# Migration, Technology Diffusion and Institutional Development at the Origin[†]

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**Abstract**

This chapter considers several mechanisms through which international migration can influence institutional development at the country of origin. Migration can promote institutional reform, and sound political and economic institutions are necessary to realize the potential growth and development gains from migration. We also highlight the neglected but crucial role migrants play in the worldwide diffusion of innovative ideas and technologies. The analysis reveals a positive relationship between inventor migration and international scientific collaboration, which can arise from the circulation of knowledge within diaspora knowledge networks.

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## 1. Introduction

International migration has reached an unprecedented pace and scale in recent years. As of 2010, 216 million people resided outside their country of origin compared to 156 million in 1992 (World Bank, 2011). Studies have shown that skilled workers are among the most likely classes to emigrate (Docquier & Marfouk, 2006; Docquier et al., 2007). Between 1990 and 2000, the share of high-skilled workers in the overall migrant population increased from 18.9% to 25.8%. Foreign-born workers with post-secondary education represented 34.6% of the OECD immigration population in 2000, when the share of world labour force with post-secondary education was just 11%. The destination patterns of these high-skilled migrants are quite pronounced. The countries enjoying the highest skilled immigration are the USA (hosting 50% of total OECD high skilled immigrants worldwide), Canada (13.4%) and Australia (7.5%). In some small countries (e.g., Guyana, Jamaica and Haiti), immigrants make up 80% of the skilled labour force.

As a result of these trends, international migration of innovators has taken on greater priority for many countries. At one end we find developed countries, with their promise of economic stability, opportunity and entrenched democratic institutions. These countries compete to attract talent from abroad, and accordingly, many have shifted their immigration policy to a merit-based focus, including Canada, Australia and the United Kingdom. The United States is not far behind, with the U.S. Senate passing a bill providing for talent-based immigration system in June of 2013.[i]

At the other end are the developing countries from which skilled migrants depart. For these countries, emigration is perceived as an alarming loss of human capital or

"brain drain," and a trend to be stifled through restrictive policies. However, as will be discussed below, obstructing mobility to prevent brain drain has proven ineffective. Such restrictions prevent a country from reaping gains from migration which could arise, for example, when high-skilled expatriates transfer knowledge attained abroad to their home countries. Bhagwati (2003) argues that source countries' policies should focus on organizing diaspora networks, and that this strategy is much more likely to succeed today than a retention policy. In fact, most attempts to control and manage skilled emigration by prohibition and taxation have failed (Lowell, 2001).

The literature on skilled migration has focused largely on the effects of migration on host and source countries. The pre-1990s literature was primarily concerned with the brain drain phenomenon and identified various mechanisms through which skilled emigration could be detrimental to country welfare and growth (e.g., Berry & Soligo, 1969; Bhagwati & Hamada, 1974; Miyagiwa, 1991). More recent literature considered the possible benefits to source countries from the migration of skilled workers. This strand of literature argues that skilled emigration need not harm emerging and developing economies and may even contribute to their development. Remittance transfers are the most direct way which migrants can contribute to their home country's economy (Ozden and Schiff, 2005). This literature has also examined the factors that turned source countries' brain drain into "brain gain" (e.g., Stark et al., 1997; Vidal, 1998; Kapur et al., 2005; Docquier & Rapoport, 2012; Gibson & McKenzie, 2012). These studies show that brain gain can take several forms. For instance, the mere prospect of migration provides an incentive for human capital formation among potential immigrants (Mountford, 1997; Fan and Stark, 2007; Beine et al., 2001, 2008). *Ex-post*, source countries benefit from any return turn of migrants

who have acquired skills abroad (Mayr and Peri, 2009; Dustmann et al. 2011), and even the skilled migrants who do not return communicate foreign knowledge to their home countries through migrants' diaspora networks and close-knit, ethnic scientific communities (Saxenian 1999, 2002; Saxenian, et al., 2002; Kerr, 2008; Agrawal et al., 2011; Devan and Tewari, 2001).

Diaspora networks can increase source countries' access to foreign-produced knowledge without skilled emigrants returning home. Instead, skilled emigrants speed the flow of knowledge between source and host countries. The influence of diaspora networks and return migration is particularly strong in China and India. Saxenian (1999) is one of the first studies to highlight the role of diaspora and ethnic professional networks in mutual aid, trust building and knowledge circulation. The author analyzed 11 443 high-tech start-up companies in Silicon Valley during the 1980-1998 period and found that 25 percent of these companies had ethnic Chinese and Indian immigrants as senior executives. In addition, 40% of the companies in Taiwan's science-based industrial park in Hschinchu were started and managed by migrant returnees. Saxenian's study highlights the role of international, ethnic professional networks in the repatriation of skilled. The typical role of immigrant associations in mutual aid and trust building was extended internationally to facilitate access to capital, marketing skills, and markets for Taiwanese start-ups. Saxenian (2002) and Saxenian, et al. (2002) provide evidence on Silicon Valley's ethnic networks and reports that 82% of Chinese and Indian immigrant scientists and engineers "share information about technology with colleagues in their native countries (and 28% do so on a regular basis)."

Devan and Tewari (2001) also encourage developing countries to mobilize their diaspora brain resources, leverage expatriate talent and encourage emigrants to play an active role in the economic development of their home countries. This recommendation is supported by the apparent success of China and India in taking advantage of their brain banks abroad.

Against that background, we note that today's knowledge economy is fast-paced, fiercely competitive and worldwide in reach. To succeed in this environment where so many fail, participating firms are driven to seek out the brightest minds from talent pools across the world. The location of talent defines the geography of innovation, and so determines a country's prospect for development and growth. What role do economic planners and policymakers have in this recruitment race? What can governments do to give homegrown firms a competitive edge internationally, while also serving the general interests of the domestic economy?

