among the LACs Argentina has about 9 patents per million inhabitants, followed by Chile (7), Mexico (6), and Brazil (4).

<insert(Table 9.1. Macroeconomic and patent data for Latin American and Asian Countries)>

This chapter is aimed at exploring further this under-performance in innovative output – namely patenting activity at the USPTO and at the EPO – describing its characteristics in terms of actors involved (inventors and applicants) and its sectoral composition. In order to do so we use the patent and patent citation databases from the USPTO-CESPRI database and from the EP-CESPRI database.[ii]

<b>2.1.<em>Inventors and Applicants

There are two ways of assigning a patent to a country. It is possible to look at the country of the inventors or at the country of the applicants (or assignees). We call the former type of patent 'Latin American *invented* patent' and the latter type 'Latin American *owned* patent'. In the first case we observe the inventive activity of individuals declaring that they have their residence in one of the selected Latin American countries. In the second case we observe the patenting activity of companies with their legal address in one of the selected Latin American countries; this also includes the subsidiaries of foreign companies.[iii] If a country's patents are counted using the applicant's address, results reflect "ownership". Of course, this counts the inventive activity of a given country's firms, even if their research facilities are located elsewhere. The patent count based on the inventor's address should reflect more directly the inventive activity of laboratories and researchers in a given country. We discuss at length this point in Montobbio and Sterzi (2013).[iv]

Tables 9.2 and 9.3 show the number of Latin American invented patents applied for at the EPO and granted at the USPTO (the USPTO started publishing applications only in 2001) from 1980 to 2004. These numbers are quite small relative to the overall trend in patenting in other countries as shown in Section 2.4 below. Top patenters at the USPTO are Brazil and Mexico with respectively 1863 and 1672 patents granted. Argentina and Venezuela follow with 882 and 640 patents. At the EPO Brazil still has the highest share with 1645 patents. Mexico, Argentina and Venezuela follow with 657, 568 and 170 patents, respectively. At the EPO the relative weights of Mexico and Venezuela are lower.[v]

<insert(Table 9.2. Patents at the USPTO by inventor's country)>

<insert(Table 9.3. Patents at the EPO by inventor's country)>

The comparison between Table 9.3 and Table 9.4 shows that counting patents with the applicant's address reduces the number of patents in the main countries by approximately 35% (from 3464 to 2261, in the period 1980–2004, EPO data). This asymmetry reflects partly the internationalization of research and the location of research and legal facilities by multinational firms and partly the fact that some Latin American inventors may be temporarily (or in some cases even permanently) active abroad and declare their address in Latin America.

<(Table 9.4. Patents at the EPO by applicant’s country)>

Table 9.5 gives the overall number of patents at the EPO and USPTO in comparison to the labour force (World Bank) of the same country. Looking at the USPTO patents Brazil is at the top with a considerable growth between the 1980s and ’90s (trends are discussed in the following section). Venezuela and Argentina follow. Mexico had one of the largest patent intensities during the ’80s but the growth of patenting relative to the labour force has not been as high in the other Latin American countries. Concerning EPO patents the similarity across the selected countries is noticeable, with two exceptions: Argentina –- which has on average twice the number of patents per million of labour force compared to other countries – and, at the opposite end, Colombia, with only 2.58 patents per million of labour force.

<(Table 9.5. Patent per million labour force)>

<b>2.2.<em>Individual Inventors

Many patents’ assignees are individual inventors. If we assign a patent to a country using the applicant’s address, 41.5% of Latin American patents at the EPO are owned by individual inventors. These shares are considerably higher than average, considering that for all patents at the USPTO and at the EPO the shares of individually owned patents are respectively 23% and 11%.[vi] However there is a quite high heterogeneity across countries. The countries with the highest share of patents owned by individual inventors are Argentina (72%), Colombia (73%) and Chile (59%).

We do not have the applicants' country for the USPTO data and therefore in this case it is difficult to give a detailed country breakdown. It is interesting though to ask what is the share of individually owned patents when we assign a patent to a country using the inventor's address. In this case 37.3% of the "Latin American invented" patents granted at the USPTO are "individually owned". Argentina (61.7%), Colombia (55.1%), Uruguay (52.5%) and Mexico[vii] (42.4%) have shares that are higher than the average.[viii]

Typically less developed countries and regions have a relatively higher share of individual inventors because firms, universities and research centres are less aware of the patent system and have relatively less resources to invest (relative to firms in the advanced countries). Therefore it is more likely that individuals decide to bear the expenses and file their own patents. Typically these patents are considered less economically and technologically valuable because they are often the result of occasional activities and do not originate from well funded R&D projects. Moreover some of such patents may actually belong to companies but have been put under the name of the owner as the applicant. This could be the case of micro companies, family companies or partly-informal companies. Given the great uncertainty of survival of small and medium companies – in a macro-economic context that often is unstable – companies prefer not to have the patent registered under the name of the company but rather under the name of the owner (for Argentina see López et al. 2005).[ix]

<b>2.3.<em>Applicants

By considering Latin American *invented* patents we observe a heterogeneous group of applicants at the EPO. These companies are either big multinational companies or national oil based companies, or companies with a technological specialization that needs to be protected in Europe. The firm with the highest number of patents is Unilever. There are six US multinational companies, heavily diversified and active mainly in Electronics but also in Pharmaceuticals (such as Johnson&Johnson or Syntex). There is a group of five big German firms active in Chemicals, Pharmaceuticals and Electronics that for historical and geographical reasons are very active patenters at the EPO. Among the companies with a Latin American address there are two firms linked to big oil producers (Petrobras and Intevep), other companies in the Metal, Machinery and House Appliances sectors and two research centres on molecular biology in Cuba. It is interesting to note that the patenting activity of Petrobras and Intevep is not concentrated in the Oil sector. In particular, 80% of Petrobras's patents are in Metals, Non Electrical Machinery and Transports. Intevep has 17 patents in the Oil sectors, 14 in Non Electrical Machinery and 11 in Chemicals and Pharmaceuticals. Table 9.6 shows the top 21 applicants and their number of patents. Patents filed by Latin American applicants (i.e. companies with a Latin American address) have been highlighted in italics.

