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The Unequal Geographical Distribution of Innovative Activity

Implications for Income Inequality and Innovation Policies[*]

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INTRODUCTION

Innovation is at the core of economic development, growth, and structural change. This has been well demonstrated previously by scholars both theoretically and empirically (WIPO, 2015). Yet, it does not spur in nor flow to all corners of the world. Not all countries innovate at the same rate; within these, not all regions either. Not even in the most innovative countries is innovation equally distributed or seamlessly flows from national championing areas to the rest of the country.

To a great extent, such unequal innovation distribution mirrors the continuing wide differences in per capita incomes across and within different countries (Crescenzi et al., 2019). Indeed, many economists argue that differences in technology diffusion go a long way in explaining income differences (e.g., Comin and Mestieri, 2018). Worldwide rankings of innovation and income per capita are, however, not necessarily written in stone. Some Asian countries – and several regions within these – were able to achieve remarkable industrial development during the past forty years. Today these regions host companies that compete at the world's technology frontier.

How has this unequal distribution of innovation evolved across and within countries? Does innovation concentrate more than other economic activities? What are the consequences of this concentration for territorial income inequality?

[*] **Disclaimer:** The views expressed in this chapter are the authors' own and do not necessarily reflect the views of WIPO or its member states.

Acknowledgments: We are deeply grateful to Christian Chacua, Massiliano Coda-Zabetta, Francesco Lissoni, and Yin Deyun for our joint research on the topic of geography of innovation, which has contributed greatly to this chapter. We are also thankful for comments from the editors, as well as Kevin Lee and Francesco Lissoni. Ernest Miguelez acknowledges financial support from the French National Research Agency (TKC project – reference: ANR-17-CE26–0016).

Can policy actions do something about this? We aim to answer these questions using patent and publication data for more than forty years, and reviewing the relevant literature.

Understanding where most of innovation happens across and within countries is of foremost importance for innovation and intellectual property (IP) policymaking. Reviewing the successful technological trajectories and the less successful ones can be informative of the paths to follow. A natural question to ask is what role public policies can play in changing the technological trajectory of countries and regions. Given the many market failures associated with knowledge acquisition and knowledge diffusion, it is also pertinent to ponder what IP policy can do specifically.

This chapter is divided into two main sections. The first section reviews and describes empirically the uneven geographical distribution of innovation and its dynamics, at both the national and subnational levels. It also compares such distribution in relation to other indicators of economic activity. The second section examines the potential consequences of such unequal distribution, particularly for its possible influence on inter-regional income inequality, and discusses how inevitable they might be. In light of available evidence, it explores what the role of policy could be.

2.1 INNOVATION'S UNEVEN GEOGRAPHICAL DISTRIBUTION

During much of the past century, knowledge was produced mostly in a few wealthy countries, in particular the United States, Japan, and some Western European economies. What is often much less appreciated is how concentrated this phenomenon is, even within these wealthy nations.[1]

The academic literature has investigated several reasons behind such concentration. Many have to do with the virtuous cycle of national innovation systems (NIS) (Edquist, 1997) and, within these, the cycles of the local innovation ecosystems (Asheim and Gertler, 2005). Long and stable positive economic cycles explain how the best higher-education and research institutions appear and consolidate in certain regions of the world. The same applies to the private sector, where research- and technology-intensive companies flourish in such conditions. The reverse causality also applies: The liveliest NIS of today are more likely to spur innovation and consequent economic growth of tomorrow. For many reasons, these research and development (R&D) intensive companies will prefer to perform their research operations and collaborate with knowledge-intensive partners close to their headquarters (Castellacci and Archibugi, 2008; Chaminade et al., 2016; Patel and Pavitt, 1991). The two directions of causality can generate virtuous and vicious cycles, perpetuating the differences across economies.

[1] This section relies substantially on the research performed in Miguelez et al. (2019) and WIPO (2019). Please refer to them for further details.

National interactions are only part of the successful cycles, the other part being the interactions within the network of successful locations (Crescenzi et al., 2019; WIPO, 2019: ch. 1). It is often argued that the concentration of innovation production can be compensated with a spread of knowledge flows in all directions. Advocates of knowledge spillovers and knowledge as a public good would argue that knowledge diffuses from the innovation production center to the less innovative neighboring countries and regions. However, there is a known imperfect diffusion of knowledge, as information does not diffuse as freely or as fast everywhere, nor is the ability to fully exploit information flows – that is, the absorptive capacity – equally distributed around the world.[2] In this sense, the choice of knowledge connections is affected by the aforementioned virtuous cycles – that is, both economic and innovative – in each of the potential locations. The motivations for these connections can be of various nature: Multinational companies (MNCs) seek knowledge strategically (Castellani and Zanfei, 2006, 2007); supply and value chains reshape their structure globally (Bathelt et al., 2004; Dunning, 1998); decentralized interpersonal networks shine where there is professional talent (Lorenzen and Mudambi, 2013); and scientists, innovators, and entrepreneurs move where there are economic and innovation opportunities (Breschi et al., 2017; Franzoni et al., 2012; Saxenian, 2002, 2006). Chaminade et al. (2016) summarize these different interactions as global innovation networks (GINs) aiming to collectively produce and disseminate new knowledge.[3]

Undoubtedly, innovation eventually diffuses to less innovative regions and countries (Comin and Mestieri, 2018). But the rate at which innovation flows from and to a country might be very different depending on the country's position in the GINs. Successful companies in equally successful countries are also likely to increase their multinational activity overseas, but these countries may also attract other foreign companies. Indeed, it is not surprising that the majority of the MNCs have either spawned in the United States, Japan, or Western Europe or moved their headquarters there. Over the past century, these MNCs have increasingly operated in foreign countries and, lately, have increased their international R&D operations and the geographical diversity of their locations. Yet, many scholars argue that technology transfer to foreign economies – especially developing ones – is imperfect. Most of MNC's overseas R&D activities in developing economies before the turn of the

[2] In the spirit of Marshall (Ellison et al., 2010; Marshall, 1920), arguably the barriers to perfect knowledge diffusion relate to the cost of moving goods, people, and ideas that carry the knowledge in a physical, codified, or tacit manner. These costs can arise from not only economic forces but also national and international legal frameworks. Hence, the legal frameworks regulating the trade of goods and services, the mobility of workers, or the transfer of IP rights could have an impact on the rate of knowledge diffusion.

[3] The GINs framework covers several related approaches, such as Coe and Bunnell's (2003) "transnational innovation networks."

century were confined to market adaptation, with limited production of new knowledge (Gerybadze and Merk, 2014; Krishna et al., 2012).

Was this virtuous cycle unattainable for the rest of the world? The pattern over the past thirty years has shown us otherwise. The last part of the past century and the early years of the twenty-first century display several East Asian and other economies emerging as innovation hubs (Branstetter et al., 2014). Several factors explain this rise. MNCs increasingly redirect foreign investment to gain access to specialized knowledge (Amendolagine et al., 2019; Reddy, 1997). High-skilled professionals and talented entrepreneurs coming from these areas move and connect across the globe, building unprecedented international knowledge pipelines (Foley and Kerr, 2013; Saxenian, 2006; Useche et al., 2020). As a result, China, India, and some other economies have created over that period the environment not only to induce inward R&D activities by MNCs but also to spawn their own local stakeholders (Awate et al., 2012; Branstetter et al., 2014).[4] Analyzing the early technological developments of Chinese clusters, Zhou and Xin (2003) found that local firms in tech clusters benefit from collaborating with MNCs, which provides them with vital technology and organizational training, in turn vastly increasing their innovative capacity.

In the following paragraphs, we make use of patent and scientific publication data to describe empirically the patterns and trends portrayed in the innovation literature earlier. We use scientific publication data from Clarivate's Web of Science (WoS) and Science Citation Index Expanded (SCIE), and patent data from EPO's Patstat, World Intellectual Property Organization (WIPO), and other patent data sources.[5]

2.1.1 *A Slow Pattern of Knowledge Internationalization?*

For the past decades, only three economies – namely the United States, Japan, and Germany – accounted for the majority of scientific and technological (S&T) production (Figure 2.1). Within these two indicators, patents' concentration is always more geographically skewed than scientific articles. Simply adding France, Italy, Switzerland, and the United Kingdom increases the concentration of patents during the second half of the past century to roughly 90 percent.

[4] During this period, several of these economies benefited from less restrictive IP frameworks, making some scholars claim a causality. Yet, many other countries – from the same and other regions – also had equally less stringent national IP laws but did not observe the same innovation boom. We discussed elsewhere (Fink and Raffo, 2019) that "[i]n the end, similar to other hypothesized determinants of industrial development and growth, we are doubtful that there is an unambiguous effect of 'IP strength' waiting to be discovered. This is not only because of the varying role of different IP policies in different sectors, but also because IP policies interact with other elements of the broader innovation ecosystem." In Chapter 1 in this volume, Keith Maskus indicates a similar reservation about the potential causality between growth of inequality and IP rights.

[5] For more details on the sources and methodology, see Miguelez et al. (2019) and WIPO (2019: technical annex).