As discussed above, the government response is nearly always to pass immigration reforms. This response serves as a frontal assault on the problem, and definitely creates the appearance of pro-active, effective governance. However, there are other, more subtle ways to derive maximum benefits from skilled migration and contribute to the development of knowledge-based economy. Taking a lead role in the growth and strengthening of diaspora networks of expatriate talent is one such opportunity. Institutional reforms might also have a significant impact on the mobility of skilled workers and the diffusion of knowledge. Indeed, with skilled migration and innovative capacity taking on greater importance for many governments, the relationship between the two and their effect on growth has received a lot of attention from researchers and policy-makers. Given that innovators are the

producers of intellectual property, home country institutions that protect the latter have a central role to play in knowledge circulation and the maximization of brain gains from innovator migration. Home country institutions are also likely to impact these countries' success in connecting to global innovation networks, which will in turn determine their ability to catch-up with other innovative economies.

A phenomenon little explored in economic literature is the effect of international migration itself on home country institutions. The first question that arises is whether or not international migration results in the depletion of active voice that promotes better institutions in the home country. Recent studies surveyed in the next section argue that institutional norms such as democratic values may in fact be transferred to the home country. The mobility of institutional norms through migration can in turn be linked with the mobility of knowledge and technology. Under what circumstances can migration play the same role as trade introduced in Eaton and Kortum (2002) in the worldwide diffusion of technology? A primary attempt to disclose this mechanism is Naghavi and Strozzi (2011), which shows that gains from international emigration can only be realized if intellectual property rights institutions are sufficient to put the newly acquired knowledge to use in the form of patents in the source countries. Nevertheless, the interplay between international migration, home country institutions and technology diffusion remains a vast unexplored field. We hope that this chapter can serve to introduce the importance of this relationship and encourage further theoretical and empirical research to explain the facts regarding the trends and the correlations that connect its elements.

## 2. Emigration as an Engine for Institutional Development

As discussed above, the literature has traditionally focused on the economic consequences of migration for sending and receiving countries. The political impact of migration in terms of institutional development has received less attention in the literature. The quality of home country institutions can also be endogenously determined as a function of migrants shaping development. Migration can affect institutions at home in several ways. First, emigration creates "exit" and "voice" alternatives, as described in Hirschman (1970). Briefly, in this context, exit is emigration to a country with relatively better institutions, while voice is remaining at home and protesting against unproductive activities and weak institutions. Exit obviously curtails the individual exiter's lobbying at home, and the direct effect of exit on institutions is similar to that of brain drain, in that it reduces the existing voice in the country. This effect is especially strong among skilled migrants, as typically additional education is associated with greater propensity for political activity. The alternative is stay at home, organize opposition to the status quo, and seek improvements in home institutions.

When a country's emigrants are from the more educated segment of the society, emigration may generate a second indirect effect on institutional development at home. Skilled workers living abroad may acquire political influence in their host country, and gain experience with the various modern political and democratic institutions offered by developed host countries. Some of these migrants ultimately revisit their lobbying efforts there with fresh vigor, and with clear conceptions of the alternative institutions and systems for which to lobby.

So what is the net effect of migration on institutional development? Spilimbergo (2009) uses a novel empirical methodology to study the relationship between the quality of institutions in the country where emigrants study and the migrants' country of origin. The variables of interest are (i) the number of students abroad as a share of total population in the sending country (lagged five years to capture the effect of foreign education), (ii) the average level of democracy in the host country (to capture the type of political institution foreign students are exposed to) and (iii) the interaction between the two (to see whether the marginal effect of foreign education depends on the level of democracy in the host country). The paper demonstrates that foreign-trained individuals who acquire their education in democratic countries promote democratic values in their home countries. The author refers to this phenomenon as the *transfer of norms*. Two micro studies, Batista and Vicente (2011) and Mahmoud et al. (2011), support this claim for Cape Verde and Moldova respectively.

Docquier et al., (2011) introduce support for a competing hypothesis introduced in Beine et al., (2001, 2007); namely that it is incentives for education caused by migration prospects rather than transfer of norms that is responsible for institutional development in the home country. They reach this conclusion by showing that both total emigration rate and human capital have a positive and significant effect on democracy and economic freedom in the home country. Their results suggest that the impact of skilled migration is ambiguous for institutional development in the home country because skilled migration in principle increases total emigration while reducing average human capital at the same time. The explanation provided for this occurring is that the impact of emigration on home country institutions is only present when the skilled remain in their country of origin.

Follow up studies have used similar strategies to determine whether the concept of transfer of norms concept applies to other types of institutions. In the spirit of Spilimbergo (2009), Beine and Sekkat (2013) conduct a direct test of the exit versus voice argument by focusing on the quality of "market friendly" institutions, as measured by Kaufmann et al. (1998). More specifically, they construct four variables of total migration rate, skilled migration rate, the weighted average of the levels of governance quality across countries of destination based on total and skilled migration. Institutions studied in this paper are (i) voice and accountability, (ii) control of corruption, (iii) government effectiveness and (iv) regulatory quality. Three interesting findings can be deduced from the exercise carried out in this paper. First, for both types of migration the coefficients are significant and negative for voice and accountability. This suggests that the "exit" channel discussed above is present, where migration reducing active voice in the country. Second, the coefficient of the transfer of norms (the interaction) related to voice and accountability is positive and significant for both types of migration. This confirms the feedback effect of values and norms from diasporas to the natives in the original country. Third, the magnitude of the above-mentioned effects are larger under skilled relative to total migration. This completes the validation of the hypothesis that the level of education of emigrants matters—that is, foreign education training is what contributes more to an enhancement of domestic institutions.

### 2.1 Rent-Seeking

Mariani (2007) develops a theoretical framework to show how skilled migration improves institutions in the home country by limiting rent-seeking and shifting the economy towards more entrepreneurial activities. The underlying assumption in this

model is that only productive skills are mobile, therefore migration reduces the relative expected returns from rent-seeking, generating a reallocation of the remaining skilled workers from wasteful to productive activities.

