Migration, Innovation, and Growth: Lessons for Middle Income Countries

Marta Prato [*]
Bocconi University

November 28th, 2023

Abstract

What is the effect of inventors' migration on innovation and growth in middle-income countries? In this paper, I present a set of empirical facts from the existing literature on the link between inventors' migration and innovation and document novel empirical evidence that centers around the experience of middle-income countries. From this analysis, I highlight key policy lessons for middle income countries.

1 Introduction

Technological progress is one of the main drivers of economic growth. In middle income countries, this process includes the creation but also, and primarily, the adoption of technologies that increase firm productivity. At the center of this process are "knowledge workers", talented and trained individuals who are involved in the process of technological improvement in the firms. These individuals are inventors, R&D workers, entrepreneurs, engineers, and other categories of workersthat oversee the adoption of new technologies in the firms.

Knowledge workers are a key input into the innovation and growth process of an economy but are also highly mobile and responsive to changes in tax rates. The topic of migration for high- skilled knowledge workers continues to be a debated and controversial subject among academics and policymakers, given its potential for both positive and negative impacts on the economy.

On the one hand, in destination countries, migrants contribute to the talent pool and expand the innovation capacity of an economy, but they may also displace local workers. For example, a large literature has documented that foreign immigrants account for a substantial share of innovation and growth in the US in the last two centuries, fostering innovation and knowledge diffusion, although there is mixed evidence on the effects of immigration on local workers.

On the other hand, origin countries may lose home-bred talent due to a "brain drain" effect, but they could also benefit from cross-border knowledge transfers facilitated by emigrants.

To document the importance of knowledge workers' migration on economic growth and development, in Section 2 I present a set of empirical facts from recent research on the connection between

[*] Email: marta.prato@unibocconi.it; Website: www.martaprato.com.

the allocation of talent in the economy and economic growth, highlighting important takeaways for middle-income countries.

Next, in Section 3 I turn to new empirical evidence on inventors' mobility in middle income countries. While technological progress in MIC often takes the form of adoption rather thancreation of new products or processes, the scarce availability of data on technology adoption limits the empirical analysis. For this reason, I turn to data on inventors from patents.

To shed light on the role of inventors' migration in middle-income countries, I document new evidence using patent data from the World Intellectual Property Organization (WIPO) that covers a sample of 34 middle-income countries over the period 1990-2015. I document the extent of the brain drain and the magnitudes of the primary migration corridors that involve middle-income countries. I find that middle income countries experience a large outflow of inventors, or brain drain, toward high income countries.

Finally, I conclude with a summary of the main policy takeaways for middle income countries.

2 Empirical Facts on Migration, Talent Allocation and Growth

In this section, I present a host of empirical facts from a recent literature that studies knowledge workers' characteristics and performance, especially in relation to their geographic mobility and their human capital accumulation process. For every empirical fact, I discuss the main results of the associated paper and the key policy lessons.

Fact 1. *R&D workers are highly mobile and their mobility decisions respond to monetary incentives. Conditional on tax rates, R&D workers are more likely to move to innovation hubs.*

