Reclaiming Brain Power: The Impact of Global Strengthening of IPRs on the Movement of Inventors

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Abstract

The number of highly skilled workers residing in a country represents a key source of national innovative capacity. Much attention has been paid to the policies in high-income countries that attract high-income immigrants, but less is known about which policies contribute to the retention of innovators in their home countries. We ask what role intellectual property rights (IPRs) play in innovators' migration decisions, and how the strengthening of IPRs in emerging and developing countries (EDCs) since the 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) affected the rate of inventor emigration (or brain drain) from EDCs. Using data on the nationalities of inventors and their countries of residence in patent filings, we document rising rates of inventor emigration from low-income to OECD countries in organizational (corporate and public) patents between 1993 and 2011. However, during the same period, the emigration rate of individual inventors declined, leading to a widening gap in estimated rates of emigration between individual and organizational (corporate and public) patentees. EDCs that implemented TRIPS experienced a significant reduction in the rate of emigration to OECD countries by individual relative to organizational inventors.

Keywords: Intellectual Property Rights, TRIPS, inventor migration, brain drain

JEL classification: O34, O33, F13, F14

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1 Introduction

The number of highly skilled workers residing in a country represents a key source of national innovative capacity, and host countries compete to attract talent from abroad (see e.g. Kerr, 2018). A substantial literature has documented the contributions of immigrant innovators and entrepreneurs in high-income countries, and many countries have special programs to facilitate permanent residency for such workers (Ganguli, Kahn, and MacGarvie, 2020). Much attention has been paid to how policies in high-income countries affect flows of skilled immigrants, but less is known about which policies contribute to the retention of innovators in their home countries. In source countries, the flight of high-skilled human capital is often perceived as an alarming loss of innovative talent (or “brain drain”) and a problem to be corrected. Immigration policy has been the main focus for governments seeking to influence flows of innovators. Yet immigration policy does not address a core issue: the government institutions and the national climate for innovation that make staying in the home country a profitable choice for innovators.

In this paper, we ask what factors are associated with the retention of inventors in the home country, recognizing that different types of inventors may be influenced by different incentives. We argue that intellectual property rights (IPRs) play a role in innovators’ migration decisions and the maximization of gains from innovator migration. This argument is perhaps not surprising, given that inventors are the producers of intellectual property, and the underlying purpose of IPRs is to ensure that inventors receive a secure monetary compensation for their inventions (Maskus, 2012). The role of IPRs in shaping inventors’ migratory patterns has been largely ignored by the prior literature, which has mainly focused on the impact of IPRs on corporate patenting. However, individual inventors are particularly important in lower income countries (Ervits, 2020), leading us to expect that variation in IPRs affecting individual inventors may have bigger effects in these countries. In this paper, we study the relationship between IPRs and inventor migration, asking the following questions. First, to what extent are flows of inventors associated with the strength of IPRs in sending countries, and which types of inventors are most affected? And how has the strengthening of IPRs in emerging and developing countries (EDCs) since the 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) affected the rate of inventor emigration (or brain drain) from EDCs?

We answer these questions using data on the migration of inventors across countries from Miguelez and Fink (2013). These data, which allow us to observe the nationality of inventors when a patent is filed, as well as the type of inventor (individual, corporate, or public sector), reveal some intriguing patterns. First, we document high rates of emigration of inventors from low-income to OECD countries in corporate patents between 1993 and 2011. However, during the same period, the emigration of individual inventors as a percentage of national inventors declined on average, leading to a widening gap in estimated rates of emigration between corporate and individual patentees. These effects are largest in lower middle income countries (LMICs), where resident patenting activity by corporations is low. Second, we find that flows of individual inventors are particularly sensitive to factors associated with the environment for commercializing innovation in a country. Countries with higher levels of human capital and financial openness tend to have lower rates of emigration of individual inventors, while these factors are not associated with lower rates of emigration among other types of inventors.