We present a simplified version of the model here to present the point regarding the mechanism at play. In the model, a nation is composed of homogeneous workers who can either carry out productive activities using their human capital to earn h or choose to engage in rent-seeking. Rent-seeking here is modeled as a meeting between the two types of agents, after which the rent-seeker extorts a fraction q of the worker's income, earning a total of qh. The proportion of rent-seekers and productive workers is identified by p and 1-p, respectively. For the sake of simplicity we assume that the number of rent-seekers exceeds the number of entrepreneurs (that is, p > 1/2). This leaves an income of (1-q)h to workers after extortion takes place, whereas the rent-seekers earn qh(1-p)/p where (1-p)/p represents the probability that a rent-seeker meets and is matched with a productive worker.

Introducing migration gives workers in the productive sector a chance to migrate to a country with better institutions, where wages (and intellectual property) are better protected. This creates a lower loss of their income that occurs due to rent-seeking f<q. This gives the probability to migrate m or to stay at home 1-m. Expected earnings of production workers and rent seekers respectively turn to:

$$v_S(p,m) = [(1-m)(1-q)] + m(1-f)]h,$$

$$v_R(p,m) = \frac{(1-m)(1-p)}{p} qh.$$

It is easy to see that a positive probability of migration, *m*, raises expected income of the skilled due to higher prospective net wages and decreases that of rent-seekers because they have a lower probability of meeting a "prey". Finally, endogenizing the proportion of rent-seekers vis-à-vis productive workers, *p*, the equilibrium value can be found by equating the income of the two segments of the society. This yields $p^e(m) = \frac{(1-m)q}{1-mf}$, which is decreasing in *m*. Lower expected rents therefore discourage predatory activities in the country of origin, or in other words result in an endogenous improvement in home country institutions.

### 2.2 Expropriation

Docquier and Rapoport (2003) tackle the issue of home country institutions by dividing the society into a minority and a majority (ethnic) group and looking at the extent of expropriation by the group in power. The factor in play here is a discriminatory tax levied on the educated segment of the minority and redistributed among the majority. Migration provides a form of protection for the minority group by decreasing discriminatory policies such as biased redistribution against the latter. In their framework, the government maximizes the welfare of a privileged majority. The population in turn decides whether to invest in education to improve their productivity in the first period and whether to emigrate in the second.

Agents are given a minimal level of human capital normalized to *1*, and are heterogeneous in their learning ability, *z*. All agents earn *1* in the first period. In the second period those who forgo education continue to earn *1*, while the ones that undergo education earn 1+z. Income in each scenario can be presented as:

$$v_{00} = 1 + \frac{1}{1+r},$$

$$v_{10} = 1 - e + \frac{1+z(1-t)}{1+r},$$

$$v_{11} = 1 - e + \frac{1+z-m}{1+r},$$

where $e$ is the cost of education, $m$ is the cost of migration, $t$ is the tax rate and $r$ is the interest rate (measuring discount rate on future earnings). The first binary subscript indicates education and the second depicts migration. The setting creates a continuum of agents assorted according to their capabilities with two thresholds $z_1$ and $z_2$, which represent the indifferent agent with respect to education and migration, respectively. Agents in the minority with ability $z<z_1$ do not invest in education, those with $z_1<z<z_2$ invest in education but stay home and the highest skilled segment ($z>z_2$) also migrate.

An increase in the tax rate, $t$, increases the size of the population in the first and the third zone, whereas those in the middle who are subject to taxes gradually disappear. This captures the role of discrimination in deterring investment in education while inducing the more educated to emigrate. The gains are more tax revenue from the educated who remain at home on the intensive margin, and the losses are the shrinking size of that group in the extensive margin. The government, which optimally sets the tax rate on the educated minority (or the extent of discrimination) must assure that enough agents choose to go through education, while limiting emigration. As migration costs decrease, optimal discriminatory taxes must be reduced to compensate and encourage the educated minority to stay in their home

country. Once again, migration is shown to improve the quality of institutions by reducing discriminatory behavior by a non-democratic government in power.[ii]

### 3. International Migration and Technology Diffusion

Knowledge circulation and technology diffusion is critical for countries' growth and performance in the modern-day knowledge economy (Romer, 1990; Aghion & Howitt, 1992). This is especially true for those developing countries where domestic innovative capacity is lacking and diffusion of foreign technologies is an important source of innovation. To access foreign technologies, countries largely rely on trade in goods and services, foreign direct investment and technology licensing—the most significant channels of technology transfer. Growing evidence also suggests that cross-border movement of inventors, researchers, scientists, engineers, entrepreneurs and the like facilitate knowledge exchange and diffusion of innovative ideas. With increased mobility of high-skilled workers, international migration could become another major channel through which innovative ideas and technologies diffuse worldwide, and carry with it important implications for the world distribution of prosperity and welfare.

The link between international migration, knowledge circulation and technology adoption has yet to be firmly established. Most of our insight comes from two separate strands of the literature. The first concerns the innovation impact of high-skilled migration. Although limited, this literature points to high-skilled migration providing an important contribution to innovation in major host countries, and the potential for increased innovative capacities in sending countries. These effects are possible when migration facilitates the exchange of knowledge and ideas across

countries through return migration, diaspora networks, ethnic communities, etc. The second strand of the literature concerns knowledge creation, international technology diffusion, and productivity growth. For the purposes of this discussion, the most relevant contributions are those of Eaton & Kortum (1999), Lucas (2009) and Comin et al. (2012), which underscore the role of individuals' knowledge, human interactions and geographical distance in the technology adoption process. In what follows, we highlight the key insights provided by each strand of the literature and then briefly outline potential connections between the two.