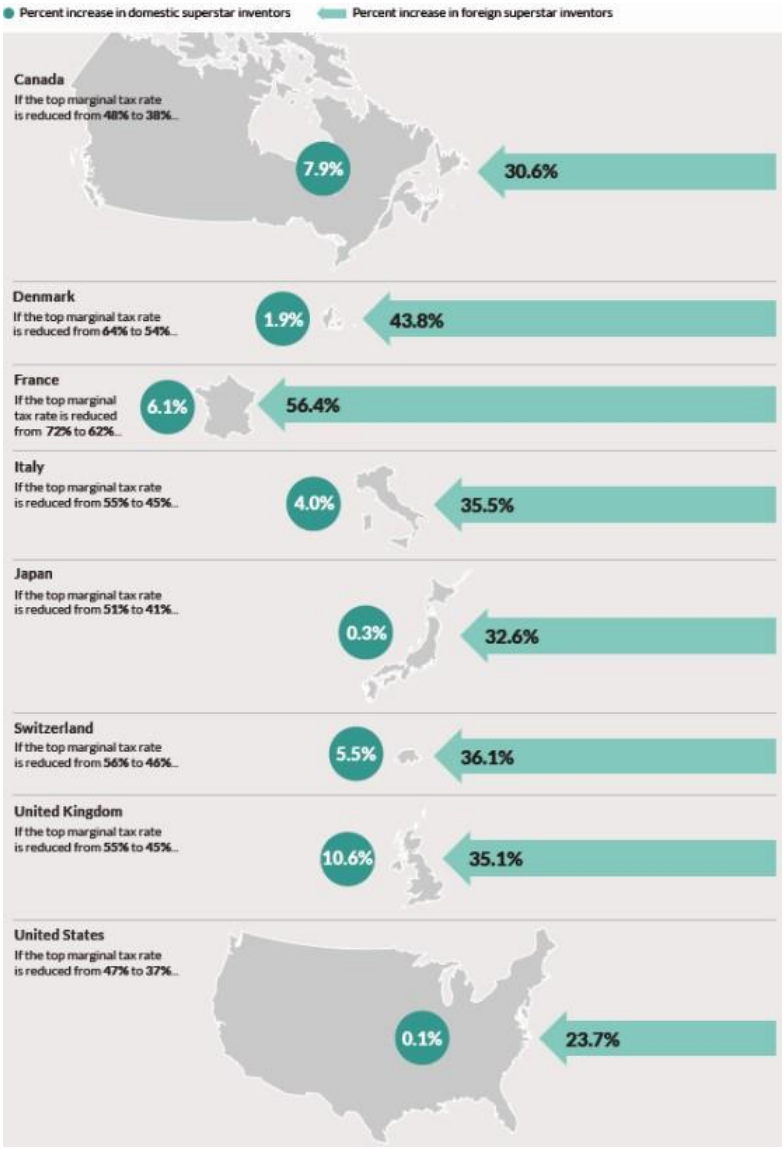
Akcigit et al. (2016) document that the location choices of the most productive inventors ("superstar inventors") are significantly affected by top tax rates. As a result, reducing tax rates leadsto an increase in the number of inventors both through the retention of domestic inventors as well as the immigration of foreign inventors. In their paper, they estimate the increase in the numberof domestic and foreign superstar inventors following a decline in the top marginal tax rate for a number of different countries, including Canada, Denmark, France, Italy, Japan, Switzerland, the United Kingdom, and the United States. The results of their estimation are summarized in Figure 1.

Key Takeaway: Monetary incentives foster the mobility of individuals and can facilitate the emergence of innovation hubs.

Fact 2. *Knowledge workers work in teams and learn from interactions with others in the economy.*

Knowledge workers, such as inventors, tend to work in teams where individuals take on differ-

Figure 1: Migration Elasticities Across Countries

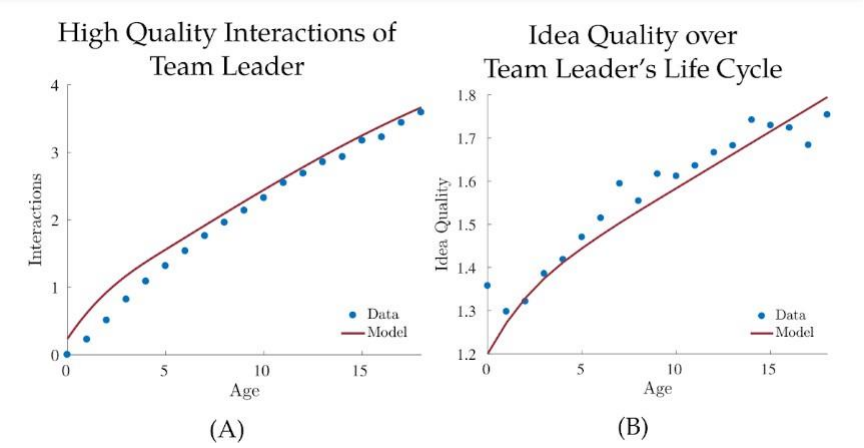


Source: Akcigit et al. (2016)

ent tasks. Typically, the most experienced person in the team is referred to as the "team leader". Akcigit et al. (2018) document the evolution of team leaders' productivity over their life-cycle. In particular, they show that inventors' productivity increases after they work and interact with other inventors who are more productive than them. This is evidence that knowledge workers learn from others around them and that these interactions help them accumulate human capital that will make them more productive in the future. This is illustrated in Figure 2, which shows that both the number of high quality interactions and the idea quality of team leaders tend to increase over their life-cycle.