These patterns raise the possibility that the strengthening of intellectual property rights that took place in many lower-income countries as a result of the TRIPS Agreement may have led to a reduction in the "brain drain" of inventors. Figure 1 illustrates the rate of inventor emigration from EDCs to OECD destinations over the period from 1993 to 2011.[1] The emigration rate for a given country is measured as the share of non-resident inventors included in patent applications filed from that country under the Patent Cooperation Treaty (PCT).[2] From Figure 1, 29% of PCT patent applications filed from the group of EDCs in 1993 were filed by non-resident inventors who were nationals of an EDC but resided in an OECD country. The rate of inventor emigration showed a steady increase in the 1990s, which substantiated concerns about brain drain. However, a noteworthy shift occurred in the early 2000s, as the trend reversed and the rate of inventor emigration started to decline. This reversal coincided with the EDCs' implementation of significant adjustments to IPR protection, in order to meet the strong standards mandated by the TRIPS Agreement. Notably, a majority of EDCs in our sample have achieved compliance with most provisions of the TRIPS Agreement in 2000-2005.

The empirical challenge of this paper is to credibly measure a causal effect of strong IPR protection on inventor migration flows in the presence of potential endogeneity in national reforms of intellectual property systems. Countries' levels of IPR protection could be motivated by an aspiration to build national innovative capability, which in turn influences inventor migration. To mitigate this concern, we follow the literature and use the TRIPS Agreement as a natural experiment.[3] We argue that the strengthening of IPRs in EDCs after the year 1994 was exogenously imposed by the TRIPS Agreement, rather than endogenously chosen by countries in response to

[1]For more details on the data, see notes under Figure 1.

[2]The PCT is an international patent law treaty administered by the World Intellectual Property Organization (WIPO). It assists applicants in seeking patent protection internationally for their inventions and provides a unified procedure for filing patent applications in more than one contracting state. As of November 2021, the PCT has 154 contracting states. Patents filed under the PCT system are often associated with the most valuable inventions, primarily because the applicants are willing to invest in protecting their intellectual property across multiple jurisdictions. Therefore, based on these data, we identify a cohort of the most skilled inventors with significant economic impact.

[3]See for example, Delgado, Kyle, and McGahan (2013), Kyle and McGahan (2012), Kyle and Qian (2014), Cockburn et al. (2022), and Cavalli et al. (2024).

domestic innovation activity. The TRIPS Agreement came out of the Uruguay Round of Multilateral Trade Negotiations and when the Round ended in 1994, acceptance of all of its results in a "single undertaking" was a compulsory requirement of membership in the World Trade Organization (WTO).[4] While all WTO members were required to sign the Agreement in 1994, many were given transitional periods before they were obliged to comply with all of the TRIPS provisions. The timing of TRIPS compliance thus varied across countries, and we exploit this variation using data on when particular countries implemented TRIPS from Delgado, Kyle, and McGahan (2013).[5]

The TRIPS Agreement provided an external push to reform national IPR regimes—which alleviates potential concerns about endogenous selection of countries into IPR reforms based on domestic innovation activity or related characteristics. But while the strengthening of IPRs was exogenously imposed, certain countries might have synchronized the reforms of IPR systems with other policy changes that also influence global inventor mobility. Such synchronization would confound our estimate of the impact of TRIPS implementation on inventor migration. To address this concern of endogeneity due to confounding domestic policy changes, we exploit variation in sensitivity to national IPR reforms across different types of inventors. Specifically, we compare the behavior of two types of inventors, based on the type of patent applications: individual and organizational patentees (the latter are corporations, universities and public research institutes). We argue that in EDCs—where innovation systems and regimes of appropriability are weaker — individual inventors are most sensitive to national IPR reforms. Although both individual and organizational inventors are affected by the TRIPS Agreement, we expect that the impact on organizational inventors is smaller because these inventors have access to alternative mechanisms for protecting IP (Zhao 2006). We can thus think of individual inventors as belonging to a "treatment" group, and use organizational inventors as "controls". Then in a difference-in-difference (DiD) setting, we examine the post-TRIPS change in the emigration rate of individual inventors compared to the post-TRIPS change in the emigration rates of organizational inventors. By comparing the inventor emigration rates over time around the TRIPS compliance year and along the two dimensions—within each country-sector pair and across sectors—we aim to isolate the causal

[4]Stegemann (2000) writes in this respect: "It is unlikely that any of the newly industrialized, developing or transition countries would have accepted the TRIPS Agreement if it had stood by itself, without compensating concessions based on other agreements in the WTO system. Also, many of these countries might not have accepted the TRIPS obligations in exchange for the new market access concessions obtained during the Uruguay Round, because these were meager and uncertain ... By 1994 everybody knew what the realistic alternative (to accepting the TRIPS Agreement) was: being forced into bilateral agreements to guarantee increased protection of intellectual property in exchange for continued access to US markets, without possessing the rights granted by the multilateral system and the collective security of its dispute settlement procedures (Stegemann, 2000; p. 1243)."