The literature on the innovation impact of high-skilled migration is still in its infancy. What we know to this point suggests that high-skilled immigrants are making major host countries more innovative. A commonly cited fact is that high-skilled immigrants account for a large share of U.S. innovation activity. As examples, immigrants started 25% of U.S. public venture-backed companies between 1990 and 2005, most of which are concentrated in sectors with the highest innovation rates, such as high-technology manufacturing, information and life sciences (Anderson and Platzer, 2006). Immigrants also represented 26% of U.S.-based Nobel Prize winners between 1990 and 2000 (Peri, 2007). By comparison, foreign-born individuals comprised 12% of U.S. population in 2000 (Hunt and Gauthier-Louise, 2008). Among college graduates in the U.S., immigrants patent about twice as much as their native counterparts (Hunt and Gauthier-Louise, 2008). Immigrant non-U.S. citizens accounted for 24% of international patent applications filed from the U.S. in 2006 (Wadhwa et al., 2007). The trends in Canada and Europe are similar. At least 35% of all Canada Research Chairs—arguably the most efficacious research talent—are foreign born, when the share of the country's foreign-born was 20% in 2000 (Downie,

2010). A positive relationship between high-skilled immigrant and patenting activity has also been found across Canadian provinces (Partridge and Furtan, 2008) and regions in Europe (Ozgen, 2013).

There is also evidence to suggest that high-skilled migration could contribute to innovative capacities of sending countries, although the evidence is more limited. These gains can be realized as migrants who have acquired skills and innovative ideas abroad return to their home countries (Mayr & Peri, 2009; Dustmann et al. 2011). Sending countries can also gain from high-skilled migration as emigrants circulate knowledge acquired abroad back to their home countries through cross-border diaspora networks and close-knit, ethnic scientific communities. In Agrawal et al. (2011), the emigration of inventors weakens local knowledge networks but creates diaspora knowledge networks which improve remaining innovators' access to foreign knowledge. The authors find that the diaspora effect on knowledge flows—also referred to as the "brain bank" effect—is particularly strong in India and is most valuable for the highest value inventions. Kerr (2008) explores whether ethnic scientific and entrepreneurial communities in the U.S. facilitates technology transfer to foreign countries of the same ethnicity. The findings suggest that the ethnicity channel plays an important role in foreign technology transfer and is particularly strong in high-tech industries and Chinese communities. Saxenian (2005) also show that highly skilled diasporas from China and India contributed significantly to the transfer of knowledge and technology from host countries to the Chinese and Indian economies.

The underlying premise of the above literature is that cross-country exchange of knowledge is facilitated by the movement of people across international borders.

Related is the literature on knowledge creation and international technology diffusion which emphasizes the role of individuals' decisions and human interactions in the process. Insightful contributions in this area are provided by Eaton & Kortum (1999), Lucas (2009) and Comin et al. (2012), which we briefly review below.

In Eaton & Kortum (1999), countries simultaneously contribute to and benefit from each other's inventions and this interdependence in innovative activity across countries contributes to productivity growth. A central measure of the innovation-growth linkage is the rate at which technologies generated abroad are eventually adopted in a given country. Countries that are quicker to adopt foreign technologies have higher productivity ranking in the steady state.

Eaton & Kortum (1999) assume that the diffusion of new technologies across countries is governed by inventors' patenting decisions. An inventor will seek patent protection in a given country if the likelihood of the invention being used in that country is high enough that the expected value of patent protection exceeds the costs of obtaining the patent in that country. Data on international patent applications are used to quantify the direction and magnitude of international technology diffusion. These data contain information on residence of inventor and country of application, allowing researchers to trace the source and uses of innovative ideas (that is, observe where an idea originates and where it is eventually used) to measure the extent to which countries utilize ideas conceived in other countries.

Eaton & Kortum (1999) fit the model to data on productivity levels, research employment and patenting from the five countries (the United States, Japan, Germany, the United Kingdom and France) in the late 1980s. The authors find that

technology diffusion is extensive: relative to the adoption of domestically generated ideas, countries generally adopt from ½ to ¾ of ideas generated abroad. The adoption of foreign ideas contributes considerably to each country's growth. In fact, the United States is the only country in which domestic innovation is a primary driver of growth.

In Lucas (2009), it is individuals who acquire and generate knowledge and in so doing shape the knowledge of an economy. As individuals interact, each person contributes to and benefits from the ideas and knowledge of people around him. Human interactions thus facilitate knowledge exchange and so further contribute to the intellectual activity of an economy and the overall growth of knowledge.

To relate an individual's knowledge to the knowledge of an economy, Lucas (2009) builds upon the Kortum (1997) and Eaton & Kortum (1999) model in which the distribution of knowledge over individuals (that is, the technology frontier) describes the state of knowledge of an economy. Since an individual's contribution to the economy's knowledge varies over the life span of the individual (e.g., knowledge is lost when the individual dies), Lucas (2009) incorporates a cohort structure with overlapping generations into the model. The focus of the paper is on modelling a technology of knowledge creation and learning, with individual behavior taken as given. One could further develop the framework to incorporate a wide range of individual allocative decisions (e.g., occupational choice and migration) which are expected to influence knowledge circulation and technology diffusion within countries or across international borders.

Comin et al. (2012) study how technology diffuses across countries and over time and propose the theory of human interactions to account for the observed pattern of

technology diffusion. The empirical analysis utilizes Comin and Hobijn (2004, 2010) Cross-Country Historical Adoption of Technology (CHAT) data on the adoption of 20 major technologies in 161 countries over the last 140 years. The focus is on the existence of cross-country interactions in technology adoption and the role of geographical distance in the transmission of technological knowledge. The key variable is the spatial distance from other countries' technology (SDT) measure. It is constructed as the interaction between distance and technology adoption:

$$\sum_{\forall k \neq c} d_{ck} x_{kt}^{j}$$

where $d_{ck}$ is the distance between countries $c$ and $k$ and $x_{kt}^{j}$ is the adoption of technology $j$ in country $k$ at time $t$. In other words, the SDT measure is the scalar product of the vector of distances to the other countries and the vector of adoption levels in these other countries. Using this measure, the authors find negative spatial effect, suggesting that adoption of technology is slower in countries which are further away from the adoption leaders. Not surprisingly however, the effect of geography diminishes over time as technology diffuses.