Key Takeaway: Facilitating interactions boosts the productivity of knowledge workers.

Figure 2: Interactions and Idea Quality over the Life Cycle



Source: Akcigit et al. (2018). Panel (A) represents the high-quality interactions of a team leader as a function of his age (age 0 is the first year in the patent data). Panel (B) represents the de-trended idea quality as a function of team leader's age.

Fact 3. *The geographic mobility of knowledge workers is associated with an increase in the productivity of migrants as well as their collaborators in the country of origin, who benefit from the knowledge spillovers channeled by the emigrants.*

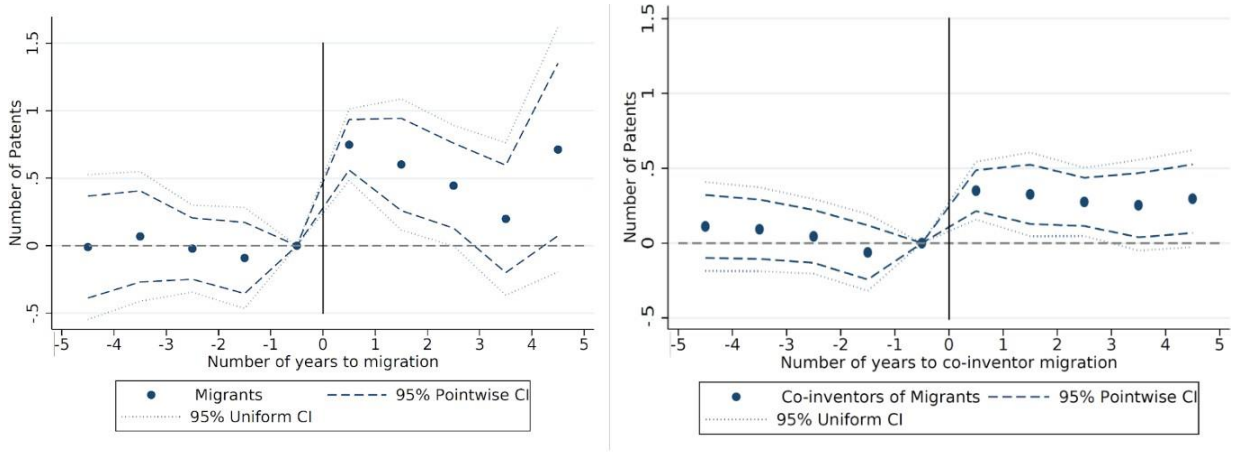
Recent studies have documented that, when inventors move abroad, they tend to increase their productivity on average. In addition, the former collaborators of these migrants in the country of origin also tend to increase their productivity after the migrant leaves, especially if they continue working together. This pattern is observed both in the patenting activity of migrant inventors along the US-EU migration corridor (Prato (2022)), illustrated in Figure 3, as well as in the publication activity of migrant academics from Turkey (Akçiğit et al. (2023)), illustrated in Figure 4.

The increase in productivity for migrants could be due to a host of reasons, such as the fact that individuals tend to move when they anticipate good opportunities in the destination country, as well as the fact that individuals may move to a location with higher factor productivity (for ex- ample, a destination country with better research labs would increase migrants' research output). However, these explanations do not apply to migrants' collaborators that remain in the country of origin. Prato (2022) argues that the increase in productivity of the migrants' local collaborators in the origin country is due to positive spillovers channeled by migrants, such as knowledge spillovers,that help locals become more productive. Thus, there are many forces associated with the mobility of knowledge workers. On the one hand, the emigration of high skilled workers, such as inventors and academics, is typically associated with a loss in human capital, sometimes referred to as a "brain drain". On the other hand, there could be benefits from mobility that partly offset this

human capital loss, such as the knowledge spillovers channeled by migrants that benefit workers in the country of origin.

Key Takeaway: Facilitating the geographic mobility of knowledge workers fosters growth through the diffusion of knowledge.

Figure 3: Patents of migrants and their collaborators in the origin country.