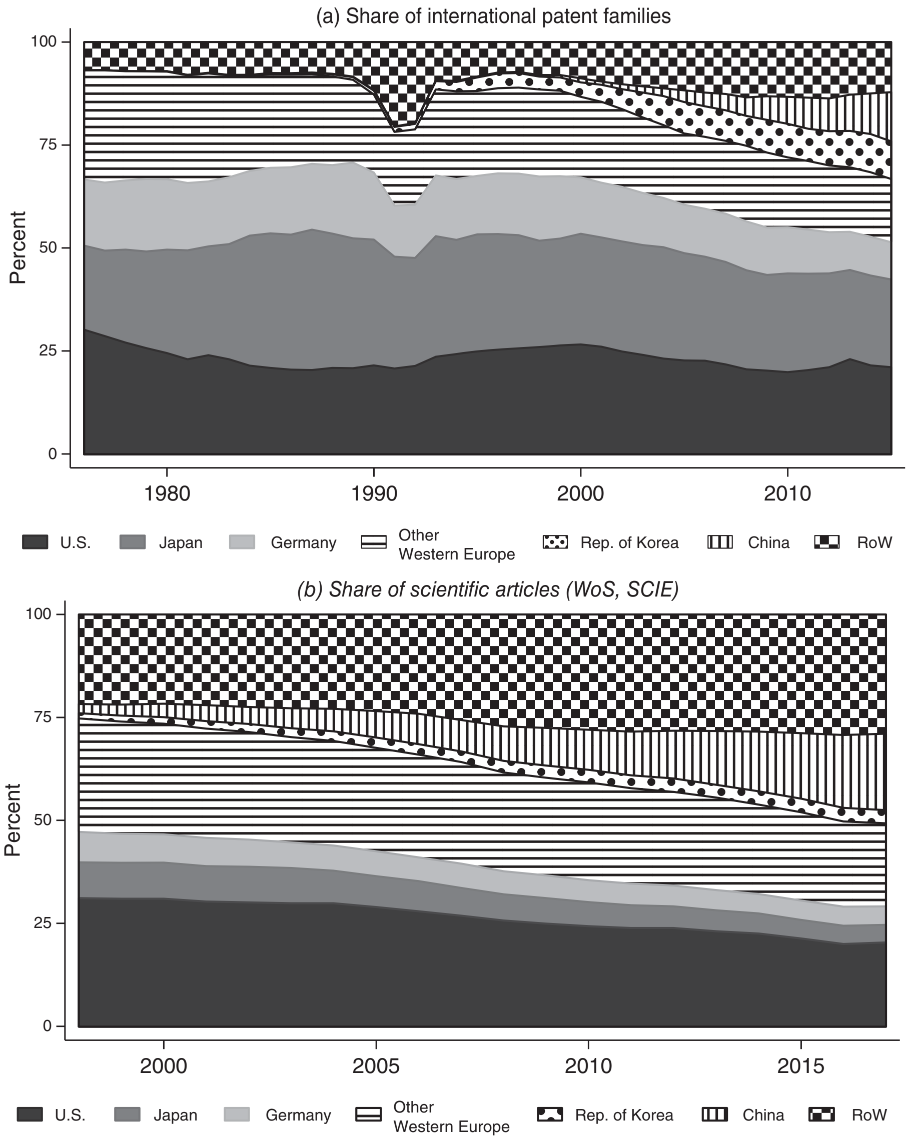


FIGURE 2.1 Evolution of (a) patenting and (b) scientific publication concentration by few economies

Source: Miguelez et al. (2019). Notes: RoW = Rest of the World. See WIPO (2019), technical notes (www.wipo.int/wipr).

These data also show that the distribution of new S&T outputs changed by the turn of the century. The growth of the Republic of Korea and China – but also the other economies grouped as a whole – has outperformed that of the United States, Japan, and Western European countries as a block. Outside of China and the

Republic of Korea, fastest innovation economies are also found in Asia. In particular, India, Iran, Israel, Singapore, and Turkey stand out. The geographical spread is more noticeable in scientific outputs than technological ones. In the rest of the world, Australia, Brazil, Egypt, and South Africa gather the lion's share of the scientific output in their respective regions. However, virtually all nontraditional regions evidence an increase in the scientific output share.

There has been, therefore, some spreading out of knowledge production. However, except for the Republic of Korea first and then China, the hierarchy of innovativeness (and income per capita) has not changed to a great extent (Kemeny, 2011), as high-income countries have managed to keep their positions through sustained innovation, and innovation of higher quality and complexity (Crescenzi et al., 2019). Moreover, the entry of these new players has not necessarily translated into a reduction of geographical concentration. Indeed, among other factors, the extremely rapid emergence of a few countries, notably the Republic of Korea and China, had recently resulted in a reconcentration phenomenon (see Figure 2.2).

By all quantitative accounts, the production of innovation remains more concentrated than other economic activities. At the country level, this is quite apparent. Figure 2.2 reports the country concentration index – Herfindahl–Hirschman Index – for a series of internationally comparable economic indicators over time. In addition to the scientific articles and international patents already discussed in the previous section, this figure also presents indicators for trade (total exports, U.S. dollars PPP),

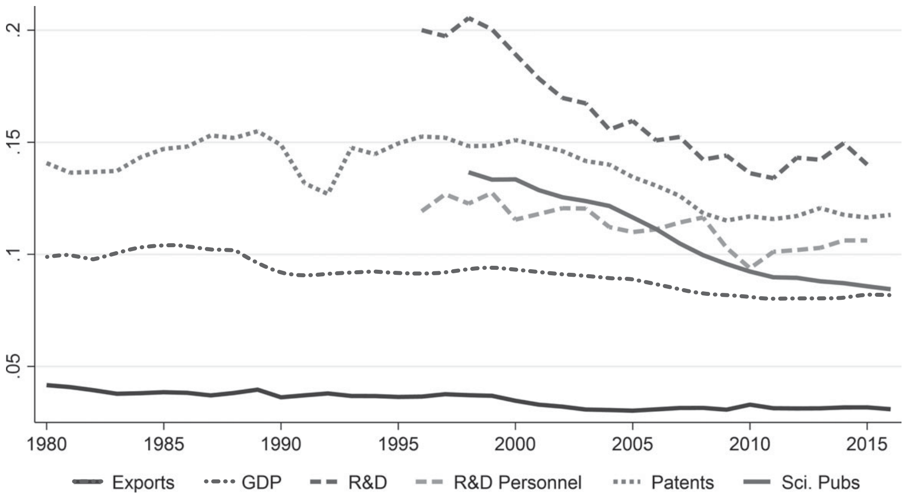


FIGURE 2.2 Innovation is more concentrated than other economic activities
Herfindahl–Hirschman index, selected innovation and economic indicators, 1980–2016.
Source: Authors based on PATSTAT, PCT, and Web of Science data. R&D and R&D personnel are retrieved from the UNESCO Institute for Statistics, while exports and GDP data from the World Development Indicators, the World Bank.

GDP (U.S. dollars PPP), R&D investments (GERD, U.S. dollars PPP), R&D personnel (FTE), and population.

These indicators suggest quite clearly that innovation-related activities are geographically more concentrated than economic ones, such as trade and GDP. The concentration of scientific articles has been declining close to the levels observed for the concentration of GDP. By contrast, R&D expenditures have observed an increase in concentration similar to that for patents since the mid-2000s. The fact that R&D investments are more concentrated than R&D personnel implicitly indicates that R&D budgets per researcher differ substantially across countries. Typically, R&D in richer countries is far more capital intensive, which translates into higher R&D labor productivity. This is in line with the differences in innovation output concentration and also their quality.[6]

What do the data tell us about S&T collaboration? The broad context is that the overall S&T collaboration – that is, local, national, and international altogether – is increasing. Within this increase in collaboration, the share of international scientific collaboration has also been steadily rising (WIPO, 2019). On the contrary, the share of international technological collaboration – as measured in international coinventions – exhibits a substantially lower and less stable pattern. Peaking at almost 11 percent in the 2000s, the share of international coinventorship came a long way from low single digits in the 1970s. Since the 2010s, however, the share of international coinventorship has plateaued and, lately, decreased – mostly explained by the declines in international coinventorship observed in the United States, China, France, and India.

Does knowledge flow globally? The majority of international S&T collaborations occur between and within the United States and Western Europe. The rest of the world is increasingly collaborating internationally, but when it does, it almost always selects a partner from the United States or Western Europe. Interestingly, both international S&T collaboration between other countries – that is, outside the United States and Western Europe – has been increasing for the last two decades but remains small in comparison. In the period 2011–2015, Western Europe gathered 49 percent and 41 percent of all international S&T collaboration, respectively. In the same period, the United States gathered 13 percent and 27 percent for the same indicators (WIPO, 2019). Nevertheless, over the years, the U.S. connections with China and India have become equally or more important than those between the United States and individual Western European countries. This is particularly the case for international coinventorships. Despite being quite advanced, established non-Western economies such as Japan, the Republic of Korea, and Australia, and emerging economies such as China, India, Singapore, and Brazil mostly collaborate

6 Indeed, more valuable patents and scientific outputs – as measured by citations – show Herfindahl-Hirschman Index values even higher than all the indicators reported in Figure 2.2 (see Miguelez et al., 2019).

with the United States and Western Europe. In sum, while collaboration in S&T has increased and, in turn, has contributed to knowledge diffusion – especially from more to less developed countries – it remains quite skewed, and the number of emerging countries entering the global network is still limited.

2.1.2 *Within Countries, Innovation Is Unevenly Localized in a Few Regions*

Be it in the traditional technologically leading countries, or the newly emerged ones, knowledge production does not take place in a spatial vacuum. The multiple sources of knowledge behind the invention, commercialization, and adoption of new products, processes, services, and social practices originate in specific locations within countries and diffuse unevenly across them.