[5]The authors complied these data using information from the WTO's original compliance schedule, the Ginarte and Park (1997) index of patent rights (updated in Park, 2008), and the Hamdan-Livramento (2009) index of IPRs.

impact of strengthening IPR protection in EDCs on the rate of inventor emigration from these countries to the OECD destinations.

Individual patentees are individual inventors, self-employed entrepreneurs or owners of small companies or enterprises, who tend to patent in their own name. As we discuss in the next section, individual inventors are most sensitive to national IPR reforms in EDCs. We argue that this is for two reasons. On one hand, they depend heavily on the IPR system to appropriate the returns from their inventions. Alternative appropriability mechanisms (e.g., ownership of specialized complementary assets) are often not a viable option for them. On the other hand, individual inventors in EDCs face a number of challenges in accessing the IPR system, including limited resources and complex and unpredictable patent prosecution processes. Reforms of IPR systems that lower these barriers by (for example) simplifying the patent procedures, reducing the cost of obtaining patents, and increasing the strength and enforceability of patents can greatly improve individual inventors' access to the IPR system.

We find that EDCs that implemented TRIPS experienced a significant reduction (by about 13 percentage points) in the rate of emigration of individual inventors into OECD destinations, relative to the control group of corporate and academic/public inventors. Consistent with the lengthy process of inventing and filing patents, the treatment effect of TRIPS compliance appears gradually but tends to persist over time (primarily in LMICs). The estimated timing of changes in the emigration rate further shows no decreases in emigration rates in the control group of organizational inventors.

This paper provides new empirical evidence about the impact of global strengthening of IPRs on innovator migration and explores whether the enactment of stronger IPR protection in EDCs limited inventor emigration from these countries. The two strands of literature that our paper contributes to—on global IPRs reforms and inventor migration—have been pursued largely in isolation of each other. The literature on IPRs has uncovered the important role that countries' IPR regimes play in determining foreign market access, production location decisions of innovative firms, and technology transfer via international trade and multinational firm activity. The overarching finding has been that stronger IPRs in foreign markets lower the risk of technology misappropriation and imitation in those markets and thereby promote production and trade there—e.g., via foreign direct investment.[6] More recent work by Cockburn et al. (2022) documents increases in basic science research and licensing revenues in pharmaceuticals within TRIPS-adopting countries. Similarly, Blomfield et al. (2022) document increased attention by high-income country researchers to the

[6]See for example, Taylor (1993), Maskus and Penubarti (1995), Javorcik (2004), Branstetter, Fisman and Foley (2006), Ivus (2010, 2015), Branstetter et al., (2011), Naghavi, Spies, and Toubal (2015), Ivus, Park and Saggi (2017), and Ivus and Park (2019).

science produced in TRIPS-adopting countries, alongside a rise in patents based on this research in high-income countries. Cavalli et al. (2024) further demonstrate that TRIPS compliance has bolstered scientific practices and enhanced research capabilities in emerging and developing countries, extending institutional systems in upper-middle-income countries to encompass scientific activities focused on locally relevant neglected diseases. This, coupled with the increase in licensing, points toward improvements in the functioning of markets for technology, creating a more favorable environment for commercialization by individual inventors and reducing their incentives to emigrate to OECD countries. Balachandran and Hernandez (2019) document an increase in international alliances after countries adopted TRIPS, particularly among more 'peripheral' firms with lower status and fewer resources. This is consistent with the idea that the business environment may have improved most for individual inventors post-TRIPS.

The literature on the international migration of innovators has largely focused on the effects of migration for source and host countries (Ivus and Naghavi, 2014). Prior to the 1990s, this literature was primarily concerned with brain drain and its impact on welfare in source and host countries.[7] Later literature considered the factors that turned brain drain into gain for source countries.[8] Consideration of how the migration decisions of innovators are determined and what role government institutions play in the process has been limited.