(a) Patents of EU-US migrants (b) Patents of co-inventors of migrants at origin

Source: Prato (2022). This figure illustrates the change in number of patent applications per years before and after migration for migrants along the EU-US corridor, in panel (a), and for their collaborators in the origin country, in panel (b).

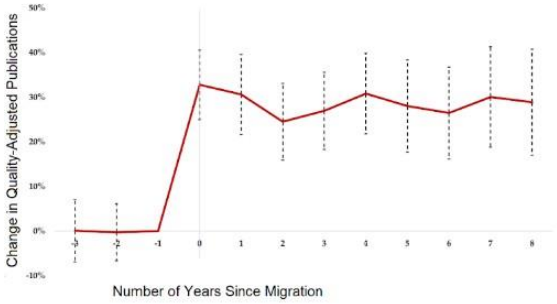
Fact 4. *The improvement and adoption of technology are the result of the joint effort of individuals who work in firms, carry out different tasks, and have different characteristics.*

While the literature on productivity growth has mostly focused on the firm side, a few recent papers have highlighted that talented individuals are at the center of the process of innovation and adoption of new technologies. Thus, the education, training, and career choice of talented individuals and their allocation in the economy are central to the process of economic growth.

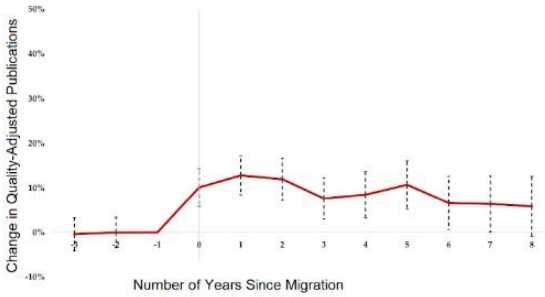
Akcigit et al. (2023) argue that there are two types of occupations that play a central role in the technological progress of firms:

- R&D workers: these individuals focus on the improvement of the firms' productivity, for example through the research, development, or adoption of better technology, products, and processes.
- Entrepreneurs: these individuals are the owners of the firm, they assemble the team, oversee the expansion of the firm, finance the improvement in technology, and commercialize the products.

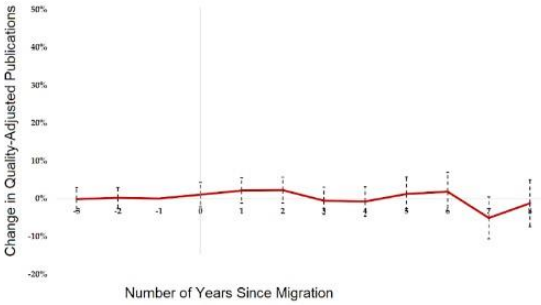
Figure 4: Publications of Turkish migrant academics and their collaborators in Turkey.



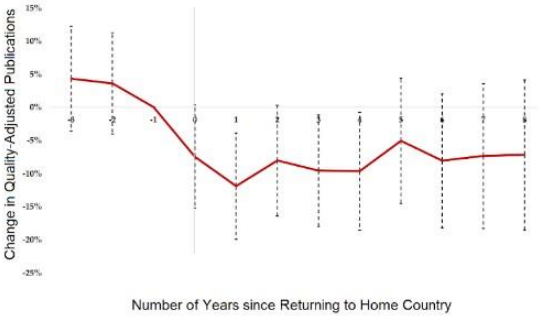
(a) Publications of Turkish migrants academics



(b) Publications of collaborators of migrants at origin if they continue working with the migrant



(c) Publications of collaborators of migrants at the origin if they stop working with the migrant