<insert(Table 9.6. Top 21 applicants at the EPO and relative patents)>

There are no Latin American companies active in high tech and high growth sectors such as Electronics, Telecommunications or Pharmaceuticals. If we consider the most important industrial groups that patent at the EPO it is remarkable that some big companies active in Electronics and Telecommunications, for example Siemens, Phillips, and companies from Japan like Canon and Sony are left out of the picture (presumably this is because they do not do any R&D in Latin America or their patents do not have Latin American residents as inventors). The picture at the USPTO (Table 9.7) is quite similar to the EPO with a lower presence of German firms and a higher presence of US companies including HP, IBM, Carrier and Colgate-Palmolive. Latin American companies are, as in the EPO list, involved in a set of heterogeneous activities that do not appear to be particularly R&D intensive (e.g. Oil, Glass, Electric, Metals and Machinery).

<insert(Table 9.7. Top 23 applicants at the USPTO and relative Patents)>

<b>2.4.<em>Patenting Trends vis à vis Other Geographical Areas

In order to compare the selected Latin American countries with other geographical areas, we have chosen a set of developing and developed areas that at the beginning of the 1980s had comparable patenting activities, and kept the US and Japan in the picture for comparison. If we look at the absolute numbers (Table 9.8) at the beginning of the 1980s the Latin American group of countries had about half the number of patents of Eastern European countries, one third of the number of patents of Australia and New Zealand and two thirds of the number of patents of the Four Asian Tiger economies (Taiwan, Hong Kong, Singapore, and South Korea). At the same time, the number of patents of Latin American countries was about five times larger than the sum of China, India, Malaysia and Thailand.

<insert(Table 9.8. Latin American patents at the USPTO vis a vis other geographical areas)>

At the end of the 1990s Latin American countries had a larger number of patents than East European countries and maintained one third of the number of New Zealand and Australian patents. Impressively, Taiwan, Hong Kong, Singapore and Korea increased their patenting activity by a factor close to 30. China, India, Malaysia and Thailand were rapidly catching up, but their absolute numbers in 2000 were still lower than the total for Latin American countries.[x]

Between the sub-periods 1985–89 and 1995–99 the growth rate for Latin American countries is 81.65%, higher than that of Eastern Europe, which in the same period is incurring deep economic and political transformations, and also higher than Australia and New Zealand's. This is a period of massive upsurge of patenting worldwide and Latin American countries score a growth rate that is also higher than that of countries such as the US and Japan, which however in the initial sub-period had a number of patents 200 and 80 times larger, respectively.[xi]

<b>2.5.<em>Technological Disadvantage, Specialization and its Dynamics

We define *international technological specialization* (ITS) as the international technological performance of a country in a specific technology relative to its overall international technological performance. Thus, a country is specialized in Chemicals or Mechanics if its technological performance in these classes at the international level is higher than its overall international technological performance. Technological specialization is related to relative (dis)advantages and not absolute ones. The technological strength of a country is approximated by the share of that country's patents to total world patents. Similarly, the technological strength of a country in a specific sector can be measured by the share of that country's patents to total world patents in that sector. This is an indicator reflecting absolute (dis)advantages.

Many authors have adopted the so-called Revealed Technological Comparative Advantage index (RTA) in order to measure the ITS in a technological field. RTA is the traditional Balassa indicator of revealed comparative advantage applied to innovation analysis (Balassa, 1965). It measures the share of patents granted to (or applied for by) firms and other organizations in country *c* in technology *j* on total world patents in technology *j*, divided by the share of total patents granted to (or applied for by) firms and other organizations in country *c* to total world patents.

<equation>

$$RTA_{\mathrm{cj}} = \frac{p_{\mathrm{cj}}}{\sum_{c} p_{\mathrm{cj}}} \bigg/ \frac{\sum_{j} p_{\mathrm{cj}}}{\sum_{j}\sum_{c} p_{\mathrm{cj}}}$$

</equation>

where p_{cj} denotes the total amount of patent applications (granted) in technological class *j* by country *c*. This index has a weighted average equal to 1 and a skewed distribution, taking values between zero and infinity. A modified and symmetric version of this index[xii] has nicer properties in order to perform statistical analyses:

<equation>$RTAN_{\mathrm{cj}}=(RTA_{\mathrm{cj}}-1)/(RTA_{\mathrm{cj}}+1)$. (9.1) </equation>

RTAN is a monotonic transformation of RTA that is better suited to the statistical analysis of ITS because it is symmetric and reduces the value of extreme observations; it has values that belong to the [–1,1] set. $RTAN_{\mathrm{cj}}>0$ ($RTAN_{\mathrm{cj}}<0$) means that country *c* is relatively specialized (de-specialized) in class *j*.

In the analysis we considered only USPTO data (results for the EPO data are not substantially different) for two sub periods. The first period considered is 1985–89 and the second period is 1995–99. We have grouped five years to avoid the noise of yearly data and catch only the robust patterns of change over 10 years.[xiii]

<c>2.5.1.<em>World patent shares

Table 9.9 shows the world patent shares of the selected group of Latin American countries in the six sectors and in the two sub-periods. In the period 1995–99 the highest shares of world patents by Latin American countries are in Drugs & Medical, Chemicals, and Others, with respectively 0.37%, 0.34% and 0.31% of world patenting activity. The lowest shares are in Computer & Communications and Electrical and Electronics, with values equal to 0.06% and 0.08% respectively. These shares are weakly increasing in all sectors. In particular for Electronics and Computer & Communications these increases are negligible. It is worth noting that these two sectors, together with Drugs & Medical, are the ones that had the largest rate of growth at the USPTO if we consider all the patents granted by the USPTO. Latin American countries therefore have a low share of world patents in particular in the technologies that seem to have the highest level of technological opportunities (apart from Drugs & Medical).

<insert(Table 9.9. World patent share of different geographical areas in different sectors in two sub-periods)>

Patent shares in China, India, and Malaysia and Thailand (taken together), grow more in particular in these high growth sectors. During the same years the growth of the world patent shares of the Four Asian Tigers is impressive. In 1985–89 in Chemicals and Drugs & Medical, Latin American countries and the Four Tigers had the same world share. After ten years, the overall share of Singapore, Taiwan, South Korea and Hong Kong had increased more than tenfold in Chemicals and three folds in Drugs & Medical. These countries display an impressive growth also in Electrical and Electronics and Computer & Communications, having in these sectors a higher starting point in the period 1985--89.