Currently, empirical research on the impact of IPR protection on brain drain is scant. One exception is Naghavi and Strozzi (2015). This paper argues, building on the conceptual framework in Naghavi and Strozzi (2017), that stronger IPRs in EDCs can encourage knowledge acquired by emigrants to flow back to their source countries through diaspora networks, and that this flow-back generates brain gain if the source country's IPRs are strong. Using data on 34 EDCs from 1995 to 2006, Naghavi and Strozzi (2015) shows that the presence of diaspora networks strengthens the link between IPR protection and innovation in the source countries. Strong IPRs increase the countries' capacity to absorb potential gains from diaspora networks and so, enhance the country's potential for innovation. While Naghavi and Strozzi (2015) focused on the interplay between the strength of IPRs and migration stocks in determining innovation activity in EDCs (measured by the number of resident patent grants), our focus is on the role of IPR protection in determining the migration decisions of inventors. We show that strengthening IPRs in EDCs has a direct role

[7]See for example, Berry and Soligo (1969) and Bhagwati and Hamada (1974).

[8]Some example are: Vidal (1998), Kapur and McHale (2005), Oettl and Agrawal (2008), Docquier and Rapoport (2012), Gibson and McKenzie (2012), and Agrawal (2014). Studies have found that the prospect of migration provides an incentive for human capital formation (Mountford, 1997; Stark, Helmenstein and Prskawetz, 1997; Beine, Docquier and Rapoport, 2008). Source countries might also benefit from the return of migrants who have acquired skills abroad (Mayr and Peri, 2009; Dustmann, Fadlon, and Weiss, 2011; Kahn and MacGarvie, 2016) or the circulation of foreign knowledge through migrants' diaspora networks and close-knit, ethnic scientific communities (Saxenian, 2002; Kerr, 2008; Agrawal et al., 2011; Miguelez and Temgoua, 2020).

to play in limiting brain drain, or reclaiming brain power.

Our paper is also closely related to two theoretical contributions that examine the relationship between skilled migration and IPRs institutions. In a model of Nash equilibrium IPR policy choice, McAusland and Kuhn (2011) shows that governments have incentives to strengthen IPRs in a bidding war for global talent. Driven by this “bidding for brains” incentive, advanced countries will pass overreaching IPRs (relative to globally efficient levels). In contrast, developing countries experiencing extant brain drain will find it optimal to offer weak IPR protection. This incentive to underprotect IPRs is due to the “expatriate brains” effect: innovations produced by the departed innovators abroad are less valued by the source-country consumers. Ivus, Naghavi and Qui (2020) compares the implications of two policies: (1) strengthening IPRs in the South, and (2) opening the North to immigration of high-talent individuals as a means of pre-empting imitation. The framework is an occupational choice model of innovative North and imitative South, in which the likelihood of imitation depends on product quality, entrepreneurial ability, and the strength of IPRs. The model shows that the policies’ impacts depend on the endogenous entrepreneurship decisions and the intensity of competition. From a global development perspective, openness of the North to high-talent migration is more appealing as it helps the South to reduce its reliance on the production sector and promote transition towards a more entrepreneurial economy. The current paper suggests an alternative mechanism through which the entrepreneurial sector in the South may be developed: by strengthening South’s IPRs to retain independent inventors.

This paper also contributes to our understanding of national innovation systems in less-developed economies. Studies of national innovation systems have primarily focused on developed economies, where robust IPR systems and well-established institutions facilitate the effective appropriation of returns from innovation. But less-developed economies encounter a distinct set of challenges in this regard. These economies often grapple with emerging innovation systems that lack the capacity to promote research and development (R&D) efforts and support technological advancements. They also suffer from weak institutional environment, which hinders the establishment of strong linkages between various components of the innovation system (Aboites and Cimoli, 2002). Weak appropriability regimes (e.g., due to dysfunctional administrative bodies and inefficient legal systems) further impede the effective prosecution and enforcement of IPRs and render the systems of IPR protection unreliable.

The remainder of the paper is structured as follows. Section 2 provides background on the implementation of the TRIPS Agreement and discusses the variation in sensitivity to TRIPS across different types of inventors in EDCs. Section 3 outlines the conceptual framework guiding our analysis. Section 4 details the data sources and empirical methodology employed. Our main results are presented in Section 5, followed by robustness checks in Section 6. Section 7 discusses the implications of our findings and concludes the paper.