(d) Publications of migrants after returning to their origin country

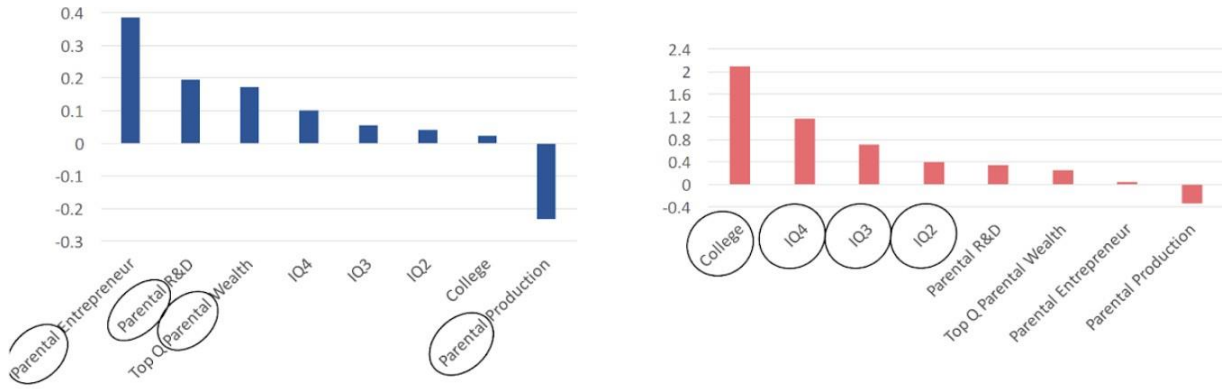
Source: Akcigit et al. (2023).

R&D workers and entrepreneurs tend to have different characteristics. R&D workers are characterized by high education and high talent, as measured, for example, by IQ (Akcigit et al. (2020)). On the other hand, individuals who become entrepreneurs do not exhibit as high education and IQ as inventors. Instead, individuals are more likely to become entrepreneurs if they have a parent whois also an entrepreneur (Akcigit et al. (2023)). Yet, when we focus on entrepreneurs who become successful in scaling their firms (for example, by reaching high growth or large size), we observe again that talent and education are predictive features of successful entrepreneurs.

These papers also document that family background, such as the income and occupations of parents, are important determinants of the educational outcome and career choice of kids. As a result, talented kids may be unable to access higher education and receive the training to contribute to technological progress if they are born into disadvantaged families. Thus, policies that facilitate or subsidize access to education can improve the allocation of talent in the economy and foster development and growth, by sorting talented kids from underprivileged backgrounds into careers where they will most contribute to technological progress.

Key Takeaway: Policies that shift the allocation of talent in the economy (such as education reforms and education subsidies) foster innovation, development, and firm growth.

Figure 5: Characteristics of Entrepreneurs and R&D Workers



(a) Entrepreneur (b) R&D Worker

Source: Akcigit et al. (2023). These figures show the coefficients from a multinomial logistic regression of the probability of being an entrepreneur, in panel (a), or an R&D worker, in panel (b), against the baseline case of beinga production worker. Each bar represents the estimated coefficient for the corresponding variable on the horizontalaxis. Data Source: Danmarks Statistik.

Fact 5. *Older workers are more likely to be displaced by new technologies, as their skills might be outdated to work with newer technologies.*

Aghion et al. (2022) find that older workers are hurt by the arrival of new technology at their firm in terms of wage returns and probability of moving out of employment. This negative effect disappears when controlling for education and, in particular, for the number of years since obtaining the last formal degree, i.e., the distance to the human capital frontier. If anything, this effect is slightly higher for non-STEM than STEM-educated co-workers. This result suggests that older workers have more difficulty adjusting their skills to new technology. As a result, retraining programs could be helpful in making the process of creative destruction and economic growth moreinclusive.

Key Takeaway: Retraining programs are useful to update the skills of workers to be compatible with newer technologies and to make growth more inclusive.

Fact 6. *There is a two-way connection between inequality and economic growth.*

On the one hand, inequality is a threat to innovation and growth because it hinders the allo-

cation of talent in the economy toward innovative activities. For example, inequality can prevent talented individuals from being able to afford higher education and contribute to innovation and growth (Akcigit, Pearce, Prato, 2020). On the other hand, innovation leads to higher social mobility, but also to higher top-income inequality (Akcigit et al., 2019).

Key Takeaway: Policies for inclusive growth should consider the two-way connection between growth and inequality.

After describing this set of results from existing research, in the next section I document some new empirical results on the migration of inventors in middle income countries.