The theory proffered in Comin et al. (2012) builds upon the insight of Eaton & Kortum (1999) and Lucas (2009). The underlying premise is that technology is diffused across countries through human interactions. Individuals meet randomly and as they interact, share ideas and learn from each other about newly adopted technologies. If only one of the two agents who meet has adopted the new technology, the other agent also adopts that technology. The speed and spatial scope of technology adoption depends on (i) the frequency of interactions and (ii) the probability that two agents from different locations meet. Interactions are more frequent for newer

technologies and so these technologies diffuse faster. The probability of interactions falls with distance. Individuals in close proximity interact the most, which is why a large portion of technological knowledge is localized.

Perhaps surprisingly, the two strands of literature discussed above have been pursued in isolation of one another. Bringing together these areas may prove useful in strengthening the link between international migration of high-skilled workers and cross-country knowledge circulation and technology diffusion. One could, for example, build on the insights provided by a theory of human interactions to model migration and incorporate it into Eaton & Kortum's (1999) theory of innovation and technology diffusion. Such theory would assume that adopting a technology requires new knowledge, which comes from interactions between adopters and non-adopters. Migration reduces social distance and helps overcome "man-made" barriers to cross-border interactions. In so doing, it increases the potential for interaction between agents from different countries and the international sharing of ideas. Migrant-innovators arrive in host countries with a plethora of knowhow and skills. This knowledge is supplemented with ideas and expertise acquired while abroad. Diffusion of technology could occur both in the host country where the innovator lives and works, and in the source country through diaspora networks and other means. In these ways, migration is expected to stimulate the diffusion of technology from the location of invention to the location of adoption.

Empirical migration studies have provided important, but limited insights. One obvious shortcoming is that the studies focused on only a few countries over short time periods. To a large extent, this deficiency is attributable to the lack of data on migration flows. The World Intellectual Property Organization (WIPO) has

acknowledged and addressed this concern directly, by committing to "develop[ing] an informed research agenda on intellectual property, migration, and associated knowledge flows, providing the basis for future studies on this topic" (WIPO, 2011). As part of this commitment, WIPO collected and recently released data on migrant inventors (Miguelez & Fink, 2013). The dataset has four principal advantages over its predecessors. First, it focuses on inventors—a specific class of high-skilled workers who create knowledge, as distinct from other tertiary educated workers. Second, it is derived from the residence and nationality information disclosed by inventors themselves in their patent applications, which is more precise than, for example, inferring migration history from the cultural origin of inventors' names. Third, this dataset is based on patent applications filed under the Patent Cooperation Treaty (PCT). This is important because PCT operates worldwide in nearly all countries, and implements a uniform application procedure and process—allowing for easier cross-country comparisons. Finally, the data cover many countries and years (241 countries/territories for every year from 1978 to 2012).

To gain a better understanding of the link between inventor migration and international knowledge circulation, we relate inventor emigration rates from Miguelez & Fink's (2013) data to the degree of international collaboration on PCT applications. The rate of inventor emigration is defined for each country of origin $i$ as follows: $D_i/(R_i + D_i)$, where $D_i$ is the number of country $i$'s inventors residing abroad and $R_{it}$ is the number of inventors residing in $i$ ($i$'s nationals and immigrants). This rate is calculated over the 2001-2011 period. The degree of international collaboration is calculated for the year 2011 as follows: $F_i/T_i$, where $F_i$ is the number of $i$'s inventors in foreign-owned PCT applications (submitted by foreign firms for

patenting in $i$) and $T_i$ is the number of $i$'s inventors in all PCT applications. The data for this measure are taken from Section A.6.2. of the WIPO World Intellectual Property Indicators (WIPO, 2012).

Figure 1 plots the data for 70 countries with highest number of inventors in all PCT applications.

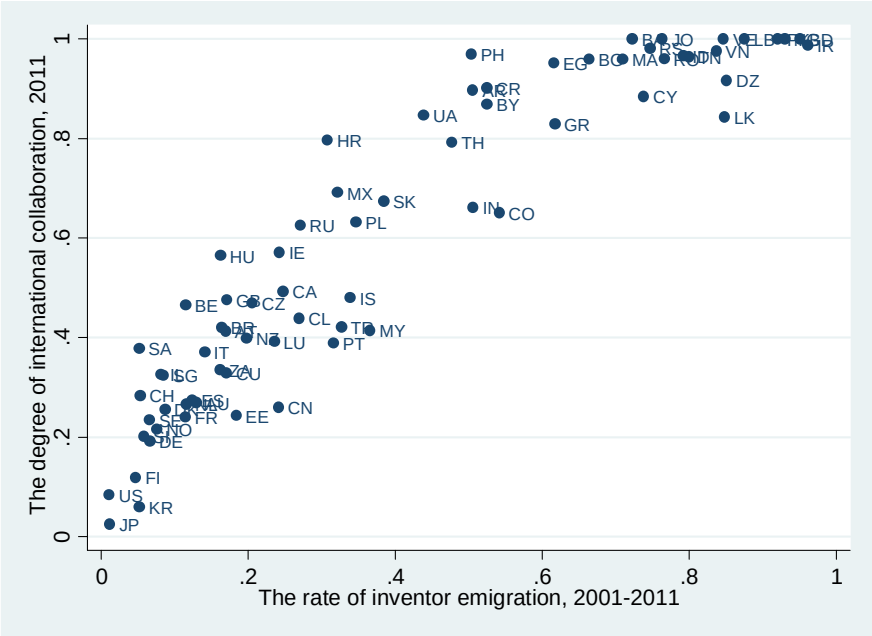


*Figure 1: Inventor collaboration and emigration by countries of inventors*

It is apparent that the two variables are positively related: cross-border collaboration on PCT applications is high in countries with high inventor emigration rates. In India, for example, the inventor emigration rate was 51% over the period of 2001-2011, with as many as 44 864 inventors residing abroad and 43 784 inventors residing in India over this period. Around 66 percent of Indian inventors (6 631 out of the total of 10 019) were included in foreign PCT applications in 2011. In China, by contrast, the rate of inventor emigration and the share of inventors in foreign-owned PCT applications were 24% and 26% respectively. A positive association between

inventor emigration rates and the degree of international collaboration could be the result of inventor migration promoting knowledge circulation and technology diffusion through diaspora knowledge networks. While further analysis is needed to reach definitive conclusions, the exhibited pattern nonetheless suggests that inventor migration facilitates international diffusion of innovative ideas and technologies.