In particular, as most economic activities, innovation benefits from economies of agglomeration (Crescenzi et al., 2019; WIPO, 2019: ch. 1). Scientists, technologists, entrepreneurs, students, and other actors seeking ideas, expertise, and education realize gains when they are colocated, as this increases the probability of recognizing opportunities and solving problems and of lowering all types of search costs. Innovation generated in large agglomerations tends to be of higher quality and more unconventional (Berkes and Gaetani, 2021). Firms, especially innovation-centered ones, are inevitably attracted to innovation clusters by the possibility to access a large and diverse supply of labor (especially labor markets for qualified workers) and of intermediate goods (especially knowledge-intensive ones) but also by the faster flow of ideas.[7] They also allow interacting and learning from peers, favoring localized knowledge spillovers (LKS) (Jaffe et al., 1993). Agglomerations are homes and hosts of multinational enterprises (MNEs) and the true beneficiaries of globalization, being centers of political influence, corporate decision-making and control, knowledge generation and exchange, skills, and jobs (Crescenzi et al., 2019; Feldman et al., 2021). Similarly, skilled workers, students, and entrepreneurs looking for jobs, knowledge, and business opportunities move to the same centers, giving rise to nonnegligible internal and international migration flows (Breschi et al., 2020). Thus, the typical innovative urban agglomeration relies heavily on the external knowledge flows channeled from the national system of innovation, the local MNC's headquarters or subsidiaries, the international science networks, and the

[7] Ellison et al. (2010) summarize Marshall's (1920) economies as "the cost of moving goods, people, and ideas that can be reduced by industrial agglomeration. … Firms … in Silicon Valley, locate near one another to learn and to speed their rate of innovation." According to Ellison and his coauthors' review, in industrial and high-density human-capital concentrations, workers learn skills quicker from each other and businesses exchange more information and benefit more from specialized networks, ultimately speeding up the flows of ideas within the cluster.

mobility of talented people and skilled workers (Bathelt et al., 2004; Lorenzen and Mudambi, 2013; Moreno and Miguélez, 2012).[8]

While both the economic and geography literatures stress the importance of agglomerations for innovative activities, their identification remains an open challenge. At the beginning of the past century, Alfred Marshall already discussed why industries agglomerate and defined the industries concentrating in Birmingham, Bedfordshire, Buckinghamshire, Manchester, or Sheffield as *districts* (Marshall, 1920). More recently, scholars have argued that innovation flourishes in dense urban areas, where knowledge spillovers can flow within and across industries (Glaeser et al., 1992; Jacobs, 1969; Porter, 2000). Indeed, several *Marshallian districts* can coexist and benefit each other in an innovative large metropolitan area. These global innovation hotspots spawn new ideas and technologies faster than other locations, thanks to the agglomeration of capital, skills, entrepreneurship, and the supporting scientific institutions (Engel, 2015; Engel and del-Palacio, 2009; WIPO, 2019: ch. 1). Porter (2000) defines as *clusters* the spatial units that concentrate geographically and thematically a whole series of private and public organizations – and the people therein – that compete and cooperate to achieve innovation. Other terminology ranges from “tech clusters” (when wishing to stress their peculiarities vis-à-vis industrial clusters; Kerr and Robert-Nicoud, 2020) to “innovation hubs” (where the emphasis is placed on cities and knowledge exchanges between them; Nijkamp and Kourtit, 2013) as well as “hotspots,” which is more neutral and used interchangeably with the former two. Other approaches, instead, identify “global cities” based on their population and economic activity, and then move on to quantify the innovation they produce (Barca et al., 2012; Castellani, 2018).

Figure 12 by Miguelez et al. (2019) shows the global distribution of international patents and scientific articles by the smallest available administrative area within each country. We observe instantly in this figure that both S&T outputs are sternly skewed to a few locations in the world. Not surprisingly, these locations are mostly confined to the same regions we have been discussing earlier, namely the United States, Western Europe, and East Asia. Within the United States, the main cities on the two coasts – such as Boston, New York, and San Francisco – stand out. In East Asia, Beijing, Seoul, Shanghai, Shenzhen, and Tokyo are among the densest S&T agglomerations. Western Europe shows a more uniform geographical distribution,

[8] Despite the sizeable evidence on the benefits of tech clustering for innovation activities, research has also found that, under certain circumstances, locating out of clusters may bring benefits to innovative firms. Oakey and Cooper (1989) find that the peripheral location of high-technology firms can be driven by the benefits from high natural amenities. Suarez-Villa and Walrod (1997) find that, in the case of Los Angeles advanced electronic sectors, “non-clustered locations may have . . . become attractive alternatives to clusters for many firms, and particularly so with respect to R&D, where privacy is usually regarded as a major concern. Not locating in a cluster may have also been an advantage in its own right, as some firms sought to maintain some independence and secrecy for their R&D activities.”

yet cities in France, Germany, Northern Italy, and the United Kingdom agglomerate more S&T outputs.

Yet, using administrative areas for worldwide analysis is problematic. Efforts to map innovation agglomerations, especially at the international level, should not rely on fixed spatial boundaries, such as administrative or political units (Carlino and Kerr, 2015). This practice suffers from both a "modifiable area unit problem" (the unit size may vary across countries, thus making quantitative comparisons impossible) and a "border effect" problem (the unit boundaries may either cut across a cross-border agglomeration or – in case of large units – include two distinct agglomerations).[9] In this chapter, we will adopt the term "innovation-dense areas," which will be proxied by the spatial boundaries computed in Miguelez et al. (2019) and WIPO (2019). In a nutshell, based on the coordinates assigned to each patent and publication (based on inventors' and scientists' addresses), the authors apply a clustering algorithm to identify a multitude of agglomerations worldwide. These are separately identified as "global innovation hotspots" (GIHs) and "niche clusters" (NCs), though for simplicity we analyze them together under the label *innovation-dense areas*.

According to WIPO (2019), the United States hosts most of the main innovation-dense areas of the world (25 percent of all), followed by Germany (12.9 percent), Japan (9.4 percent), China (6.8 percent), the United Kingdom (4.9 percent), and France (4.3 percent).[10] By continent, Europe concentrates 40.5 percent of the most innovation-dense areas, followed by North America (28 percent), Asia (25 percent), Latin America (2.9 percent), Oceania (2.7 percent), and Africa (1 percent).

Figure 2.3 depicts the share of patents and publications produced in the innovation-dense areas of the United States, Japan, Germany, the United Kingdom, the Republic of Korea, China, India, and Brazil, and the population residing in these countries. Several patterns arise from analyzing the innovation-dense areas of these countries. First, in all cases, they account for a disproportionate amount of the S&T output with respect to population. Clearly, in all countries shown here, science and innovation are substantially more concentrated than

[9] In Krugman's (1991: 483) words,

> one of the most remarkable things about the United States is that in a generally sparsely populated country, much of whose land is fertile, the bulk of the population resides in a few clusters of metropolitan areas; a quarter of the inhabitants are crowded into a not especially inviting section of the East Coast. It has often been noted that nighttime satellite photos of Europe reveal little of political boundaries but clearly suggest a center-periphery pattern whose hub is somewhere in or near Belgium.

Indeed, many clusters fall in the definition of *transnational innovation systems*, particularly in Europe (Chaminade and Nielsen, 2011).

[10] For all the quantitative discussion in this section, we use WIPO's (2019) definition of the 487 most innovation-dense areas of the world (GIHs and NCs), which are the densest agglomeration of innovation activities as measured by scientific publications and international patent families by km^2. Most of the statistics discussed would show little variation with other definitions, and much less differences on the substance discussed.