3 Brain Drain in Middle Income Countries

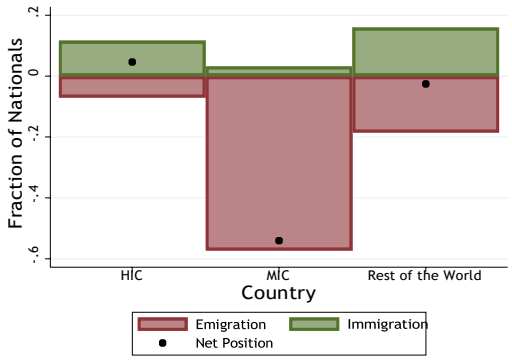
The empirical facts presented in the previous mostly focus on high income countries, due to the better availability of data for these countries. Yet, many of the lessons from Higher Income Countries (HICs) are useful for Middle Income Countries (MICs) as well. To bridge the evidence from HICs to MICs, in this section, I present new evidence on migration corridors for inventors in MICs.

I document empirical trends regarding the mobility of inventors from MIC using data from the WIPO (Miguelez and Fink (2013)) for the year 2001-2010. The dataset on migratory patternsof inventors by Miguelez and Fink (2013) is extracted from information included in patent applications filed under the Patent Cooperation Treaty (PCT). The PCT is an international treaty administered by the World Intellectual Property Organization (WIPO), which facilitates the route for seeking international patent protection. The PCT data cover about 54% of all international patent applications. Individuals can file a PCT application only if they are nationals or residents of a PCT member country. Thus, PCT applications have the unique feature of recording both the residence and nationality of inventors for most patents to verify the applicants' eligibility. A migrant is defined as someone who lives in a country other than the country of nationality. Due to records on nationality, these data offer a comprehensive measure of migration that I use to quantify aggregate migration flows.

I begin by describing the extent of "brain drain", which I define as the difference between gross emigration and gross immigration of inventors, across countries. To do this, for every country I compute the total number of immigrant inventors and emigrant inventors as a fraction of national inventors residing in the home country, obtaining the gross immigration and emigration rates respectively. I then group countries into three categories, HICs, MICs, and the Rest of the World, and compute the average mobility rates across countries within each category. The results are presented in Figure 6.

Figure 6 presents two main patterns. First, the gross mobility rates are larger than the net mobility rates for all groups of countries. Second, the net mobility rates are remarkably different across different groups. For HICs, the immigration rate is larger than the emigration rate, resulting

Figure 6: Inventors' Brain Drain: Middle vs. High Income Countries, 2001-2010



Note: The figure displays immigration, emigration, and net position of inventors for High Income Countries, Middle Income Countries, and the Rest of the World between 2001 and 2010. The green bars denote the inflow of foreign immigrant inventors as a fraction of the number of national inventors residing in the home country. The red bars denote the outflow of national emigrant inventors as a fraction of the number of national inventors residing in the home country. The black dot indicates the net position, which is the difference between the immigration rate and the emigration rate. Data Source: WIPO.

in a positive net position. This is sometimes referred to as a "brain gain": on average, HICs tend to attract inventors from other countries in the world, resulting in a gain in human capital. The opposite is true for MICs, that have a much higher emigration than immigration rate. The result is a negative position of -0.6, which means that about 60% of the inventors from MIC leave somewhere else in the world, generating a large human capital loss for MICs.

Table 1 reports the largest migration corridors for MICs, describing the average number of migrants per year by country of origin and destination for the 30 largest corridors. All top 30 migration corridors from MICs have a destination in a HIC. In particular, the main destinations are the US, Japan, Singapore, Germany, and the UK. The US emerges as the most popular destination. The two largest corridors are between (i) China and the US and (ii) India and the US. Together these two corridors account for over 8,000 inventors moving from MICs to the US on average per year.

Given the large brain drain from MICs to HICs, further research should explore the potential benefits associated with inventors' mobility. As mentioned in the previous section, one source of potential benefits is given by knowledge spillovers channeled by emigrants. In addition, a large literature has documented that emigrants are an important source of remittances, which can help the process of development in the origin country.

4 Conclusion

In this paper, I presented a set of empirical facts from recent research on the importance of talent allocation and geographic mobility for economic growth.

The facts focus on R&D workers, who are central to the process of growth and development.