China and India also display a considerably higher percentage growth of their world shares between the two sub-periods, in particular in high opportunity sectors like Electrical and Electronics and Computer & Communications. For example, comparing China and the Latin American countries in these two sectors we observe that China is ahead in both sectors even though ten years earlier its absolute technological performance was far behind.

Table 9.10 shows the world patent shares for each Latin American country considered. Most of the patterns highlighted above are guided by the highest shares that belong to Argentina, Brazil, Mexico, and, to a minor extent, Venezuela. All Latin American countries increased their shares in Chemicals (apart from Colombia). The observed improvement in Drugs & Medical is mainly driven by Argentina and Brazil. On the contrary, Mexico is mainly responsible for the improvement in patent shares in Electrical and Electronics and Computer & Communications. In the latter sector there is improvement also from Brazil's share and a remarkable decline in Argentina and, in particular, in Venezuela. All countries improved (with the exception of Uruguay) their shares in the residual sector 'Others', which includes most of the traditional activities. In smaller countries we observe that Chile's share has improved in all sectors but one (Mechanical) and Colombia experienced a decline in Computer & Communications, Chemicals and Mechanical and gained shares in the other sectors. Finally, Venezuela has a negative performance in all sectors except Chemicals and Mechanical.

<insert(Table 9.10. World patent shares for the selected Latin American countries in different sectors in two sub-periods)>

<c>2.5.2.<em>International technological specialization

Table 9.11 shows the ITS of Latin American countries as measured by equation (9.1). In the period 1995–99 Latin American countries are specialized in Chemicals, Drugs & Medical and 'Others', with values of the RTAN index ranging from 0.19 in Others to 0.27 in Chemicals. At the same time they are heavily de-specialized in Electrical and Electronics and Computer & Communications with values respectively equal to −0.45 and −0.53. It is noteworthy that, if we consider all the Latin American countries together, the Latin American area seems to deepen its specialization pattern over the ten years considered. Apart from the Mechanical sector, the RTAN grows in the sectors where in the first period it is positive and declines in the sectors where in the first period it is negative (as we show in the next section).

<insert(Table 9.11. Revealed Technological Advantages (eq.1) of different geographical areas in different sectors in two sub-periods)>

China and India are also becoming more specialized in Chemicals. However, they are massively counteracting the initial de-specialization in Computers & Communication and in particular India also in Electrical and Electronics. Conversely, the Latin American area is the only one that increases its relative specialization in the less technological intensive sectors grouped in 'Others'.

The analysis of the standard deviations and their change over time (Table 9.11) suggests that the Latin American countries are together with India the countries with the highest standard deviation and therefore they display the higher degree of specialization. Moreover India and Latin American areas' standard deviation have the highest growth (with the US which has, however, a relatively much lower specialization). Despite these similarities the nature of patterns of specialization in India and Latin America differs substantially because India is heavily reducing its degree of de-specialization in Electrical and Electronics and Computers & Communication and at the same time exiting technological activities in lower growth technological fields like Mechanicals and Others. Latin American countries become more specialized in 'Others' and seem to increasingly have a relatively slower pace of innovation in Electrical and Electronics and Computers & Communication.

Looking more specifically at each Latin American country (Table 9.12) we notice that, in the most recent period 1995–99, all countries have a revealed technological advantage in Chemicals (except Argentina and Uruguay), in Drugs & Medical (except Venezuela) and 'Others'. In parallel all countries are de-specialized in Electrical and Electronics (except for Uruguay) and Computers & Communication. In parallel, some heterogeneity in the patterns of structural change emerges: over ten years some countries are becoming more specialized and other countries are becoming less specialized. In particular, in Argentina, Brazil, Chile and Venezuela the standard deviation of the RTAN increases substantially (Table 9.12 – last three rows). For all these countries we have a large decline in the RTAN in Electrical and Electronics and Computers & Communication (excluding Brazil in this latter case). At the same time, for these four countries RTAN values increase in Chemicals and also show a positive trend in Drugs & Medical (excluding Chile and Venezuela).

<insert(Table 9.12. Revealed Technological Advantages (eq. 1) of selected Latin American countries in different sectors in two sub-periods)>

Mexico shows a quite different process of structural change and reduces its technological specialization over the ten years considered (Table 9.13 – last row). Apart from the Mechanical and Others sectors where changes in the RTAN are very small, the RTAN declines in the sectors where in the first period it is positive (Chemicals and Drugs & Medical) and grows in the sectors where in the first period it is negative (Electrical and Electronics and Computers & Communication). This is consistent with the evidence provided in the previous section with Mexico being the only Latin American country which improves its patent shares in both Electrical and Electronics and Computer & Communications.

Overall these data show also considerable stability and no major structural changes in Latin American countries in the period considered (see also Montobbio, 2008). We do not observe big shifts in the technological activity of Latin American countries. The overall level of specialization of countries is analysed looking at the standard deviation of the RTAN indexes across sectors for each country. Table 9.13 shows that this type of specialization increases in all countries except Colombia, Cuba and Mexico. An increase in the dispersion can be interpreted as a movement towards a more narrow specialization pattern (Cantwell, 1989). In sum in a context of a broad stability of technological specialization patterns we observe an increased level of overall specialization in particular for Chile and Venezuela but also for Argentina, Brazil and Uruguay.

<a>3.<em> SOURCES AND DETERMINANTS OF LATIN AMERICAN PATENTING ACTIVITY

This section analyses the determinants of the technological activity of LACs described above, focusing in particular on the impact of different mechanisms of international knowledge flows. In LACs we observe a relatively low level of R&D intensity and the weak performance in international patenting is clearly related to this scant – both private and public – domestic R&D effort. As a consequence international technological activity in LACs depends upon international R&D efforts, first because – as our evidence suggests – a great part of LAC international patents are linked to the activities of multinational corporations and, secondly, because international knowledge flows could facilitate the accumulation of capabilities (Cimoli et al. 2006, 2009) and innovation in parallel with the domestic R&D effort.