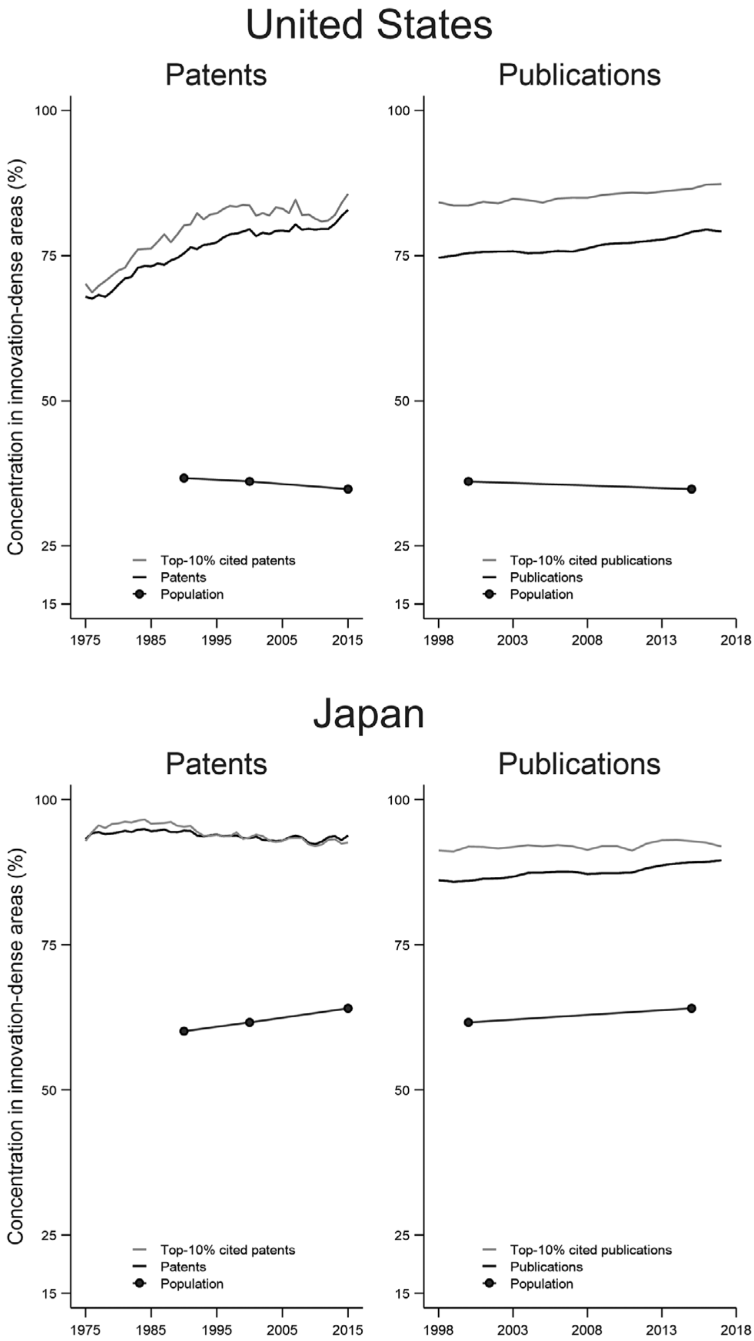
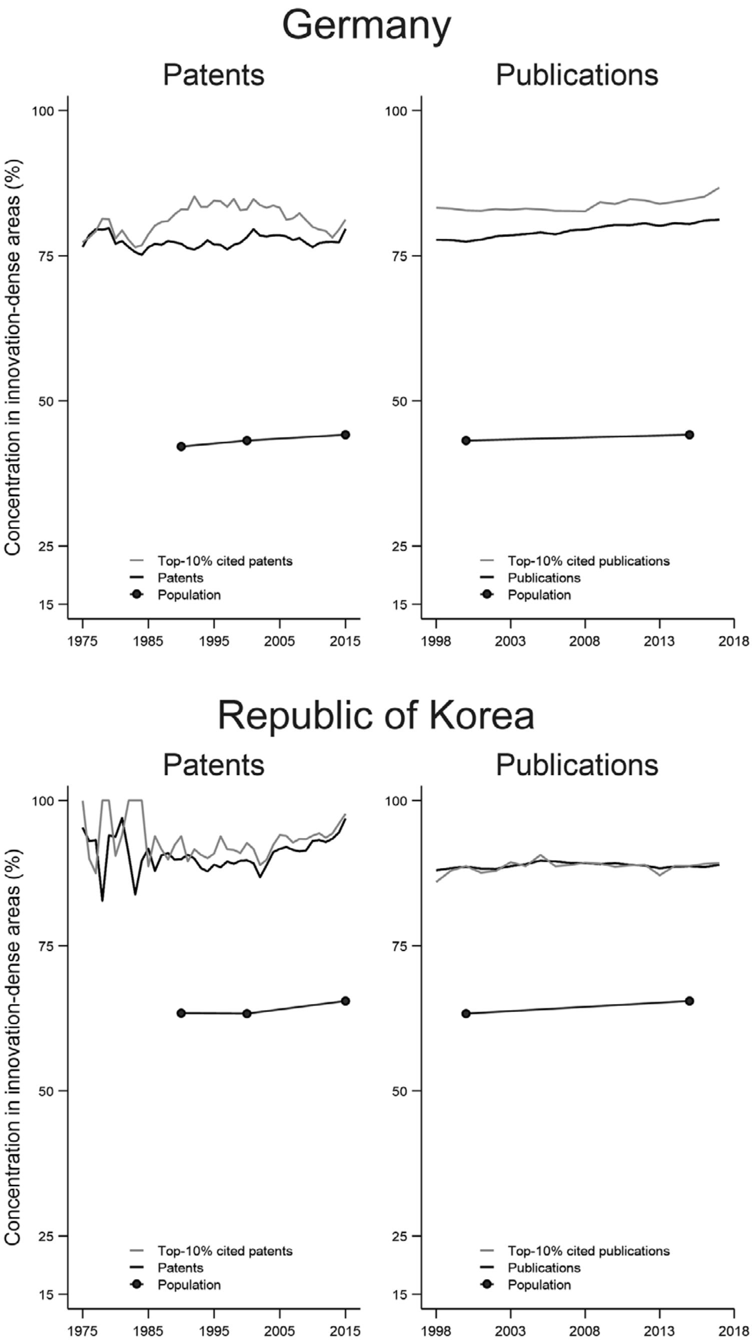


FIGURE 2.3 Share of patenting and scientific publishing in innovation-dense areas, by selected countries

Note: largest innovation-dense areas follow WIPO (2019), www.wipo.int/wipr.

Source: Miguelez et al. (2019).



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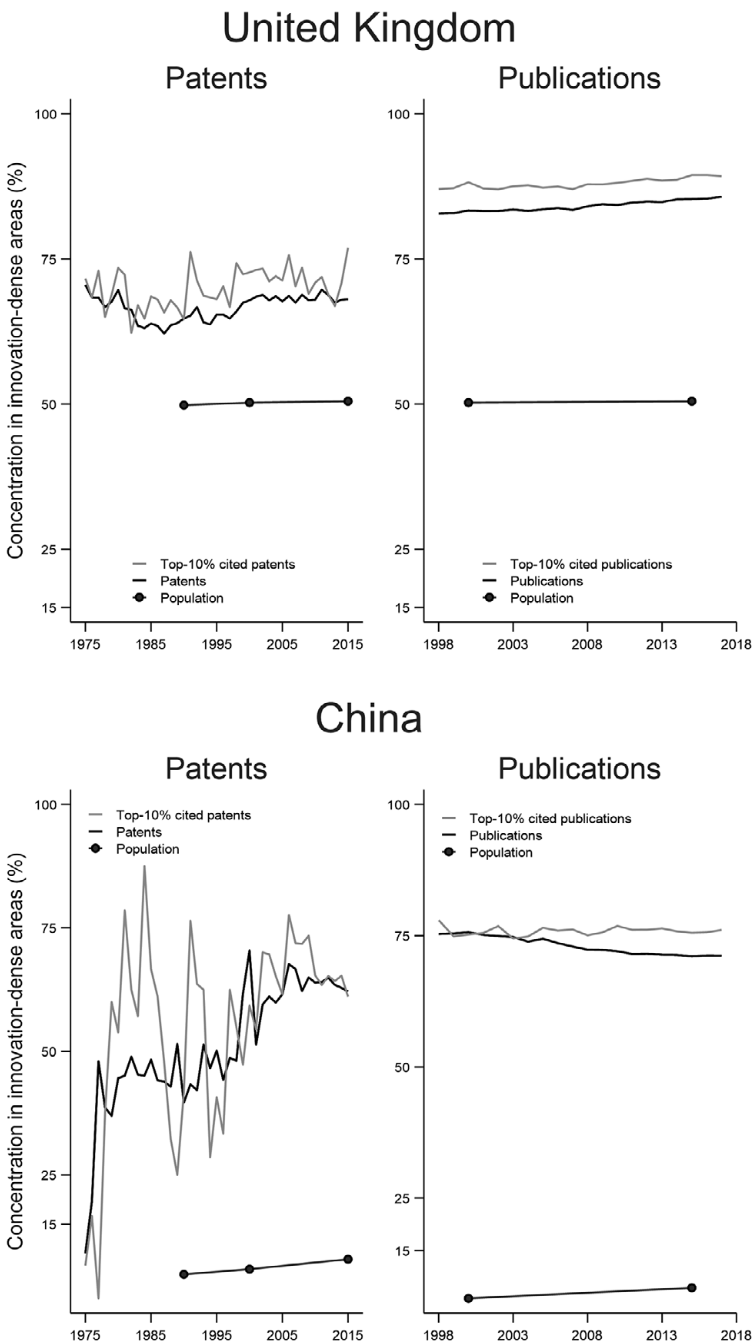

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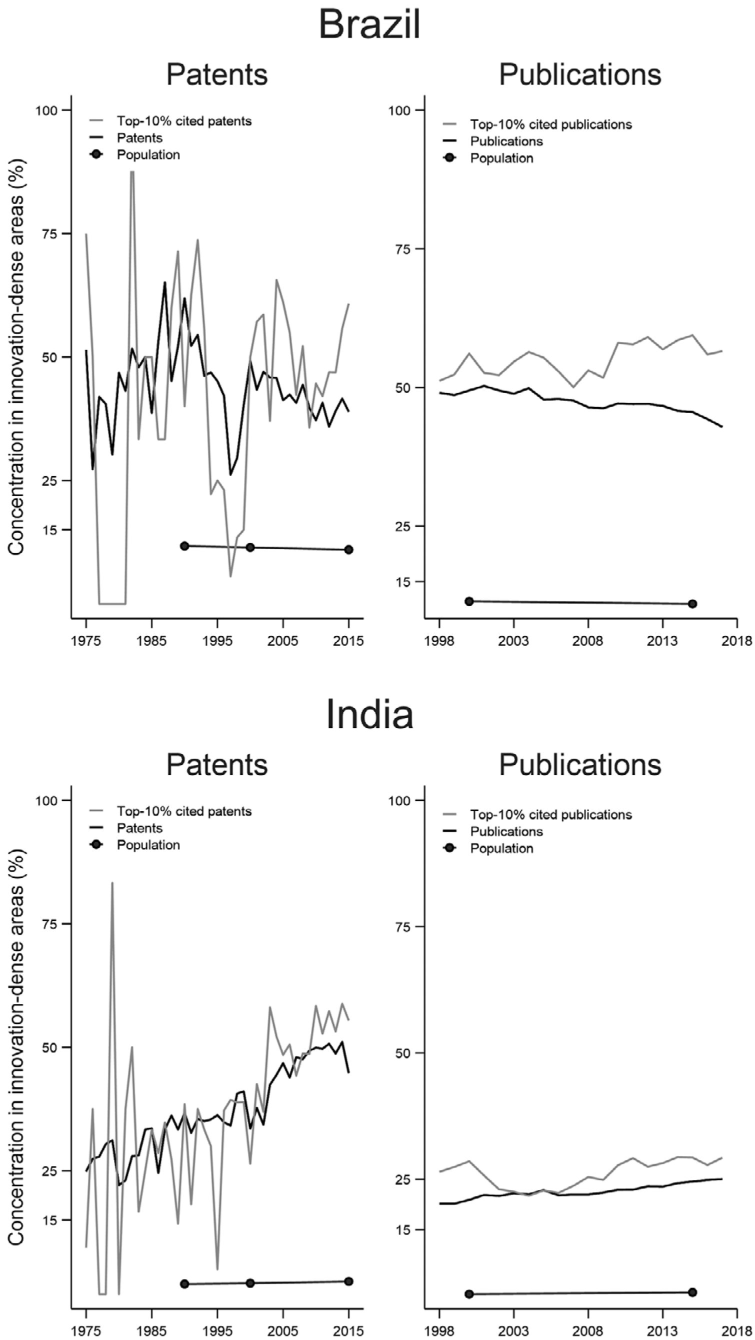