## 4. Can Better Home Country Institutions Transform Brain Drain to Brain Gain?

Naghavi and Strozzi (2011) turn the question regarding the role of migration on the development of home country institutions around and ask whether the latter can influence the impact of migration on the home economy. As the focus of this paper is on innovation, the institution they consider is the legal infrastructure to protect intellectual property rights (IPRs). They show that although emigration out of a developing country may cause brain drain, it also generates brain gain through diaspora knowledge networks, the extent of which depends on the IPR institutions in the country of origin. In a sense they investigate the role of IPRs in the country of origin on promoting technology diffusion through migration.

Similar to the framework of Docquier and Rapoport (2003) discussed in Section 2.2, they built a model of agents with heterogeneous abilities, who decide to attain an education and migrate to a country with better wage opportunities. They however divide the economy into two sectors: production and innovation. The least skilled up to a threshold level $z_1$ work in the production sector, whereas workers with abilities above that threshold choose to put their skills to work in the innovation sector. Those with the highest skills above a higher threshold $z_2$, can also afford to pay migration

costs and emigrate. Obviously the skills that leave the economy cause an immediate brain drain on the extensive margin. However, Naghavi and Strozzi (2011) introduce a potential channel through which superior knowledge acquired abroad can flow back to the country of origin. This increases the skills of the remaining workers in the innovation sector in the intensive margin.

The protection of IPRs is presented as an increase in the probability that an inventor can exercise monopoly power in the market for his invention, and in turn, the value of skills. A higher probability of obtaining a patent also increases returns from skills, attracting workers into the innovation sector. On the lower side of skills more workers invest in education generating a shift of workers from production to innovation activities. On the higher end better enhanced returns to skills at home makes potential migrants think twice brains in the home country. New skills learned abroad and sent back by emigrants can be diffused over a larger innovation sector (the middle zone between $z_1$ and $z_2$), increasing potential gains from migration. A net brain gain is the outcome of migration if the magnitude of this skill upgrading is large enough to outweigh the direct negative effects of an outflow of skills on innovation.

The results show that diaspora networks may generate positive knowledge flows, but only to the extent that there is enough absorptive capacity in the home country. IPR protection creates the conditions for an innovation sector, in terms of either industrial development or foreign direct investment, employing workers into skilled occupations that can benefit from diasporas. They show that the strength of IPR institutions is a moderating factor to enable gains from diaspora networks. The results obtained by stronger IPRs are in line with an alternative explanation for brain gain, namely human capital incentives (Bein et al., 2001) and return migration (Mayer and

Peri, 2009). IPRs function as an intermediary channel to exploit gains from migration by encouraging investment in education and thereby human capital formation in the sending country. Better IPR protection also encourages workers who have obtained better skills to return to the innovation sector of their home country. Notwithstanding the channel in play, one can conclude that skilled migration generates technology fusion when institutional development in the home country is sufficiently evolved to allow the absorption of knowledge flows through human capital development, return migration, or intellectual diaspora networks.

The impact of emigration to OECD in the presence of IPRs on patenting activities by residents in the country of origin is empirically tested in Naghavi and Strozzi (2011) on a sample of 35 emerging and developing countries with data ranging from 1995 to 2006. The results of the paper find a direct negative and significant effect of emigration on innovation activities performed in the home economy, suggesting that the depletion of skill can initially result in brain drain. However a positive interaction between emigration and IPR protection confirm a positive correlation between emigration and innovation when IPRs are sufficiently strong.

As an example, two countries with the weakest IPR regimes were Bangladesh and Iran (with an index lower than 2 out of 5), while in the same year Hungary and Bulgaria are the two countries with the highest degree of IPR protection (with an index higher than 4.5). In the same year, China and India had an index of 4.08 and 3.76 respectively. The findings show that the emerging and developing countries that had an IPR protection index greater than 3.6 can exploit the beneficial effects of migration on innovation and experience technological progress. With data taken from 2006, this implies that an increase in the number of emigrants by 10% in China leads

to an increase in the number of patents there by 1.3%. The same increase in Iran leads to a decrease in the number of patents there by 4.6% (Naghavi and Strozzi, 2012). This reinforces the role of intellectual property rights institutions in the home country in determining whether international migration can result in brain drain or brain gain.

Interestingly, the authors also conduct an analysis in spirit of Spilimbergo (2009) to see whether the intensity of knowledge transferred back to the countries of origin depends on the level of development in the host countries. To do so, emigration is weighed according to GDP per capital in the host countries to account for differences in potential technology diffusion between country pairs according to where emigrants land. More specifically, the emigration index lies between *0* if all emigrants are in countries with the lowest potential for learning better technologies, and *1* if all emigrants go to the most advanced countries. The above results are confirmed: emigrating to countries with better potential for technology diffusion is more likely to instigate innovation in the home country when the quality of IPR institutions is adequate. The conclusion confirms the opportunity provided by emigration for emerging and developing country and suggests that the greatest benefits can best be realized under a strong and well-developed regulatory environment.

## 5. Conclusion

This chapter has aimed to reveal the interplay between international migration, home country institutions and technology diffusion. We first looked at the theoretical link between migration and home country institutions. In short, migration can effect home country institutions in many ways and it is not trivial that brain drain can result in a deterioration of home country institutions.