2 Background

2.1 TRIPS implementation

The TRIPS Agreement is an international accord that establishes minimum standards for IPRs at the level of major developed countries and requires all members of the WTO—regardless of their economic conditions and technological capabilities—to comply with these standards. The Agreement covers a wide range of aspects that member countries must incorporate into their national legal systems, such as provisions regarding the duration of protection, the extent of rights conferred, enforcement procedures, remedies for infringement, etc. The standards apply to various forms of intellectual property, including patents, copyright, trademarks, geographical indications, industrial designs, and trade secrets. Unlike the previous international IPRs treaties—e.g., the Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886)—the TRIPS Agreement places a strong emphasis on effective enforcement and provides mechanisms for addressing IPRs-related disputes through the WTO dispute settlement system.[9]

The TRIPS Agreement was designed to achieve universal standards of intellectual property laws, ensuring that IPRs are protected and enforced uniformly and consistently across nations. Achieving this goal necessarily required implementing asymmetric increases in the strength of IPR protection across the world. Countries with weaker IPRs, predominantly EDCs and least-developed countries (LDCs), were compelled to enact relatively more substantial improvements to their own IPR regimes. Many such countries opposed the TRIPS Agreement.[10] Recognizing this opposition, the WTO did not impose an immediate implementation of the Agreement but rather, included the provision of different transitional arrangements. The duration of the transitional periods depended on the country's level of development, institutional capacity, and whether a country was obliged to extend product patent protection to areas of technology not protectable in its territory when the Agreement took effect. Under Article 65 of the Agreement, countries self-designated as 'developing' when they joined the WTO and economies in transition from central planning were

[9] See Maskus (2012) for an insightful discussion of the global changes in IPRs policies since 1994 and an in-depth analysis of the benefits and costs of the global IPR system.

[10] Saggi and Ivus (2020) discusses the rationale for international coordination over national patent policies and explains why developed and developing countries often have radically different views of IPR protection.

given till 1 January 2000 to fully adopt the TRIPS provisions. Economies undertaking structural reform of their IPR systems and facing special problems in the preparation and implementation of intellectual property laws and regulations were entitled to the same transitional arrangement. For developing countries that did not provide product patent protection in a particular area of technology when the TRIPS Agreement came into force, the deadline was extended to 2005 to introduce the protection.[11] LDCs were initially given until 1 January 2006 to apply most TRIPS provisions. Most new members who joined the WTO after its creation in 1995 have agreed to apply the TRIPS Agreement upon joining.[12]

The WTO also aimed to ensure a consistent and standardized approach, with a predictable timeline, for the integration of TRIPS provisions into national laws and regulations. So once the schedule of compliance with TRIPS was determined, it was quite strictly prescribed. Countries were limited in their ability to change the deadlines.[13] By enforcing the schedule, the WTO sought to prevent undue delays or exceptions that could undermine a consistent and timely implementation of TRIPS provisions.

The TRIPS Agreement significantly enhances our empirical strategy by providing an exogenous impetus to strengthen IPRs in EDCs. The timing of TRIPS implementation allows us to leverage data from 1993 to 2011 to identify its impact. Although the Agreement was signed in 1994, the delayed implementation across countries enables us to observe migration flows both before and after TRIPS for 70 EDCs in our sample. This over-time variation within each TRIPS-compliant country helps us estimate changes in migration patterns following TRIPS implementation, mitigating the influence of unobserved permanent differences across countries. Additionally, by comparing TRIPS-compliant countries to 32 EDCs that did not comply during our sample period, we can control for global migration trends common to all countries but potentially varying across sectors. Furthermore, by exploiting the differential sensitivity to TRIPS between individual and organizational inventors, we address concerns about confounding time effects common to both groups. This approach allows us to isolate the effects of TRIPS from other concurrent domestic policy reforms that influence inventor migration decisions in all sectors.

[11]Some developing countries have used this provision to delay patent protection for pharmaceutical products and agricultural chemicals.

[12]The specific terms of each member's accession may vary according to the new member's terms of accession, which it negotiates with the existing WTO members.

[13]The WTO allows members to request an extension of the transitional period for compliance with certain TRIPS provisions. The extension is not automatic and is subject to negotiation between the requesting country and other WTO members. Its duration is also limited. The LDCs have used this option to extend their transitional period twice, first until 2013 and then further until 1 July 2021 (and first until 2016 and then until 1 July 2033 for pharmaceuticals specifically).

2.2 Variation in sensitivity to TRIPS

Central to our identification strategy is the argument that in EDCs, individual inventors are particularly sensitive to national adjustments of IPR systems mandated by the TRIPS Agreement. It is important to emphasize here that we argue this in the context of EDCs, where national innovation systems are less extensive and regimes of appropriability are weak.