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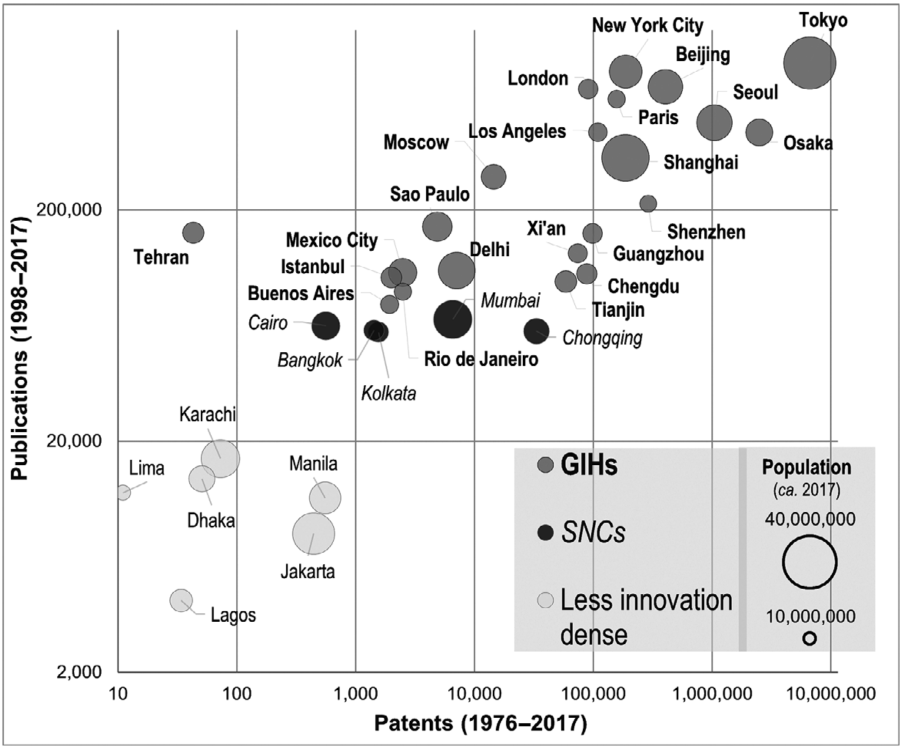

FIGURE 2.4 Population density does not ensure high innovation density
Patents and scientific articles in the top thirty-five largest cities, 1980–2016.
Source: WIPO (2019) based on PATSTAT, PCT, and Web of Science data, and top cities from The City Mayors Foundation (September 2019). Notes: Size of bubble refers to the metropolitan area population (circa 2017). Axis in logarithmic scale. Due to low scientific publication or patent values, Kinshasa and Shijiazhuang are omitted from the chart area.

population, indicating that concentration of population only partially explains the geographical concentration of innovation. Second, the most valuable S&T output – as proxied by the top ten cited patents and publications – is typically more concentrated than the rest. Third, in general, the concentration trends are stable over time. However, we observe some increases in subnational concentration in Figure 2.3. Such increases are found more often in patents than scientific articles.

Yet, while innovation tends to concentrate in large metropolitan areas, not all urban agglomerations concentrate on the equivalent level of innovation-related activities. Figure 2.4 displays the top thirty-five most-populated metropolitan areas in the world and their S&T outputs. Only twenty-two cities out of these are innovation-dense areas. The top-right quadrant shows that Beijing, London, Los Angeles, New York, Osaka, Paris, Seoul, and Tokyo concentrate a large amount of both patents and scientific publishing. In comparison, Shanghai is only less populated than Tokyo but has fewer patents and scientific publications than all of them.

A second-tier group of innovation-dense areas include the metropolitan areas of cities such as Buenos Aires, Delhi, Istanbul, Mexico City, Moscow, São Paulo, and Tehran. Despite their large populations, they concentrate much fewer scientific publications and patents. Other densely populated cities such as Cairo, Bangkok, Kolkata, and Chongqing have only enough innovation density in some specialized scientific or technological fields. Last, in the bottom-left quadrant, Dhaka, Jakarta, Karachi, Lagos, Lima, and Manila do not have an innovation density corresponding to their highly populated metropolitan areas, despite concentrating most of their respective national S&T output. As noted, innovation is even more concentrated than general economic activity and population.

Nevertheless, the lack of innovation-dense output in otherwise economically dense agglomerations is not exclusive to less developed economies. Even within high-income countries, the agglomeration of innovation activities seems to follow only partially the pattern of population and economic activity agglomeration.

2.1.3 A *Concentrated Network of a Few* Innovation-Dense Areas

Why does more collaboration not necessarily lead to less inequality in innovation distribution within and across countries?

The rising concentration of science and innovation production in innovation-dense areas, and the parallel global spreading out of innovation and international team formation, characterizes a globalized hub-to-hub system, which links national and regional systems of innovation and global firms through a spiky geography of knowledge creation (Crescenzi et al., 2019). Many of these hubs are better connected to one another than to their neighboring areas inside their countries. The collaborative scientific communities, the talented migrants, the supply chains, and the knowledge-seeking MNCs give rise to global innovation-dense "hotspots" around the world. The successful regions discussed earlier cannot rely uniquely on the local innovation ecosystem they form – whether private companies, higher-education or research institutions, etc. – but they build national and international links to complementary pools of knowledge abroad (Awate and Mudambi, 2017; Bathelt et al., 2004; Lorenzen and Mudambi, 2013; Turkina and Van Assche, 2018).

Figure 17 by Miguelez et al. (2019) depicts the global network of highly connected innovation-dense areas. As expected, this network is denser within and between a few agglomerations in the United States, the United Kingdom, Germany, France, Japan, the Republic of Korea, China, and India. The United States, Germany, Japan, and the Republic of Korea also show thick national networks.

Even in these countries hosting most of the world's innovation output, we observe that just a few innovation-dense areas concentrate most of the international connections. A handful of cities, mostly on the two coasts of the United States, account for much of the U.S. international coinventorship. Similarly, Western European innovation agglomerations connect mostly nationally to Paris, London, Frankfurt, and

Berlin. Figuratively, these European innovation hubs mediate most of the other European international connections, as if they are Europe's international "gatekeepers." The same pattern happens in Asia, where Tokyo, Seoul, Beijing, Shanghai, Mumbai, and Bengaluru are the key gateways for international coinventions. The same analysis for scientific outputs would cast a much denser network but with an equivalent underlying pattern of concentration of international ties in a few hubs. In sum, S&T outputs are more likely to connect international partners if produced within these already concentrated innovation hotspots. The bias is even more apparent when focusing on the most valuable S&T output (Miguelez et al., 2019).

As a result, these global networks favor a few innovation-dense areas that concentrate the knowledge flows. This is a double-edged sword: While these areas spread knowledge, they do so mostly among themselves. The resulting GINs, in turn, cement the innovation "hotspot" advantages.

2.2 CONSEQUENCES OF THE UNEQUAL INNOVATION DISTRIBUTION AND POSSIBLE POLICY ACTIONS

We have just shown that the global production of innovation is extremely concentrated in a few areas of the world. Moreover, it is even more concentrated than other economic activities. Does this concentration pose a problem? What does it mean for economic and innovation policymaking? We attempt to answer these questions in three parts. First, we rely on the economic geography literature to explore in which ways this unequal distribution of innovative activity relates to one of the biggest challenges of present times, namely growing income inequality (Piketty and Saez, 2003). In particular, we will focus our attention on the relationship between innovation concentration and territorial income inequality. Second, we discuss if this unequal distribution of innovation (and income) across and within countries is inevitable. Last, we conclude by revisiting the role of policy in the light of our discussion.

2.2.1 *Does the Unequal Distribution of Innovative Activity Really Matter?*

Despite the global spread of knowledge production and the emergence of new local innovation giants (in both developed and developing countries), there remain high levels of within (and between) country concentration of innovation. Before diving into the role of policy, it is pertinent to ask if this is a problem that policy has to address.

In a simplified economic view, innovation and the knowledge to produce it have the characteristics of a public good (Arrow, 1962). Many individuals, firms, and regions can use at the same time the knowledge produced by others somewhere else, without rivaling the use by the originators. Indeed, artificial intelligence emerged from a limited number of scientific organizations in a few regions of the world, and today a large number of companies and individuals employ the underlying science for a wide variety of innovative applications around the world. A similar point can be made for mobile communications technology, which has flown to remote corners of the world.