Table 1: Largest Migration Corridors from Middle Income Countries, 2001-2010

Origin	Destination	Average Migrants per Year
China	United States of America	4445
India	United States of America	3562
Korea	United States of America	727
Russian Federation	United States of America	434
China	Japan	251
China	Singapore	192
Turkey	United States of America	192
Iran	United States of America	144
Russian Federation	Germany	121
Mexico	United States of America	116
Brazil	United States of America	112
Malaysia	Singapore	109
Korea	Japan	108
Ukraine	United States of America	98
China	United Kingdom	92
China	Germany	89
India	Singapore	85
Argentina	United States of America	82
Serbia	United States of America	77
Malaysia	United States of America	73
South Africa	United States of America	72
Egypt	United States of America	67
China	Canada	65
Bulgaria	United States of America	63
Pakistan	United States of America	63
Turkey	Germany	60
India	United Kingdom	56
India	Germany	54
Colombia	United States of America	53
Thailand	United States of America	49

Notes: The table displays the top 30 largest migration corridors with origin in a Middle Income Country between 2001 and 2010. The third column indicates the average number of inventors per year with nationality of the Origin country and living in the Destination country. Data source: WIPO.

They are talented and educated individuals who tend to be highly mobile. These individuals also continue learning throughout their careers by working with, interacting, and learning from other inventors. As a result, when migrant inventors move abroad, they also spread knowledge and are a source of knowledge diffusion that can benefit local inventors in their origin countries.

In addition, technological progress is the result of the effort conducted by individuals in many occupations: not only R&D workers but also entrepreneurs. The education and allocation of these talented individuals in the economy are central to technological progress.

Finally, technological progress can also harm workers who do not have the right skill set to

adapt to new technologies. In addition, while growth can be conducive to higher social mobility, it may also lead to higher income inequality.

In addition to these findings from the literature, I also presented some evidence that shows that middle income countries face a large brain drain of inventors toward higher income countries. While this human capital loss constitutes a challenge, many policy interventions could help reap benefits from inventors' mobility.

The evidence presented in this paper can suggest multiple policy interventions. First, inventors' location decisions are highly responsive to monetary incentives. These incentives could induce some migrants to return to their origin countries, even for temporary periods. In addition, facilitating the interactions between migrants and locals at origin can help diffuse knowledge and improve the productivity of locals. Policies to facilitate interactions include, for example, conferences for expats in the country of origin or mentorship programs where emigrants can share their knowledge with locals at origin.

On the education side, policies such as education subsidies could help talented individuals gain the necessary skills to contribute to the process of technological development and growth. On the other hand, retraining programs are useful to update the skills of workers to be able to work with new technologies and make growth more inclusive.

In conclusion, while there are both positive and negative effects associated with the mobility of inventors in middle income countries, policy interventions can help reduce human capital loss and facilitate an efficient allocation of talent and diffusion of knowledge.

References

Philippe Aghion, Ufuk Akcigit, Ari Hyytinen, and Otto Toivanen. A Year Older, A Year Wiser (and Farther from Frontier): Invention Rents and Human Capital Depreciation. *The Review of Economics and Statistics*, 1–31, 2022.

Ufuk Akcigit, Salomé Baslandze, and Stefanie Stantcheva. Taxation and the international mobility of inventors. *American Economic Review*, 106(10):2930–2981, 2016.

Ufuk Akcigit, Santiago Caicedo, Ernest Miguelez, Stefanie Stantcheva, and Valerio Sterzi. Dancing with the Stars: Innovation Through Interactions. *NBER Working Paper No. 24466*, 2018.

Ufuk Akcigit, Jeremy Pearce, and Marta Prato. Tapping into Talent: Coupling Education and Innovation Policies for Economic Growth. *NBER Working Paper #27862*, 2020.

Ufuk Akcigit, Harun Alp, Jeremy Pearce, and Marta Prato. Career Choice of Entrepreneurs and the Rise of Smart Firms. 2023.

Ufuk Akçiğit, Çağatay Koç, Parmar Sinan, Jeremy Pearce, Z. Berkay Saygın, Younghun Shim, Nil Taşpınar, and Deniz Tokmakoğlu. Türkiye Akademik Diaspora Raporu: Beyin Göçünden Beyin Gücüne. Technical report, 2023.

Ernest Miguelez and Carsten Fink. Measuring the International Mobility of Inventors: A New Database. *WIPO Economic Research Working Paper*, (8), 2013.

Marta Prato. The Global Race for Talent: Brain Drain, Knowledge Transfer, and Growth. *SSRN Electronic Journal*, nov 2022.