Several papers have studied domestic patenting activity in less-developed economies,[14] revealing that these regions often exhibit distinct traits within their national innovation systems. These include a predominant role of individuals in patenting activities, minimal corporate participation in innovation, sporadic patenting efforts, and a lack of effective collaboration between businesses and local academic or research entities. Such patterns emerge from the challenges posed by underdeveloped innovation systems, including resource scarcity, unstable environments, complex patenting processes, and obstacles to academia-industry cooperation.

The above findings were established for Brazil, India, Mexico, South Africa, and Taiwan. Using data on Indian patents from 1974 to 1991, Rajeswari (1996) found that domestic individual inventors published the majority of patents (36.4%), followed by private industry (33.5%), and public R&D institutions (19.8%). The low patenting activity by the public R&D institutions is attributed to complex patenting procedures that discourage scientists from applying for patents and the allocation of R&D funding primarily to salaries rather than innovation projects. Albuquerque (2000) reports similar findings for Brazil, using both domestic and U.S. patent data. Between 1980 and 1995, Brazilian resident individuals owned a significant share of patents (34.4% of domestic patents and 42.7% of USPTO patents), while corporations and other institutions were minimally involved in patenting activities.[15] Additionally, only 38% of firms had more than one patent during this 16-year period. In Taiwan, the patenting share of individual inventors is particularly high. Choung (1998) finds, using U.S. patent data from 1969 to 1992, that individual inventors accounted for 80-90% of U.S. patenting. This high share reflects Taiwan's volatile environment with limited resources, a substantial number of self-employed entrepreneurs, and numerous small firms. Aboites and Cimoli (2002) further notes that in Mexico, universities and public research centers are not considered significant knowledge sources for domestic science-based firms. Albuquerque (2003) compares the national innovation systems of Brazil, India, Mexico, and South Africa using USPTO data from 1981 to 2001. The study focuses on the nationality (resident and foreign) and type (individual and firm/institution) of inventors/assignees, reporting high shares of individual

[14] See for example, Rajeswari (1996), Albuquerque (2000), Choung (1998), Aboites and Cimoli (2002), and Albuquerque (2003).

[15] Some individual patents stemmed from the public R&D infrastructure by researchers.

inventors and assignees in patenting. In Brazil, resident individuals are the first inventors on 32% of patents for which the first assignee is a resident. This percentage is 23% in India, 53% in Mexico, and 46% in South Africa. Among patents where the first inventor is a resident, the first resident assignee is an individual in 34% of cases in Brazil, 23% in India, 56% in Mexico, and 47% in South Africa.

In less-developed economies, patents serve as a crucial mechanism for individuals with limited resources to safeguard their intellectual property from larger, well-financed entities. Penrose (1973) highlights the importance of this protective function (p.769):

> "*[O]ne of the effects of patents is supposed to be to assist the small man with few resources to protect his position against the large well-financed firm. This may not be very important in a modern industrial country... But a less-developed country can itself, in a sense, be looked on as a 'small man' vis-a-vis the developed industrial country, and one can argue that a domestic patent system may protect a local inventor from having his ideas taken over without his permission and without adequate compensation by multinational enterprises operating in the country.*"

This protective role of patents ensures that local inventors can secure their innovations from unauthorized use or theft, thereby encouraging them to invest in creative endeavors and the commercialization of their patented inventions.

By contrast, changes in the strength of IPRs have a relatively smaller impact on inventors employed by corporations. First, corporate inventors have access to a broader range of resources and support systems (e.g., financial backing, legal expertise, technological know-how). So their ability to appropriate the returns from their inventions does not critically depend on the system of IPRs . Sirilli (1987) also argues that inventors in corporations often have difficulty evaluating the causal links between their inventive activity and the protection of the results derived from it. This is because the patenting process within corporations is often complex and involves multiple stakeholders, including legal and business teams.[16] Furthermore in less-developed countries, where the legal appropriability environment is weak, corporations tend to rely more heavily on mechanisms other than patents to capture value from innovation. Commonly used mechanisms are firm specificity in R&D, control of specialized complementary assets, secrecy, lead time advantages, relational mechanisms of governance, and novel management practices (Levin et al.,

[16]Sirilli (1987) writes: "the data indicate that the individual inventors are more patent-oriented while those working in companies with more than 500 employees would in any case have produced the invention. In the latter case such factors come into play as the capacity of the larger companies to protect their own technology using means other than the patent, and the difficulty encountered by employees in large industrial complexes in evaluating the causal links between inventive activity and protection of the results deriving from it."