The economic literature underlines different possible channels of knowledge transfer between developed and developing countries. Knowledge flows when countries trade (both import and export) (Coe and Helpman, 1995), when foreign direct investments occur (Branstetter, 2006), or skilled people from different countries decide to cooperate (Montobbio and Sterzi, 2011 and 2013). In this chapter we consider two main channels of knowledge flows. The first one regards knowledge that is codified and published. We measure this type of knowledge flow using patent citations.[xiv] Patent citations measure flows of knowledge acquired by direct reading and comprehension of written and available documents. The second one is knowledge flows through interpersonal and social links. In order to measure this type of flow we use technological collaborations and, in particular, co-signed international patents. These can be seen as a diffusion mechanism of non-codified knowledge (e.g. technical know-how, non-standardized production procedures etc.). In fact diffusion of non-codified knowledge requires, at least periodically, face-to-face interactions and it is likely to have a great impact on technological learning and transfer.

If technological knowledge created abroad is a public good, processes of learning are costless and foreign R&D has a positive effect on the innovative activity of the LACs without any consideration on the level of LACs' effort in using and appropriating it. However, if knowledge has not the characteristics of public good (and it is at least partly excludable), it requires some efforts in order to be appropriated. In order to appropriate the knowledge created abroad a firm has to dedicate time (money and resources) to capture it. Signals of this effort can be found using international patent citations and patent collaborations. Considering two firms *i* and *j* from different countries, if firm *i* cites firm *j*, firm *i* has devoted some effort in order to use knowledge from firm *j* that, on the one side has codified the knowledge into the patent, but, on the other side, has not made any specific effort to transfer knowledge to firm *i*. We call this phenomenon *knowledge spillovers*[xv] *captured by the patent citations*. On the other side, whenever inventors from firm *i* collaborate with inventors from firm *j*, both firms dedicate some resources to exchange knowledge. We refer to this phenomenon as *knowledge flows captured by the cooperation between inventors*.

In sum we disentangle the flows of knowledge in (1) *knowledge spillover* when the knowledge produced becomes freely available, (2) *knowledge spillovers captured by the patent citations* when the knowledge is freely available but requires some efforts and absorptive capacity in order to be used and appropriated, and (3) *knowledge spillovers* *captured by technological collaboration between inventors*. In this case knowledge is transferred through interpersonal links and possibly face to face contacts. In this case some effort to exchange and communicate knowledge is required of inventors from both host and recipient countries' firms.

In this section we underline the impact on the LACs' innovative performance of international knowledge flows from foreign R&D and analyse the determinants of the innovative activity in five LACs (Argentina, Brazil, Chile, Colombia and Mexico) at sectoral level[xvi] in the period 1988–2003, following the methodology used in Montobbio and Sterzi (2011). From the econometric point of view, we consider the first type of knowledge flows simply by considering the sum of R&D performed abroad. We consider the five more advanced economies (US, Japan, France, Germany and UK), and we build the first variable (*Spillover*) simply adding the five national R&D stocks[xvii] (in logarithm) performed at sectoral level. Under this assumption $1 in R&D will have a direct impact on the knowledge production in other countries. We call this variable:

<equation>

$$Spillover = foreignR\&D\_tot_{h,j,t} = \sum_{f} \ln R\&D_{f,j,t}$$

(9.2)</equation>

In addition, we have shown that the USPTO activity of Latin American countries is tightly linked to the activity of US companies and universities. Therefore, R&D expenditures in the United States are particularly important in terms of spillovers generated to Latin American countries. Thus, in our regressions we also control for this aspect considering only the *US_Spillover.*

The second spillover effect is captured by patent citations. The greater the number of citations a country receives the greater is the knowledge that is transferred to the citing country. So we use USPTO citations to build a set of matrices that map citations from the five LACs to the G5 countries we consider. We build these matrices for each sector and for each year. The citation-spillover is therefore calculated as follows:

<equation>

$$Citation\_Spillover = foreignR\&D\_cit_{h,j,t} = \sum_{f} cit_{h,f,j,t} \ln R\&D_{f,j,t}$$

(9.3)</equation>

Citation_Spillover is the weighted sum of R&D performed in the G5 economies and the $cit_{h,f,j,t}$ is the ratio of the number of citations flowing from country *h* to country *f* in sector *j* at time *t* over the total number of citations flowing from country *h* to all the G-5 countries in sector *j* at time *t*.

Finally the third channel of knowledge transmission is related to interpersonal links and possibly face-to-face contacts. We again use USPTO patent data to build up a second set of matrices. In this case, each cell *(h,f)* of the matrix is the number of patents with at least one inventor resident in country *h* and one inventor resident in country *f*. The co-inventors spillover is then calculated as follows:

</equation>

$$Coinventors\_Spillover = foreignR\&D\_coinv_{h,j,t} = \sum_{f} coinv_{h,f,j,t} \ln R\&D_{f,j,t}$$

(9.4)

which is the weighted sum of R&D performed in the G5 economies and the $coinv_{h,f,j,t}$, as the ratio of the number of patents with co-inventors in country *h* and country *f* in sector *j* at time *t* over the total number of patents with inventors in country *h* and all the G-5 industrialized countries in sector *j* at time *t*.

We expect that the international knowledge spillovers have a positive effect beyond the role of domestic economic activity on the innovative performance in the LACs. We estimate a knowledge production function which allows for spillover effects. Hence, we propose to estimate the following logarithmic specification:

<equation>

$$\ln P_{h,i,t} = \alpha_1 \ln X_{h,i,t} + \beta_1 Spillover + \beta_2 Citations\_Spillover + \beta_3 Coinventors\_Spillover + \theta_t + \varsigma_{h,i,t}$$

(9.5)</equation>

where the dependent variable is the log of the number of USPTO patents in county *h* (*h*=1,..5), sector *i*(*i*=1,..5), and time *t* (t=1,...16, for the period 1988–2003).[xviii] The *X* variable is the valued added at constant prices which captures the domestic effort.[xix]

In Table 9.13 we present our baseline econometric results based upon simple OLS estimators.[xx] Fixed effects are included in the regression for each country-sector pair. In the first column we simply consider the domestic economic activity (Value Added) and the *Spillover* variable as determinants of the domestic innovative activity. The *Value Added* has a positive effect although not significant, perhaps because of the low level of R&D effort relative to the GDP. The (pure) international spillover variable, which is the total foreign R&D stock (i.e. USA, Japan, Germany, UK, and France), has a positive and significant effect: an increase of 1% in total foreign R&D stock increases the innovative activity by 0.095% in terms of international patenting of the 5 LACs.