In this sense, if innovation were a pure global public good, it would not necessarily matter where innovative activity takes place. In such a scenario, innovation would flow without attrition benefiting all regions equally. Moreover, there would be strong arguments in favor of agglomerating resources in a few regions to benefit from economies of scale, which will eventually flow to all regions in the world. The "new economic geography" (NEG) school of thought made a strong case that geographical concentration of economic activities is inevitable and even desirable. Regional concentration happens in an iterative manner, where regions progressively attract productive companies and skilled labor, which in turn makes them more attractive for new companies and workers to join the same region. The key to this school of thought is that circumstantial regional advantages in productivity can trigger divergent geographical concentration paths. This simple mechanism can explain how agglomerations emerge but also how existing ones can strengthen their position to the detriment of the outer regions (Krugman, 1991). In this scenario, mainstream theories predict that processes of inter-regional labor mobility, knowledge diffusion, and trickle-down effects will occur, and income convergence will follow. Thus, policy intervention to favor disadvantaged areas is not necessary (World Bank, 2009). This theoretical framework, implicitly, concerns innovation activities. too. While NEG early proponents dismissed high-tech sectors as a particular case, empirical evidence largely found that concentration is particularly salient in knowledge- and innovation-based economic activities (Audretsch and Feldman, 1996), which was largely attributed to the importance of LKS as a localization force (Jaffe et al., 1993; Krugman, 2010).

But several recent economic studies suggest that converging mechanisms might not be working as predicted (Hope and Limberg, 2022; Iammarino et al., 2019). If the benefits of successful innovations depend on the location of innovation, patterns of agglomeration have a direct effect on spatial economic development outcomes, and while the concentration of innovation in a few places may benefit the worldwide rate of innovation, it also hinders the innovative prospects of other areas.

If innovation is indeed "sticky," it is not a pure public good.[11] Why might this be the case? Beyond market size and talent availability, there are notable positive agglomeration externalities arising from knowledge spillovers (Jaffe et al., 1993; Krugman, 2010). The tacit nature of knowledge makes the colocation of innovative

[11] Exclusive IP rights may also erode the notion of innovation as a pure public good. However, IP rights do not turn knowledge into an eternal private good. They are territorial in nature and time bound; most patents, in particular, are only registered in selected high-income economies, and they only last for a maximum of twenty years. Even while they are protected, patents can be licensed, thus enabling knowledge adoption by others. Finally, the patent system offers incentives for knowledge disclosure, which ultimately promotes dissemination. The full effectiveness of IP as means of diffusion is still argued in the innovation economic literature, yet several studies have found evidence of patents being an effective source of knowledge. See, among others, Cohen et al. (2002), Denicolò and Franzoni (2003), Graham et al. (2009), Jaffe et al. (2000), and Moser (2011).

firms, academic centers, and talented human resources a more effective environment for these externalities to arise (Crescenzi et al., 2019; WIPO, 2019: ch. 1). Information may flow relatively free over the geographical space, but knowledge flows are far less fluid. Trade flows, for instance, may help diffuse routinized and codified information, but knowledge that is not economically ubiquitous generates innovative rents to specific geographical locations (Feldman et al., 2021). When the codification of knowledge is difficult – that is, knowledge is more tacit – organizations and, especially, individuals have to physically move with the knowledge embedded in themselves to realize these knowledge flows. Movement of and interactions between individuals and organizations are invariably easier in close proximity. Global networks, such as GINs, while allegedly a mechanism of knowledge diffusion, end up reinforcing concentration effects, as different types of workers are differently exposed to offshoring and outsourcing (Autor and Handel, 2013; Gagliardi et al., 2021). A similar pattern holds for highly skilled migrants holding science and technology jobs, who tend to concentrate in innovative cities (Coda-Zabetta et al., 2022).

As a consequence of the above, some scholars argue that the uneven distribution of science and technology, as well as skilled labor, has translated into rising levels of income inequality (Iammarino et al., 2019). This phenomenon occurs both inside highly innovative superstar cities, and between them and the rest of the country – the "Left Behind Regions" (Rodríguez-Pose, 2018). Starting in many developed countries from around 1980, this process of economic divergence is known as "the great inversion" (Crescenzi et al., 2019; Florida, 2017; Kemeny and Storper, 2020). Moreover, superstar cities and innovation-dense areas tend to host highly skilled, nonroutinized employment but also attract low-skilled, nonroutinized jobs. In such a scenario, inter-regional migration does not occur, either because of high housing costs in superstar cities, unaffordable for medium- and low-skilled workers, or simply because "skill requirements in these superstar cities tend to be both high and specific" (Kemeny and Storper, 2020: 27). Meanwhile, this technological change also reduces employment in many previously dominant manufacturing sectors through automation (Iammarino et al., 2019).

Another related trend is growing evidence of falling R&D productivity. Recent empirical studies indicate that current technological progress is requiring increasingly more innovation investments (Bloom et al., 2020). This is apparent in the information and communication technology (ICT) industries, for example, where continuously achieving Moore's law – that is, doubling the number of transistors on a computer chip every two years – requires eighteen times more researchers than it did in the early 1970s. Other industries evidence a similar pattern: Increases in life expectancy or crop yields require much more investments in medical or agricultural R&D. The innovation frontier problems to be solved seem to be increasingly complex and, thus, requiring increasingly larger research teams and specialization (Hidalgo, 2021; WIPO, 2019: ch. 2). These R&D productivity trends have subsequent negative effects on overall productivity. Some economic scholars have indeed argued that current innovations boost economic productivity to a much smaller extent than the innovations associated with the Second Industrial Revolution (Gordon, 2018).

How does falling R&D productivity relate to geographical inequality? Falling R&D productivity makes a strong case for pooling resources to optimize the local knowledge spillovers. It might be socially desirable to concentrate innovation resources in a few hotspots in the world, but this may generate, again, a whole set of regional imbalances to be sorted out by policymakers. Regardless of which region or country emerges as the concentration champion, any resulting concentration implies a transition period during which large transfers of resources – including human capital – from noninnovation-dense areas occur. These transitions are usually – if not always – socially costly. There are also within-region imbalances. A side effect of innovation agglomeration is the centrifugal forces pushing less innovative firms and unskilled labor to the periphery of the innovation-dense areas. This is unquestionably one of the causes behind the rising housing prices and widening income disparities in Silicon Valley and more recently in Tel Aviv (Srivastava, 2018).

2.2.2 *Can Diverging Innovation Paths in Economies and Regions Be Changed? Lessons from Asia*

We discussed in the previous sections how the geographical concentration of innovation can be instrumental for both regional and economy-wide development outcomes. We also pointed to the social costs associated with such concentration, mainly in terms of not all countries benefiting from the spread of the knowledge economy, and inter-regional income inequality rising even in highly innovative economies. We now turn to evidence on past geographical trends and discuss if and how policy may have played a role.

The global spread of knowledge production documented earlier, the existence of GINs, and the international flows of knowledge were probably necessary but not sufficient conditions for countries to successfully ignite economic development through technological change. Indeed, national innovation strategies and policies played a critical role in making this happen (Crescenzi et al., 2019). The most successful examples of technological catch-up are found in Asia. The spread of knowledge production and global networks toward these countries has coincided with the emergence of strong NIS in them. In turn, public R&D spending and public incentives to private spending, among other things, may have played a role in the development of these NIS (Archibugi and Filippetti, 2018).

In what follows, we first focus on GDP and innovation concentration across countries, where more evidence and policy discussion have consistently emerged.

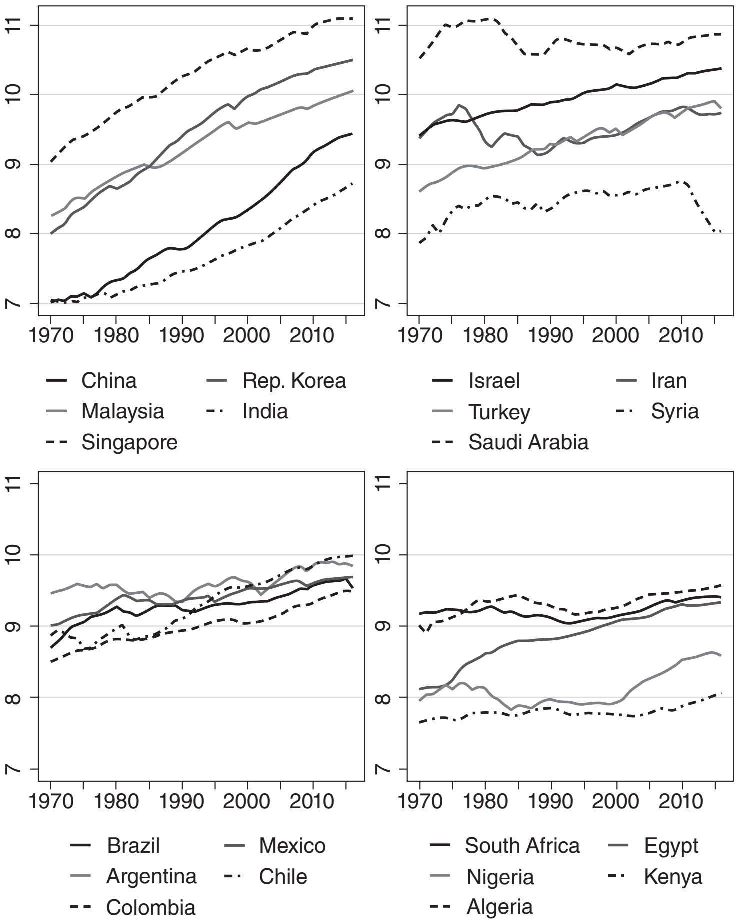

FIGURE 2.5 Diverging growth paths
Real GDP per capita in 2011US$ (logs), selected economies
Sources: Maddison Project Database, version 2018. Bolt et al. (2018)

In terms of overall development, there is still considerable variation in GDP per capita levels and growth across countries and within regions of the world. Asia as a region has the highest income per capita outside the Western world. Latin America, Africa, and, to some extent, the Middle East observe a less remarkable evolution (Figure 2.5).