1987; Cohen, Nelson and Walsh, 2000; Teece, 2000; Zhao, 2006; Somaya, 2012; James, Leiblein and Lu, 2013; Jean, Sinkovics and Hiebaum, 2014; Barros, 2015; and Kotabe, Jiang and Murray, 2017).[17] Kotabe, Jiang and Murray (2017) further emphasize the organizational capability of firms in emerging markets to acquire resources through political networking with government officials.[18] Some firms employ a value capture strategy that includes a bundle of mechanisms, such as the simultaneous use of patents and trade secrets (Somaya, 2012).

Academic and public inventors face distinct incentives and constraints compared to individual and corporate inventors. Their reliance on public funding, often tied to conditions like open access or intellectual property restrictions, significantly influences their patenting behavior. Those engaged in basic research prioritize rapid dissemination over patenting, while applied researchers are more patent-oriented. However, commercializing applied research findings typically requires additional development through industry collaboration. In less-developed countries, universities may lack experience with industry collaboration on innovation projects due to cultural and institutional barriers.[19] Consequently, their innovation activities are less likely to lead to commercially exploitable patents. Moreover, the absence of supportive institutions like technology transfer offices and business incubators limits academic/public inventors' ability to realize value from their inventions through patents (Gong et al., 2020).

3 Conceptual Framework

In what follows, we present a conceptual framework that generates predictions about how IPRs affect the migration decision and the rate of emigration for individual and organizational inventors. We then turn to the data to assess these predictions.

[17]Barros (2015), for example, finds that when appropriability regime is weak, firms adopt novel management practices to reinforce their ability to capture value from innovation. The data on patent behavior of firms in Brazil, where legal system is inefficient and levels of safeguarding against infringements of property rights are low, supports this finding. Zhao (2006) stresses the ability of multinational companies to substitute internal organizations for external IPRs in countries with weak institutional environments. This explains why multinational companies conduct R&D in weak IPRs countries, like China and India. The multinational firm is in essence a mechanism for arbitraging institutional gaps around the world using, where available, its close internal global knowledge network so as to exploit underutilized human capital in areas with relatively weak IPR protections.

[18]The results from a survey of 108 senior executives in China show that political connections allow firms to strengthen their enforcement mechanism for innovative activities (e.g., stop unlawful imitations by rivals).

[19]Among such barriers, Guimón (2013) underscores universities' lack of resources and capabilities to produce research results that can be exploited commercially and industry's own low R&D capacity and technological capability necessary to absorb the products of public research. Zuñiga (2011) further writes than in less-developed countries, "institutional constraints such as employment rules for civil servants and bans on creating private organizations at public universities (or joint ventures with firms) limit academic entrepreneurship and the potential exploitation of patents and other forms of IP."

Consider a start-up inventor residing in her home country with an idea for an invention for which there is demand on the global market. The inventor files a patent domestically and considers how to develop and commercialize the invention.[20] She must decide whether to commercialize independently or collaborate with an established organization, which involves assigning international patents to the organization.[21]

Let V denote the value of the invention. Collaborating with an established organization generally reduces the costs of commercialization due to the firm's specialized complementary assets, established distribution networks, and other resources. This collaboration lowers the inventor's cost of commercializing and patenting the idea internationally from C_i to $C_o < C_i$.[22]

The inventor's value from independent commercialization is equal to $\Pi_i = V - C_i$. If the inventor chooses to collaborate with an organization, the inventor will retain the share δ of the value of the invention. So the inventor's value from commercializing through the organization is equal to $\Pi_o = \delta V - C_o$. The inventor will choose independent over organizational commercialization if the value from independent commercialization exceeds that from organizational commercialization: $\Pi_i > \Pi_o$. Using the solutions for Π_i and Π_o, we obtain:

$$\Pi_i > \Pi_o \qquad \text{if} \qquad (1-\delta)V > C_i - C_o \qquad \Leftrightarrow \qquad C_i < (1-\delta)V + C_o.$$

In other words, the inventor will choose independent over organizational commercialization if the extra value from independent commercialization exceeds the extra cost.

Conditional on the chosen type of commercialization, the inventor decides on her country of residence. The inventor can develop the invention for commercial application while residing at home or emigrating abroad (A) to a country with stronger IPRs.