<insert(Table 9.13. Estimation results of Equation 9.5. Dependent variable: log of the number of patents)>

In column 2 we find evidence of the importance of US knowledge spillovers in Latin America: the estimated elasticity of *US Spillover* is more than 0.3%. In column 3 and 4 we add to the *US Spillover* the other spillovers variables. The size of the elasticity in this case is particularly high. However since the *US_Spillover* variable is non stationary the estimation of this coefficient may not be precise. Column 4 shows that part of the knowledge flows is linked both to patent citations and pattern of co-inventorship. The estimated elasticities are 0.032 and 0.027 respectively. If we look at Column 5 we find that part of the positive effect of *Spillovers* is explained by *Citations_Spillover* and *Coinventors_Spillover.* This confirms our hypothesis that international knowledge spillovers which are embedded in codified documents – such as patents – and in interpersonal links and contacts – such as cross-country collaborative efforts on specific innovations – play an important role in determining LACs' international patenting activities.

<a>4.<em>CONCLUSIONS

In this chapter we have analysed the international patenting activity of Latin American countries. We show that international patenting in Latin America is growing but is not a pervasive and diffused activity. Not only is the Latin American share of world patents extremely low, but Latin American countries tend to be specialized in low tech sectors. Moreover the more important actors involved in Latin American patenting are mainly US and German companies with a foreign address or their foreign subsidiaries with a Latin American address, while the domestic firms are mainly concentrated in the Oil sectors. The dominance of foreign companies and foreign collaborations goes together with a big share of patenting by individuals, possibly as the result of occasional activities.

The weak role played by domestic companies in patenting activity implies that policy intervention should be designed to reinforce the local knowledge base. A way to do that is to try to facilitate the transfer of knowledge from foreign companies to the local firms and to increase the internationalization of inventors' activity and their international mobility. For this reason in Section 3 of the chapter we focused on international knowledge spillovers. In particular we focused on three channels of R&D spillovers – foreign R&D, patent citations-related spillovers and face-to-face contact spillovers based on co-inventorship relations – following the idea that the knowledge is a (quasi) public good and hence, once it is generated, it creates externalities which spill over the national boundaries.

In the empirical analysis we use data at sector level from five LACs (Argentina, Brazil, Chile, Colombia and Mexico) and the G-5 countries (France, Germany, Japan, UK and USA) in the years 1988–2003. We find clear evidence of a positive effect of R&D performed in the industrialized countries – especially the United States – on Latin American patenting activity. Moreover we find also that bilateral patent citations and face-to-face relationships between inventors are both important additional mechanisms of knowledge transmission.

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Table 9.1<em>Macroeconomic and patent data for Latin American and Asian countries

	Avg. Annual GDP % Growth (2000–07)	R&D intensity (2007) (%)	USPTO Patents per capita (2000–07, millions of inhabitants)
Argentina	4.7	0.5	9.1
Brazil	3.3	1.0	4.2
Chile	4,5	0.7	6.8
Mexico	2.6	0.5	5.6
Korea	4.7	3.5	733.2
Malaysia	5.1	0.64	24.3
China	10.2	1.5	2.3
India	7.8	0.8	2.3

Sources: WDR 2009 – WB; UNESCO Science and Technology facts sheet – our own elaboration, Population data: CIA (2009).

Table 9.2<em>Patents at the USPTO by inventor's country

	ARG	BRA	CHL	COL	CUB	MEX	URY	VEN	Total
1980–84	87	141	13	29	3	213	2	62	550
1985–89	93	226	25	23	4	217	8	110	706
1990–94	169	361	43	43	13	266	9	157	1061
1995–99	259	572	85	45	20	506	14	182	1683
2000––04	274	563	55	46	26	470	8	129	1571
Total	882	1863	221	186	66	1672	41	640	5571

Source: USPTO-CESPRI and USPTO (2007) for the period 2000–04; when the patent is a co-invention by inventors from different countries it is counted more than once.

Table 9.3<em>Patents at the EPO by inventor’s country

	AR	BR	CL	CO	CU	MX	UY	VE	Total
1980–84	37	106	7	19	0	37	2	10	218
1985–89	44	134	13	8	2	61	4	21	287
1990–94	91	251	21	19	29	93	2	32	538
1995–99	191	504	44	27	30	222	13	72	1103
2000–04	205	650	64	37	60	244	23	35	1318
Total	568	1645	149	110	121	657	44	170	3464

Source: EP-CESPRI database. When the patent is a co-invention by inventors from different countries it is counted more than once.

Table 9.4<em>Patents at the EPO by applicant's country

	AR	BR	CL	CO	CU	MX	UY	VE	Total
1980–84	17	65	6	12	0	16	2	7	125
1985–89	28	69	7	2	2	28	3	13	152
1990–94	61	157	8	8	28	48	8	13	331
1995–99	122	312	28	16	28	106	9	37	658
2000–03	126	546	48	25	63	137	19	31	995
Total	354	1149	97	63	121	335	41	101	2261

Source: EP-CESPRI database. When the patent is a co-applied by applicants from different countries it is counted more than once.

Table 9.5<em>Patents per million labour force (labour force refers to 1989 and 1999)

	USPTO		EPO	
	1980–89	1990–99	1980–89	1990–99
Argentina	15.00	29.99	6.75	19.76
Brazil	5.76	65.37	3.77	9.71
Chile	7.82	21.00	4.12	10.67
Colombia	3.89	4.93	2.02	2.58
Cuba	1.50	6.00	0.43	10.73
Mexico	14.45	19.60	3.29	8.00
Uruguay	7.51	15.52	4.50	10.12
Venezuela	24.11	35.07	4.35	10.76

Sources: EPO-CESPRI (1978-2001), USPTO-CESPRI, World-Bank.