We saw that skilled migrants can influence the actions of the remaining population in the home country and ultimately the authorities. The emigration of politically active agents to jurisdictions with better protections naturally curtails lobbying efforts at home. However, better norms and institutions can be adopted and transferred to strengthen institutions in the home country. Emigrants can for instance engage in economic and political activities to reform institutions in their home country. The phenomenon can be thought of as a political economy process in which migrants' lobbying efforts and potential migration push domestic reforms of institutions.

We also argued that for diaspora networks to improve source countries' access to foreign-produced knowledge, it is not required that skilled emigrants return to their home countries or make direct financial contributions to their home economies. Instead skilled emigrants can speed up the flow of knowledge between source and host countries. First by living and working abroad, skilled emigrants increase access to foreign country markets and allow source countries to tap into foreign knowledge, which can then flow back to source countries as emigrants share their expertise with residents of their home countries. Migrant inventors, researchers, scientists, engineers, entrepreneurs and the like are thus not permanently lost to source countries; they have a potential to provide an invaluable contribution to knowledge and development of their home economics.

International migration also has an important role in technology diffusion, which has to a great degree been ignored in economic literature. Turning our attention away from trade and foreign direct investment and towards migration, we considered how the mobility of inventors can indeed result in the diffusion of new technologies.

Although further research remains to be conducted in this area, stylized facts clearly signal a correlation between the physical diffusion of human capital and that of intellectual property.

Finally, we refer to the work of Naghavi and Strozzi (2011) which bring all the three above-mentioned elements together to see how (exogenously) stronger home country institutions enable a country to absorb potential gains from international migration. Although South-North migration results in skill upgrading of migrants, for this knowledge to be exploited in a sending country, institutions need to be sufficiently strong. Although this work looks solely at the intellectual property rights institutions, it would be worth looking at the effect of other political and economic institutions in force. Nonetheless, this chapter once again confirms the link between our three variables of interest and begs for further research to explore the links and potential causalities between them. We also expect this survey will provide the information and motivation needed to empower policymakers, economic planners, intergovernmental organizations and non-governmental organizations in their respective efforts to manage the impacts of high skill worker migration for the benefit of all.

**References**

Aghion, P., and Howitt, P. (1992). A Model of Growth Through Creative Destruction. Econometrica, 60(2), 323-351.

Agrawal, A., Kapur, D., McHale, J. (2011) Brain drain or brain bank? the impact of skilled emigration on poor-country innovation, *Journal of Urban Economics*, 69 (1), 43-55.

Anderson, S., & Platzer, M. D. (2006). American Made: the impact of immigrant entrepreneurs and professionals on US competitiveness. National Venture Capital Association.

Batista, C. and P.C. Vicente (2011): Do migrants improve governance at home? Evidence from a voting experiment, World Bank Economic Review, 25 (1): 77-104.

Beine, M., Docquier, F., Rapoport, H. (2001) Brain Drain and Economic Growth: Theory and Evidence, *Journal of Development Economics*, 64, 275-289.

Beine, M., Docquier, F., Rapoport, H. (2008) Brain Drain and Human Capital Formation in Developing Countries: Winners and Losers, *Economic Journal*, 118, 631-652.

Beine M. and Sekkat K. (2013) Skilled Migration and the Transfer of Institutional Norms, *IZA Journal of Migration* 2: 9.

Berry, R. and Soligo, R. (1969) Some Welfare Aspects of International Migration, Journal of Political Economy 77(5), 778-94.

Bhagwati, J. and Hamada, K. (1974) The Brain Drain, International Integration of Markets for Professionals and Unemployment: A Theoretical Analysis. *Journal of Development Economics,*1(1), 19-42.

Bhagwati, J. (2003) Borders Beyond Control. *Foreign Affairs,* 82 (1), 98–104.

Comin, D., and B. Hobijn (2004). Cross-country Technology Adoption: Making the Theories Face the Facts, Journal of Monetary Economics, 51, 39–83.

Comin, D., and B. Hobijn (2010). An Exploration of Technology Diffusion, American Economic Review, 100(5), 2031–2059.

Comin, D. A., Dmitriev, M., & Rossi-Hansberg, E. (2012). The spatial diffusion of technology (No. w18534). National Bureau of Economic Research.

Devan, J., & Tewari, P. S. (2001). Speakout: when the best brains go abroad. *IEEE Spectrum*, *38*(10), 16-18.

Docquier, F. & Marfouk, A. (2006). International migration by education attainment, 1990-2000. In C. Ozden and M. Schiff (eds.), International Migration, Brain Drain and Remittances, New York: Palgrave Macmillan.

Docquier, F., Lowell, B.L., Marfouk, A. (2007) A Gendered Assessment of the Brain Drain, IZA Discussion Paper 3235.

Docquier F., Lodigiani, E., Rapoport, H., Schiff, M. (2011) Emigration and Democracy, IZA Discussion Paper 5496.

Docquier, F. and Rapoport H. (2003): Ethnic discrimination and the migration of skilled labor, Journal of Development Economics, 70, 159-72.

Docquier, F., & Rapoport, H. (2012). Globalization, brain drain, and development. Journal of Economic Literature, 50(3), 681-730.

Downie, M. (2010). Immigrants as Innovators Boosting Canada's Global Competitiveness. Conference Board of Canada.

Dustmann, C., Fadlon I., Weiss, Y. (2011) Return Migration, Human Capital Accumulation and the Brain Drain, *Journal of Development Economics*, 95 (1), 58-67.

Eaton, J. and Kortum, S. (1999). International Technology Diffusion: Theory and Measurement. *International Economic Review*, 40(3), 537-70.

Eaton J. and Kortum, S. (2002). Technology, Geography, and Trade. Econometrica, 70 (5), 1741-1779.

Fan, C. S., and Stark, O. (2007). International migration and "educated unemployment". Journal of Development Economics, 83(1), 76-87.

Gibson, J., and McKenzie, D. (2012). The Economic Consequences of 'Brain Drain' of the Best and Brightest: Microeconomic Evidence from Five Countries. The Economic Journal, 122(560), 339-375.