More recently, the evolution in GDP per capita has correlated with the increase in S&T outputs. Since the 2000s, Asia has increased its share of total patenting from 32 percent to 48 percent and its share of total scientific publishing from 17 percent to 36 percent. This reflects the rise of China and the Republic of Korea and comes despite the relative decline of Japan's share of patents and publications.

Furthermore, considering their low starting point, most selected Asian economies have seen a remarkable increase in their share of S&T outputs in a few decades (Table 2.1). Within these economies, Turkey, Israel, India, Singapore, and Iran stand out as the largest innovating economies.

However, this does not mean that all cities from successful East Asian economies have followed the same pattern. Table 2.2 looks at the top three innovation-dense areas for selected countries in two different periods and the share of patenting and scientific publication they account for in their respective countries. First, the list of top innovation-dense areas per country barely differs in time and between patents and scientific publications, showing the stability of the concentration phenomenon. Second, in all countries shown, the share of the top three is quite high, ranging from around 20 percent up to more than 100 percent.[12] With the exception of Chinese and Indian patenting, the share of the top three patenting and publishing hotspots decreases over time, showing that, within countries, S&T activities seem to be spreading geographically. However, overall, the concentration of S&T output remains relatively high. China and India also show some dispersion trends in scientific publications, but their top three hotspots still hold about a quarter and a third of all national scientific publications, respectively.

Did national and regional policies play a role in such divergent economic performance? At the national level, economic scholars are still quite divided. There is not even full consensus on the source of the divergent paths. Development economists enumerate, among the possible sources of diverging economic performance, insufficient capital accumulation (Young, 1995, 2000a,2000b), a distorted size of the natural resource sector (Sachs and Warner, 1995), and declining terms of trade for low value-added goods (Prebisch, 1962). Alternative theories give more prominence to the role of institutions in economic growth (North, 1990) and their capacity to absorb new technologies (Nelson and Pack, 1999).

Historically, several policies to solve a suspected *natural resource disadvantage* and *declining terms of trade* have been suggested, mostly based on import substitution and state-led industrialization (e.g., Prebisch, 1962; Singer, 1950). They coincided with high sustained returns to capital investment in Asia, with the capacity of absorbing new technologies playing a crucial role (Nelson and Park, 1999), which in turn set the grounds for rapid capital accumulation. As a synthesis, institutional characteristics related to innovation such as education, R&D, S&T infrastructure, and science–industry linkages can go a long way in explaining why some Asian economies outperformed the rest of the developing world (Freeman, 1995).

[12] Singapore innovation agglomeration exceeds the national boundaries.

TABLE 2.1 *Evolution of patenting and scientific publishing, by selected countries*

	Patents							Publications			
Country	1970–1979	1980–1989	1990–1999	2000–2004	2005–2009	2010–2014	2015–2017	2000–2004	2005–2009	2010–2014	2015–2017
China	0.007%	0.064%	0.275%	1.313%	4.043%	8.164%	13.671%	2.446%	4.370%	7.848%	12.011%
Rep. of Korea	0.014%	0.308%	2.579%	5.212%	7.562%	8.506%	8.368%	1.389%	2.003%	2.679%	3.157%
Malaysia	0.005%	0.007%	0.027%	0.078%	0.148%	0.169%	0.115%	0.076%	0.092%	0.181%	0.435%
India	0.031%	0.034%	0.114%	0.533%	0.997%	1.358%	1.334%	1.942%	2.033%	2.635%	3.164%
Singapore	0.005%	0.015%	0.118%	0.308%	0.358%	0.372%	0.343%	0.302%	0.428%	0.474%	0.495%
Israel	0.239%	0.312%	0.576%	0.931%	1.148%	1.083%	1.047%	0.930%	0.908%	0.763%	0.615%
Iran	0.006%	0.003%	0.005%	0.007%	0.017%	0.023%	0.053%	0.116%	0.258%	0.817%	1.555%
Turkey	0.003%	0.005%	0.017%	0.064%	0.168%	0.262%	0.363%	0.587%	0.979%	1.544%	1.671%
Syria	0.001%	0.001%	0.002%	0.002%	0.002%	0.002%	0.001%	0.009%	0.010%	0.011%	0.014%
Saudi Arabia	0.003%	0.007%	0.009%	0.014%	0.031%	0.103%	0.166%	0.165%	0.137%	0.122%	0.305%
Brazil	0.067%	0.093%	0.122%	0.169%	0.245%	0.281%	0.271%	1.110%	1.454%	1.963%	2.325%
Mexico	0.077%	0.048%	0.063%	0.091%	0.107%	0.123%	0.149%	0.442%	0.514%	0.576%	0.593%
Argentina	0.050%	0.042%	0.057%	0.059%	0.056%	0.041%	0.038%	0.461%	0.475%	0.433%	0.456%
Chile	0.006%	0.006%	0.011%	0.018%	0.033%	0.056%	0.053%	0.170%	0.196%	0.221%	0.254%
Colombia	0.007%	0.006%	0.008%	0.015%	0.021%	0.032%	0.038%	0.042%	0.053%	0.091%	0.141%
South Africa	0.224%	0.196%	0.195%	0.211%	0.167%	0.131%	0.098%	0.375%	0.329%	0.351%	0.404%
Egypt	0.002%	0.003%	0.005%	0.013%	0.026%	0.026%	0.021%	0.245%	0.266%	0.294%	0.395%
Nigeria	0.001%	0.001%	0.001%	0.002%	0.002%	0.003%	0.002%	0.081%	0.072%	0.131%	0.128%
Kenya	0.002%	0.001%	0.002%	0.004%	0.003%	0.005%	0.004%	0.040%	0.033%	0.038%	0.043%
Algeria	0.000%	0.001%	0.001%	0.003%	0.003%	0.003%	0.003%	0.029%	0.043%	0.078%	0.105%

Source: Miguelez et al. (2019).

TABLE 2.2 *Top innovation-dense Asian agglomerations and national concentration of S&T outputs, 1991–1995 and 2011–2015, selected economies*

	Patents				Publications			
Country	1991–1995	%	2011–2015	%	2001–2005	%	2011–2015	%
China	Shenzhen-Hong Kong Beijing Shanghai	**48.5**	Shenzhen-Hong Kong Beijing Shanghai	**51.0**	Beijing Shanghai Nanjing	**43.9**	Beijing Shanghai Nanjing	**35.8**
India	Bengaluru Mumbai Delhi	**41.5**	Bengaluru Hyderabad Delhi	**46.2**	Delhi Mumbai Bengaluru	**27.7**	Delhi Mumbai Kolkata	**24.6**
Iran	ND	**ND**	ND	**ND**	Tehran	**57.6**	Tehran	**46.1**
Israel	Tel Aviv Haifa Jerusalem	**85.6**	Tel Aviv Haifa Jerusalem	**82.3**	Tel Aviv Jerusalem Haifa	**86.4**	Tel Aviv Haifa Jerusalem	**86.1**
Rep. of Korea	Seoul Daejeon Icheon-si	**75.8**	Seoul Daejeon Beolgyo	**70.3**	Seoul Daejeon Busan	**71.3**	Seoul Daejeon Busan	**69.9**
Malaysia	Kuala Lumpur	**61.5**	Kuala Lumpur	**58.0**	Kuala Lumpur	**51.4**	Kuala Lumpur	**59.4**
Saudi Arabia	Dammam	**42.4**	Dammam	**38.8**	Dammam	**21.0**	Dammam	**7.8**
Singapore	Singapore	**100.8**	Singapore	**100.3**	Singapore	**100.0**	Singapore	**100.0**
Turkey	Istanbul Ankara	**59.1**	Istanbul Ankara	**38.8**	Ankara Istanbul	**46.5**	Ankara Istanbul	**42.8**

Source: Miguelez et al. (2019).
Notes: Up to three top innovation-dense agglomerations displayed per country, in case of more than one found by the algorithm. Some agglomerations may exceed the national borders (e.g., Singapore). "ND" = No data available.

2.2.3 *What Is the Role for Policy?*

In the context of an uneven geographical distribution of innovation, the relevant question for policymakers is what type of policies can stimulate the institutional environment that better attracts external innovation – that is, technological absorption – and, in turn, better generates new technologies. Traditionally, this question was often simplified as to either favor market liberalizing policies or government interventionist ones.[13]

When it comes to dealing with the unequal distribution of innovation and income, in both developed and developing countries, a similar trade-off arises between efficiency and equity (Iammarino et al., 2019). Efficiency reasons may suggest allowing market forces to generate as many agglomerations as possible, which might be the most efficient for the whole economy, with spatial equity occurring through a trickle-down process – for example, through labor mobility (Glaeser, 2011; World Bank, 2009). Equity concerns may call for greater intervention to directly achieve some redistribution, even at the expense of damaging national champions and overall economic growth. The chosen approach to solving problems of between- and within-country income inequality may determine the chosen type of policies, too: spatially blind policies versus spatially based ones. Again, the former advocates for policies that apply to all locations, without accounting for space and the local context (e.g., regulations ensuring market efficiency), as spatially targeted approaches may deter growth coming from agglomerations (mostly represented by the World Bank's (2009) report, focused on developing countries). The latter prefers policies highly contingent on context, rooted in the local community and local stakeholders (Barca et al., 2012). One approach is based on the need for full-fledged market forces to let Schumpeter's creative destruction of firms and sectors to take place. The other bases its logic on the existence of negative externalities hampering the development of such innovative capacity, which only government policy can overcome. Both underlying economic theories are sound, but the practical policy setups can easily differ.