Table 9.6<em>Top 21 applicants at the EPO (1978–2001) and number of patents

Company	Country[a]	# of patents
Unilever	NL and GB	79
Empresa Brasileira De Compressores S/A – Embraco [+]	*BR*	*69*
Petroleo Brasileiro S.A. – Petrobras	*BR*	*69*
Intevep	*VE*	*48*
Bayer[*]	DE	39
Procter & Gamble	US	37
Centro De Ingenieria Genetica Y Biotecnologia	*CU*	*32*
Johnson & Johnson [**]	*BR and US*	*27*
Voith [***]	DE	23
Hylsa	*MX*	*21*
Praxair Technology	US	21
BASF	DE	20
Multibras S.A. Eletrodomesticos	*BR*	*16*
Metagal Industria E Comercio	*BR*	*15*
Centro De Inmunologia Molecular	*CU*	*14*
Robert Bosch	DE	14

Hoechst	DE	13
Delphi Technologies	US	12
General Electric	US	12
Syntex	US	10
Servicios Condumex	*MX*	*10*

Notes:
Italics = applicant with Latin American address.
[a] This is the address of the applicant.
[*] Includes also Bayer Cropscience.

[**] Includes Johnson & Johnson Industria E Comercio (BR), Johnson & Johnson Consumer Products (US), Johnson & Johnson Industrial (BR).

[***] Includes Voith Paper Patent and Voith Sulzer Papiermaschinen.

[+] Owned by Whirlpool S.A.

Source: EPO-CESPRI (1978-2001).

Table 9.7<em>Top 23 applicants at the USPTO (1978–2001) and number of patents

Company	# of patents
Intevep	243
Petroleo Brasileiro S.A. Petrobras	157
Empresa Brazileira De Compressores S/A Embraco	70
Hylsa	66
Carrier	51
Hewlett-Packard	41
Bayer Aktiengesellschaft	37
Delphi Technologies	37
Syntex U.S.A	34
Vitro Tec Fideicomiso	33
Metal Leve	30
Procter & Gamble	30
Metagal Industria E Comercio	30
International Business Machines	24
Praxair Technology	19
General Electric	18
Centro De Investigacion Y De Estudios Avanzados Del Instituto Politecnico Nacion	17

Cardiothoracic Systems	17
Colgate-Palmolive	15
Industrias Romi	15
T & R Chemicals	15
Vidrio Plano De Mexico	15
Servicios Condumex	15

Source: USPTO-CESPRI.

Table 9.8<em>Latin American patents at the USPTO vis à vis other geographical areas (by inventor's country)

	LAC[a]	East Europe[b]	Australia and New Zeland	Four Tigers[c]	China	India	Malaysia and Thailand	US	Japan
1980–84	550	1202	1771	758	21	82	23	183 915	54 373
1985–89	703	1009	2 462	2 774	249	162	42	218 059	88 707
1990–94	1 058	659	2 828	7 766	360	260	118	297 211	117 760
1995–99	1 673	971	4 828	21 617	789	830	383	434 567	161 186
2000–04*	1 581	813	5 113	45 940	1 507	1 413	494	425 300	169 457
Total	5 565	4 654	17 002	78 855	2 926	2 747	1 060	1 559 052	591 483

Notes:

When the patent is a co-invention by inventors from different countries it is counted more than once.

[a] Argentina, Brazil, Chile, Colombia, Cuba, Mexico, Uruguay, Venezuela.

[b] Latvia, Estonia, Lithuania, Byelorussia, Ukraine, Poland, Czech Republic, Hungary, Romania and Bulgaria.

[c] South Korea, Hong Kong, Singapore and Taiwan.

* *Source*: *USPTO (2007); residence in this case is determined by the residence of the first-named inventor at the time of grant. Data for the period 2000-2004 are therefore not directly comparable with data 1980-2000.

Table 9.9<em>World patent share of different geographical areas in different sectors in two sub-periods (USPTO data)

	Years	Australia & NZ	China	East Europe	Four Tigers	India	Latin America	Malaysia & Thailand	Japan	US
Chemical	85_89	0.506	0.082	0.317	0.217	0.080	0.189	0.011	20.283	51.222
Chemical	95_99	0.590	0.179	0.192	1.427	0.237	0.337	0.048	20.403	51.815
Computers & Communications	85_89	0.298	0.019	0.078	0.456	0.024	0.059	0.009	34.956	48.423
Computers & Communications	95_99	0.418	0.066	0.051	1.555	0.104	0.065	0.035	25.536	56.962
Drugs & Medical	85_89	0.713	0.092	0.718	0.199	0.092	0.268	0.009	12.211	60.136
Drugs & Medical	95_99	1.129	0.157	0.302	0.607	0.246	0.372	0.048	8.080	68.345
Electrical & Electronic	85_89	0.335	0.063	0.209	0.656	0.014	0.071	0.007	25.636	50.808
Electrical & Electronic	95_99	0.258	0.088	0.102	5.825	0.053	0.080	0.056	26.726	48.669

Mechanical	85_89	0.618	0.056	0.194	0.740	0.017	0.191	0.008	24.845	46.900
Mechanical	95_99	0.618	0.069	0.088	2.563	0.039	0.222	0.039	24.475	49.394
Others	85_89	0.956	0.048	0.149	1.313	0.032	0.223	0.015	12.509	60.584
Others	95_99	0.926	0.081	0.089	3.705	0.022	0.314	0.070	12.171	62.031

Source: Own elaboration on USPTO-CESPRI.