Hirschman A.O. (1970) Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States, Cambridge: Harvard University Press.

Hunt, J., & Gauthier-Loiselle, M. (2010). How Much Does Immigration Boost Innovation?. American Economic Journal: Macroeconomics, 31-56.

Kaufmann D., Kraay, A., Zoido-Lopaton, P. (1999) Governance matters. World Bank Policy Research Working Papers 2196.

Kapur, D. (2001) Diasporas & Technology Transfer, *Journal of Human Development* 2 (2): 265-86.

Kapur, D., McHale, J., & McHale, J. F. (2005). Give us your best and brightest: The global hunt for talent and its impact on the developing world. Brookings Inst Press.

Kerr, W.R. (2008) Ethnic Scientific Communities and International Technology Diffusion, *The Review of Economics and Statistics*, 90 (3), 518-537.

Kortum, S. (1997). Research, patenting, and technological change. Econometrica, 65, 1389–419.

Kuznetsov, Y. (2006) Diaspora Networks and the International Migration of Skills: How Countries Can Draw on Their Talent Abroad, The International Bank for Reconstruction and Development, World Bank, Washington D.C., World Bank Publications.

Lowell, L.B. (2001) Policy Responses to the International Mobility of Skilled Labour, International Migration Paper 45, International Labour Office, Geneva.

Lucas, R.E. (2009). Ideas and Growth. Economica, 76, 1-19.

Mahmoud, T. O., H. Rapoport, A. Steinmayr, and C. Trebesch (2011). Do Migrants Remit Political Change? Westward Migration and the Decay of the Communist Party in Moldova. Mimeo.

Mariani F. (2007) Migration as an Antidote to Rent-seeking, *Journal of Development Economics*, 84 (2), 609-630.

Mayr, K. and Peri, G. (2009) Return Migration as a Channel of Brain Gain, *B. E. Journal of Economic Analysis & Policy*, 9(1), Article 49.

Miguelez, E. and Fink, C. (2013) Measuring the International Mobility of Inventors: A New Database, WIPO Economics & Statistics Series Working Paper Nr. 8, WIPO.

Miyagiwa, K. (1991) Scale Economies in Education and the Brain Drain Problem, *International Economic Review* 32(3), 743-759.

Mountford, A. (1997) Can a Brain Drain be Good for Frowth in the Source Economy? *Journal of Development Economics*, 53(2), 287-303.

Naghavi, A. and Strozzi, C. (2011) Intellectual Property Rights, Migration, and Diaspora, IZA Discussion Paper 5864.

Naghavi, A. and Strozzi, C. (2012) Sparking off the Magic of Diasporas, Vox column, November 18, http://www.voxeu.org/article/sparking-magic-diasporas.

Ozden, C. and Schiff, M. (2005) International Migration, Remittances, and the Brain Drain. New York: Palgrave Macmillan.

Ozgen, C. (2013). Immigration and Innovation in European Regions. The Quarterly Journal of Economics, 128(1), 249-85.

Partridge, J., and Furtan, H. (2008). Increasing Canada's international competitiveness: is there a link between skilled immigrants and innovation. In American Agricultural Economics Association Annual Meeting, Orlando FL, July (pp. 27-29).

Peri, G. (2007). Higher education, innovation and growth. Education and Training in Europe. G. Brunello, P. Garibaldi and E. Wasmer. Oxford, Oxford University Press.

Romer, P. M. (1990). Endogenous Technological Change. Journal of Political Economy, 98, S71-S102.

Saxenian, A.L. (1999) Silicon Valley's New Immigrant Entrepreneurs. San Francisco, CA: Public Policy Institute of California.

Saxenian, A., Motoyama, Y., & Quan, X. (2002). Local and global networks of immigrant professionals in Silicon Valley. Public Policy Instit. of CA.

Saxenian, A. (2002). Silicon Valley's new immigrant high-growth entrepreneurs. Economic development quarterly, 16(1), 20-31.

Saxenian, A.L. (2004) "The Bangalore Boom: From Brain Drain to Brain Circulation?" in K. Kennistan and D. Kumar (Eds), IT Experience in India: Bridging the Digital Divide, New Delhi: Sage Publications.

Saxenian, A.L. (2005) From Brain Drain to Brain Circulation: Transnational Communities and Regional Upgrading in India and China, *Studies in Comparative International Development*, 40(2), 35-61.

Stark, O., Helmenstein, C., Prskawetz, A. (1997) A Brain Gain with a Brain Drain, *Economics Letters*, 55, 227-234.

Spilimbergo A. (2009) Foreign Education and Democracy, *American Economic Review*, 99 (1), 528-543.

Testaverde, M. (2013) Emigration, Redistribution and Political Institutions in Origin Countries, mimeo, University of Southampton.

Vidal, J. P. (1998). The effect of emigration on human capital formation. Journal of Population Economics, 11(4), 589-600.

Wadhwa, V., Saxenian, A., Rissing, B., & Gereffi, G. (2007). America's new Immigrant entrepreneurs: Part I. Duke Science, Technology & Innovation Paper, (23).

WIPO, (2011). Intellectual Property (IP) and Brain Drain. The World Intellectual Property Organization, Committee on Development and Intellectual Property (CDIP), Seventh Session, March 3.

WIPO (2012) World Intellectual Property Indicators. WIPO Economics & Statistics Series, WIPO.

The World Bank, (2011). Migration and Remittances Factbook, 2nd Edition.

[i] Senate bill S.744, entitled "Border Security, Economic Opportunity, and Immigration Modernization Act of 2013"

[ii] Testaverde (2013) takes a different approach, in which democracy is defined as a redistribution system. A rich ruling elite tries to maintain power by giving concessions to the poor, who can revolt or migrate. Migration increases wages making the level of redistribution required by the poor lower. Democracy therefore becomes relatively less costly for the elite. In addition, less numerous poor increases payoff of a successful revolution making them less willing to accept concessions. Migration therefore fosters a democratic redistribution system.