Arguably, any past policy successes in boosting national technological capacity might not be as relevant in the current context. As innovation is increasingly fragmented in innovation-dense metropolitan areas, which astonishingly are more globally interconnected, a different policy toolbox may be necessary. Likewise, the increasing international interconnectivity of innovation hotspots is also the result of national and multilateral policies promoting openness and international cooperation. The institutional setup favoring openness and cooperation should not be taken for granted, as recently public perception has become more skeptical of the benefits of openness (WIPO, 2019: ch. 5).

[13] World Bank (1993) and Amsden (1994) are samples of these rivaling perspectives.

Any reduced openness of innovation ecosystems will likely affect the rate of knowledge diffusion. Knowledge may not flow across borders as much if researchers cannot move around the world or access scientific journals and patent documents published elsewhere. Limitations to international trade can also impact innovation openness, as a substantial part of technological flows happens through imported parts and components.

However, there are also limits to how widely knowledge can be shared. In fact, we have discussed in Section 2.1 how concentrated the production of new S&T knowledge is within and across countries. Still there are mutual gains for openness, if outward knowledge flows increase economic benefits abroad without reducing the local use. But several opinions perceive innovation as a zero-sum game, where breakthrough innovation can provide a competitive advantage to regions or countries. In the long run, this perspective has little base, as both winning and losing economies will find new equilibria where they are better off. Nevertheless, there are extreme scenarios where such "zero-sum" outcomes could happen (Grossman and Helpman, 1991).

In the short run, things might be different. As discussed earlier, regional differences in productivity and innovativeness can lead to divergent paths of geographical distribution within countries of incomes, technology production, high-skilled employment, and wages. Regional competitive advantages can have profound negative effects for some regions in the short run, as it takes time to reconvert human capital to new industrial needs. Indeed, in the United States, as mentioned earlier, regional divergence started to accelerate in the 1980s and 1990s, after decades of postwar convergence (Ganong and Shoag, 2017). The same applies to the European context since the great recession in 2008 (Alcidi et al., 2018). Moreover, such inequality is also likely to sprout within successful regions. Vibrant innovation hotspots may produce spiked salaries of highly skilled workers, putting upward pressure on local prices, especially for housing, and directly affecting the disposable income of low-skilled workers (see WIPO, 2019: chs. 1 and 5).

How to address such rising regional imbalances is probably one of the most challenging questions that regional policymakers face in current times. Counterweighing the agglomeration forces of the main national innovation hubs might not be the best policy strategy, as it might affect the national innovation outcomes. More importantly, being realistic, it might not even be possible. Similarly, redirecting inward the international connections of the globally successful regions may not have the desired effect and risks slowing down the technological diffusion toward all hubs in the country.

The key problem might be clear, but its solutions are probably not. Labor, capital, and the companies containing these only gradually move from lingering regions to successful innovation agglomerations. Accelerating the structural transformation of economic activity might reduce imbalances, but the social impact might leave long-lasting scars. Individuals, in particular, are geographically bounded, as they may not have the capacity or willingness to move. Public and other supporting institutions – government agencies, schools, transport, etc. – are also extremely hard to transplant geographically.

Alternatively, policy can be directed to mitigate the agglomeration forces by simply financially supporting declining regions. The beneficial social contention of these policies is without question here, but the long-lasting economic results have less consensus. Yet, there are some relevant lessons worth having in mind when designing such policies (Foray, 2015; Rodríguez-Pose, 2018). First, any regional development policy should aim at enhancing existing local advantages by investing in infrastructure, education, and technology. Second, the process of identifying existing capabilities has to rely on inputs from a broad array of local stakeholders. Regional advantages can take several forms – for example, relatively cheap land or labor, existing industrial capabilities, or reputational assets – but, by all means, they have to avoid formulaic solutions transposed from unalike regions.[14] Third, any implemented policies should be assessed regularly. By policy design, distortions will arise if the policies are successful, which inevitably imply that there will be winners and losers within the targeted region.

Is there a specific role for IP policies? History and the rather limited empirical evidence suggest that policies related to IP strengthening played a side part in the industrial development process of countries, and even more of regions.[15] What could be the channel where IP – especially patents – could affect innovation geographical concentration and spread? This is not as straightforward as many would think about it.

In most cases, IP rights have a national jurisdiction, which can be extended to other national jurisdictions. With a valid IP right within a country, right holders could use their IP to exclude the access of competitors to the technology or brand as much inside a cluster than in the neighboring areas outside the cluster. Internationally, holders can, and often do, use their IP to exclude competitors to produce in or export to protected jurisdictions. Still, there is no evidence of the reciprocal being clearly the case. Patent protection for technologies is low in many jurisdictions, yet these technologies do not diffuse to all countries and regions equally. In other words, the fact that large proportions of patented technologies do not have enforceable rights in other countries does not necessarily generate technological diffusion. This is mostly a result of the different local innovation capabilities to exploit the existing technologies, regardless of whether they are publicly available or not.

Overall, there is ample theoretical and empirical literature on how different standards of IP protection affect technology transfer, foreign direct investment

[14] History provides a vast collection of failed "new" Silicon Valleys, while there are several examples of regions specializing "smartly" in a given technology exploiting their relative knowledge and natural advantages. See several examples for Latin American–specific clusters in Pietrobelli and Rabellotti (2006).

[15] See footnote 4.

(FDI), trade flows, and domestic innovation in developing economies, which Keun Lee's chapter in this volume discusses in further detail (see Chapter 4). Two elements are however worth recalling: (i) most patent rights are not protected in poorer economies because of a lack of imitative threat, and (ii) those economies (notably China and the Republic of Korea) that successfully integrated in GINs did so through firms that pro-actively built up patent portfolios (mostly in relation to information technology), mainly to be able to export to rich country markets.

This is not to say that IP cannot be a useful policy instrument to overcome market failures related to knowledge as a public good. Indeed, all the core innovation hotspots show an intensive use of the IP system, both nationally and internationally.

It is also important to mention that IP policies always interact with other public policy tools – namely public funding of R&D activities and infrastructure – aiming at stimulating innovation activity in the private sector. Interestingly, outside the core innovation countries and regions of the world, we do observe a promising increase in scientific activity, but we fail to observe the equivalent use of the patent system. Indeed, in these peripheral regions, most of the patenting results from research produced in universities and research institutions, which are largely publicly funded. It is not always clear to what extent patented inventions are then transformed into commercialized products.

Innovation policies – and IP policies within these – that stimulate the participation of the private sector in the creation of new knowledge and technologies could go a long way toward improving the local innovation ecosystem of these economies. Embedding IP into the targeted regional capability-enhancing policies described earlier is certainly a complementary and feasible strategy. Policymakers should be actively conscious of any cumbersome IP procedures or other barriers preventing local entrepreneurs and companies from using the IP system efficiently. They should also be realistic about policy priorities, as in many cases innovation is hampered by other more pressing matters than IP.

2.3 CONCLUSIONS

In this chapter, we have revisited empirically the unequal geographical distribution of innovation by exploiting rich data from international patent applications and scientific articles.

Despite some new countries – notably in Asia – joining the traditional core economies in the production of new S&T outputs, the global spread of innovation remains limited. Our analysis also shows that, within these economies, the production of innovation is unevenly concentrated in large metropolitan areas.

The secular trends offer some room for optimism, especially if the technologies reducing the cost and enhancing the quality of interconnectivity keep progressing. Our analysis supports in part such optimism. Innovation-related collaboration, in general, and international collaboration, in particular, are mostly increasing. The challenges observed relate to who would reap more benefits from such enhanced connectivity. Indeed, our analysis also shows that, in the current form, the global network of S&T flows is largely concentrated as well. Only a few economies, and a few hotspots within these, represent the bulk of the connections.

There is also some room for pessimism. Recent years show some increase in innovation concentration. Indicators of R&D investments and international patents – especially those highly cited or relating to high-tech or complex technologies – evidence a reconcentration pattern since the second half of the 2000s. Hopefully, this process may just be the result of a new cycle of breakthrough innovation, led by more technologically advanced countries and regions (Kemeny and Storper, 2020). If this is the case, we expect that technological diffusion – and the associated geographical innovation spread – will resume shortly. Nonetheless, it is also apparent in our analysis that only a few countries and regions will act as the main gateways to access the new technology.

Part of the unequal geographical distribution of innovation seems unsolvable by itself, as the economic benefits of agglomeration go far beyond innovation. Nevertheless, we have also documented that innovation is much more geographically skewed – both nationally and subnationally – than other economic activities. This increases the challenge faced by policymakers. National policymakers around the world are already struggling with the problems that regional disparities of income, unemployment, or infrastructure convey. More skewed innovation outputs and flows just make their tasks even harder.

Last, we give some thoughts about what policy consensus the innovation and economic geography literatures can offer. We make the case for national and regional innovation policies that are balanced and attainable. It is always a good practice to acknowledge that these policies are likely to have distributional consequences within countries and regions.

In the context of growing skepticism toward multilateralism after the Great Recession, we also discuss the benefits of openness, as it should not be taken for granted. Certain signs of globalization reversal – or *slowbalization* – are troubling. The increasing self-sufficiency of the largest innovation hotspots and their isolation in an exclusive innovation network could be really bad news for economies and regions aspiring to catch up technologically and, in turn, economically.

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