Table 9.10<em>World patent shares for the selected Latin American countries in different sectors in two sub-periods (USPTO data)

	Years	AR	BR	CL	CO	CU	MX	VE	UY
Chemical	85_89	0.0133	0.0485	0.0061	0.0121	0.0012	0.0485	0.0606	0.0000
Chemical	95_99	0.0239	0.1194	0.0264	0.0085	0.0043	0.0819	0.0742	0.0009
Computers & Communications	85_89	0.0118	0.0165	0.0000	0.0024	0.0024	0.0047	0.0213	0.0000
Computers & Communications	95_99	0.0100	0.0232	0.0031	0.0025	0.0000	0.0245	0.0019	0.0000
Drugs & Medical	85_89	0.0404	0.0606	0.0115	0.0173	0.0058	0.1039	0.0202	0.0115
Drugs & Medical	95_99	0.1115	0.0886	0.0164	0.0186	0.0164	0.0995	0.0175	0.0087
Electrical & Electronic	85_89	0.0098	0.0335	0.0000	0.0014	0.0000	0.0167	0.0098	0.0000
Electrical & Electronic	95_99	0.0102	0.0300	0.0014	0.0020	0.0000	0.0273	0.0075	0.0020
Mechanical	85	0.0148	0.0752	0.0127	0.0032	0.0000	0.0699	0.0127	0.0021

	_89								
Mechanical	95_99	0.0200	0.0750	0.0114	0.0021	0.0000	0.0885	0.0243	0.0014
Others	85_89	0.0474	0.0710	0.0045	0.0023	0.0000	0.0688	0.0282	0.0023
Others	95_99	0.0543	0.1280	0.0124	0.0062	0.0000	0.0900	0.0241	0.0000

Source: Own elaboration on USPTO-CESPRI.

Table 9.11<em>Revealed technological advantages of different geographical areas in different sectors in two sub-periods (USPTO data)

	Years	Australia_NZ	China	East_Europe	Four_Tigers	India	Latin_America	Malaysia_Thai	JP	US
Chemical	85_89	−0.08	0.16	0.13	−0.51	0.34	0.05	0.04	−0.03	−0.01
Chemical	95_99	−0.02	0.28	0.22	−0.32	0.38	0.22	−0.01	0.00	−0.03
Computers & Communications	85_89	−0.33	−0.52	−0.52	−0.19	−0.25	−0.48	−0.04	0.24	−0.04
Computers & Communications	95_99	−0.19	−0.21	−0.41	−0.28	−0.01	−0.53	−0.16	0.11	0.01
Drugs & Medical	85_89	0.09	0.21	0.49	−0.54	0.41	0.23	−0.08	−0.27	0.07
Drugs & Medical	95_99	0.29	0.22	0.42	−0.64	0.40	0.27	−0.01	−0.44	0.10
Electrical & Electronic	85_89	−0.28	0.02	−0.08	−0.01	−0.47	−0.41	−0.18	0.09	−0.02
Electrical & Electronic	95_99	−0.41	−0.07	−0.10	0.36	−0.33	−0.45	0.07	0.13	−0.07
Mechanical	85_89	0.02	−0.03	−0.11	0.05	−0.40	0.06	−0.09	0.07	−0.06
Mechanical	95_9	0.00	−0.19	−0.17	−0.04	−0.46	0.02	−0.11	0.09	−0.06

	9									
Others	85_89	0.23	−0.11	−0.24	0.32	−0.11	0.14	0.18	−0.26	0.07
Others	95_99	0.20	−0.11	−0.16	0.15	−0.66	0.19	0.18	−0.26	0.06
Standard deviation 85_89 (a)		*0.22*	*0.26*	*0.34*	*0.34*	*0.37*	*0.30*	*0.13*	*0.21*	*0.05*
Standard deviation 95_99 (b)		*0.26*	*0.21*	*0.30*	*0.36*	*0.44*	*0.36*	*0.12*	*0.23*	*0.07*
(b)/(a)		*1.18*	*0.80*	*0.88*	*1.06*	*1.19*	*1.19*	*0.97*	*1.13*	*1.24*

Source: Own elaboration on USPTO-CESPRI.

Table 9.12<em>Revealed technological advantages of selected Latin American countries in different sectors in two sub-periods (USPTO data)

	Years	AR	BR	CL	CO	CU	MX	VE	UY	St. Dev.	95_99/ 85_89
Chemical	85_89	−0.25	−0.06	0.00	0.37	0.11	−0.04	0.39	0.00	0.22	
Chemical	95_99	−0.16	0.24	0.42	0.20	0.25	0.12	0.52	−0.35	0.29	1.31
Computers & Communications	85_89	−0.31	−0.53	0.00	−0.40	0.42	−0.83	−0.11	0.00	0.38	
Computers & Communications	95_99	−0.53	−0.52	−0.55	−0.39	0.00	−0.45	−0.85	0.00	0.29	0.75
Drugs & Medical	85_89	0.29	0.05	0.31	0.51	0.71	0.33	−0.14	0.71	0.30	
Drugs & Medical	95_99	0.54	0.10	0.20	0.53	0.73	0.21	−0.14	0.66	0.31	1.03
Electrical & Electronic	85_89	−0.39	−0.24	0.00	−0.60	0.00	−0.52	−0.46	0.00	0.25	
Electrical & Electronic	95_99	−0.53	−0.42	−0.78	−0.47	0.00	−0.41	−0.51	0.07	0.28	1.12
Mechanical	85_89	−0.20	0.16	0.36	−0.27	0.00	0.14	−0.35	0.05	0.24	
Mechanical	95_99	−0.25	0.01	0.03	−0.46	0.00	0.16	0.02	−0.11	0.19	0.80
Others	85_89	0.36	0.13	−0.14	−0.42	0.00	0.14	0.03	0.08	0.23	
Others	95_99	0.24	0.27	0.07	0.04	0.00	0.16	0.02	0.00	0.11	0.49
St.dev. (a)	*85_89*	*0.32*	*0.27*	*0.20*	*0.46*	*0.30*	*0.45*	*0.30*	*0.28*		

St.dev. (b)	*95_99*	*0.43*	*0.34*	*0.46*	*0.41*	*0.30*	*0.31*	*0.48*	*0.34*
(b)/(a)		*1.33*	*1.27*	*2.31*	*0.89*	*1.00*	*0.68*	*1.58*	*1.19*

Source: Own elaboration on USPTO-CESPRI.

Table 9.13<em>Estimation results of equation (9.5). Dependent variable: log of the number of patents

	(1) OLS-FE	(2) OLS-FE	(3) OLS-FE	(4) OLS-FE	(5) OLS-FE
Spillovers	0.095***				0.081***
	(0.018)				(0.017)
US Spillovers		0.301***	0.289***	0.246***	
		(0.065)	(0.064)	(0.065)	
Citations_Spillover			0.034***	0.032***	0.032***
			(0.009)	(0.008)	(0.008)
Coinventors_Spillovers				0.027***	0.027***
				(0.005)	(0.005)
Value added	0.191	0.251	0.286**	0.263*	0.213
	(0.150)	(0.146)	(0.145)	(0.145)	(0.143)
Constant	−4.99***	−3.83**	−4.60***	−4.05**	−4.66***
	(1.45)	(1.46)	(1.55)	(1.59)	(1.40)
Observations	400	400	400	400	400
Number of i	25	25	25	25	25
Year dummies	Yes	Yes	Yes	Yes	Yes
R-squared (total)	0.8990	0.8971	0.9014	0.9086	0.9103
R-squared (within)	0.5062	0.4967	0.5177	0.5529	0.5612

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 All variables are in logarithms. R&D depreciation rate 12%. We set zeroes equal to one and allow the corresponding observations to have a separate intercept (zero dummy).

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[i] The first part of this chapter is based on a report "Patenting Activity in Latin American and Caribbean Countries" (Montobbio, 2008). The report was drafted for the research project "Study on Intellectual Property Management in Open Economies: A Strategic Vision for Latin America" sponsored by the World Intellectual Property Organization (WIPO) and Economic Commission for Latin America and the Caribbean (ECLAC). We would like to thank Esteban Burrone, Mario Cimoli, Andrès Lopez, Bronwyn Hall and Annalisa Primi for their suggestions and Gianluca Tarasconi for data assistance. The second part of this chapter summarizes some of the results of Montobbio and Sterzi (2011).

[ii] The following characteristics of patents are particularly relevant. Firstly, patents are dated with the priority date which is the closest date to the year of invention. Priority dates are used for the EPO patents. For the USPTO-CESPRI database priority dates are not available and therefore the application date has been used. Secondly, the country of a patent, as explained in the following section, could refer to the address of the inventors or to the address of the applicants (or assignees). In this study we use both inventors' and applicants' addresses, as the results obtained are different and enable us to draw some interesting conclusions. It should be noted that patents include information on the stated address (and country of residence) of the inventor rather than the nationality. Thirdly, patents are classified using classification systems which facilitate the identification of the technological field. In this study, the International Patent Classification (IPC) is used for EPO patents, while the US patent classification is used for USPTO patents.

[iii] It has to be emphasized that in this chapter the use of the term "Latin American owned patent" refers to the legal address of the owner and not to the nationality of ownership of the company.

[iv] Typically, countries like the United States or the Netherlands, where many multinational companies are located, have a relatively higher patent share when country is assigned on the basis of the applicant's address. The opposite occurs in most developing countries. See also Dernis et al. (2001).

[v] In Table 9.1 the official USPTO figures have been included for the period 2002–2006 (USPTO, 2007). These observations are not directly comparable with the figures provided by the USPTO-CESPRI database and possibly underestimate the patenting activity in a given country because the origin of the patent is determined only by the residence of the first-named inventor at the time of grant.

[vi] The higher share of individually owned patents at the USPTO is due to the 'first to invent' rule. The assignee can be declared in a second stage after the registration at the patent office.

[vii] Note also that 75% of the Mexican owned patents at the Mexican Patent Office belong to individual inventors (WIPO data).

[viii] Of course if we look again at the EPO data and consider Latin American invented patents, we discover that the share of Latin American invented drops to 25.2%. Again the countries with the highest share are Argentina (46%), Chile (40.5%), Colombia (37.7%) and Uruguay (33.3%). This means that very few foreign assignees of Latin American invented patents are individual inventors.

[ix] There might be some exceptions to this interpretation. Some inventors, active abroad, might want to keep the address of their home country (e.g. some Argentinean patents are highly cited and come from the activity of a professor active at the Washington School of Medicine in St. Louis, US). Even if this inventive activity is valuable, these individual patents can hardly be related to innovation occurring in Latin America.

[x] We are comparing a whole continent with individual countries and with Malaysia and Thailand taken together. The single largest country in Latin America (Brazil) has fewer patents than China (since 1987) and India (since 1996).

[xi] If we break down the figure by Latin American countries, Cuba, Chile, Argentina and Brazil grow above the average (looking at the USPTO data). Results for Chile and Cuba are affected by the low numbers in the first sub-period. Results for the EPO data are similar with the exception of Mexico which displays a higher growth rate of patents in Europe.

[xii] See Grupp (1990), Laursen (1998) and Malerba and Montobbio (2003) for a discussion.

[xiii] We used macro sectors as provided by the re-aggregation of SIC codes by the USPTO. In particular the six sectors are: Chemicals, Drugs & Medical, Computer & Communications, Mechanicals and Others. The residual sector 'Others' is not irrelevant for our analysis because it includes a set of relatively less technological intensive sectors, for example Agriculture, Food, Amusement Devices, Apparel & Textile, Furniture, Fixtures, Heating and Pipes & Joints. However a closer look at

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'Others' shows that potentially high tech (biotech) agricultural patents are very few and do not affect substantially the count of patents in this sector.

[xiv] Many articles use patent citations to measure knowledge flows. Jaffe and Trajtenberg (2002) bring together a set of important papers from the NBER group. Trajtenberg (1990), Harhoff et al. (1999), Lanjouw and Shankermann (2004), and Hall et al. (2005) are fundamental references on patent citations and the value of innovations. Bacchiocchi and Montobbio (2010) discuss the differences between patent citations at the EPO and USPTO and the biases generated by the different examination procedures in the two offices.

[xv] For a discussion of the concept of knowledge spillovers see Los and Verspagen (2003) and Montobbio and Sterzi (2011).

[xvi] Textiles and Food, Chemicals and Pharmaceuticals, Metals, Instruments Electronic and Non-Electrical Machinery, and Transportation (see Montobbio and Sterzi 2011 for details on the concordance between the ISIC industrial sectors and IPC classification).

[xvii] The R&D stock in country f and sector i is calculated using the *perpetual inventory method* and, following the standard practice in the literature, we set the rate of depreciation δ at 0.12 (see Montobbio and Sterzi 2011 for more details).

[xviii] Note that our observational unit refers to industries (sectors) in different countries for a total of 25 different groups.

[xix] Due to the lack of data we use Value Added instead of the level of domestic R&D.

[xx] For further econometric checks and different specifications see Montobbio and Sterzi (2011) where we control for test for stationarity and estimate a dynamic panel with a lagged dependent variable.