Assume that emigrating permits the inventor to develop the invention for commercial application at a reduced cost abroad: $C_i^A < C_i$ and $C_o^A < C_o$. Stronger IPRs abroad mitigate the risks of idea misappropriation and imitation and reduce the need to allocate extra resources to alterna-

[20] We assume that inventors receive ideas as random draws from a distribution of idea quality. The patent system does not primarily stimulate the generation of these ideas. Instead, it plays a crucial role in promoting the development and commercialization of these ideas. By providing legal protection and potential financial rewards, patents incentivize inventors and investors to allocate resources towards refining, developing, and bringing these ideas to market. This framework underscores the importance of IPRs in transforming raw ideas into commercially viable products, thereby fostering innovation. The perspective that patents provide substantial *ex post* incentives to commercialize inventions, rather than merely *ex ante* incentives to invent, is emphasized in Sichelman and Graham (2010), for example.

[21] The inventor can either work as employee of the organization or transfer the ownership of the patent.

[22] Even if the inventor transfers ownership of the patent, they will generally still incur some costs associated with collaborating on the invention's development with the organization. However, in the extreme case where the inventor has minimal involvement in commercialization, $C_o = 0$.

tive protection mechanisms for the invention. Additionally, a robust intellectual property system and innovation ecosystem abroad can provide the inventor with access to specialized expertise, resources, and supportive networks, thereby facilitating a more efficient and effective process of developing the invention. Let $\varphi_i \equiv 1 - C_i^A/C_i$ and $\varphi_o \equiv 1 - C_o^A/C_o$ denote, respectively, the home's cost disadvantage (relative to the cost abroad) for the individual inventor (who commercializes independently) and organizational inventor (who commercializes through an organization). It is reasonable to assume that the home's cost disadvantage is greater for the individual inventor: $\varphi_i > \varphi_0$. This could reflect the fact that established organizations have complementary assets that dampen the effects on costs of differences in the economic (or intellectual property) environment across locations, while the costs of independent inventors are more sensitive to the strength of IPRs as they have fewer alternative mechanisms for protecting their inventions.

Assume further that emigrating allows the inventor to retain a higher share of the invention's value when collaborating with a foreign organization compared to a domestic one: $\delta^A = \rho\delta$, where $\rho > 1$. By paying a premium ($\rho > 1$) to the inventor, a foreign organization compensates for the additional value it gains from accessing intellectual property from another country. This premium reflects the potential benefits for a foreign organization, such as tapping into talent pools and expertise that may be scarce in the organization's home country, diversifying the patent portfolio, and gaining competitive advantage.[23]

Emigrating also involves a relocation expense, F. For simplicity, we assume that this expense does not depend on the inventor type: $F_i = F_o$.

It follows that for the individual inventor, the value from developing the invention abroad is $\Pi_i^A = V - C_i^A - F = V - (1-\varphi_i)C_i - F$, while the value from developing it at home is $\Pi_i = V - C_i$. The independent inventor will choose to emigrate over residing at home if

$$\Pi_i^A > \Pi_i \qquad \Leftrightarrow \qquad \varphi_i C_i > F \qquad \Leftrightarrow \qquad C_i > \frac{F}{\varphi_i}.$$

Thus, emigrating is optimal for the individual inventor if the cost savings from developing the idea abroad, $\varphi_i C_i$, exceed the relocation expense, F.

For the organizational inventor, the value from developing the invention abroad is $\Pi_o^A = \delta^A V - C_o^A - F = \rho\delta V - (1 - \varphi_o)C_o - F$, while the value from developing it at home is $\Pi_o = \delta V - C_o$.

[23] Our results remain valid even if we assume that $\rho = 1$.

The organizational inventor will choose to emigrate over residing at home if

$$\Pi_o^A > \Pi_o \qquad \Leftrightarrow \qquad (\rho-1)\delta V + \varphi_o C_o > F \qquad \Leftrightarrow \qquad C_o > \frac{F-(\rho-1)\delta V}{\varphi_o}.$$

That is, emigrating is optimal for the organizational inventor if the resulting increase in the retained value of the invention, $(\rho-1)\delta V$, combined with the cost savings from developing the idea abroad, $\varphi_o C_o$, exceeds the relocation expense, F.

The inventor's location and the form of patent ownership depend on the values of the parameters discussed above. Figure 2 (on the left) illustrates the parameter ranges over which the inventor will choose one of the four options: independent residing at home (R_i), independent emigrating abroad (E_i), organizational residing at home (R_o), and organizational emigrating abroad (E_o). The emigration rates of independent and organizational inventors are denoted $E_i/(E_i+R_i)$ and $E_o/(E_o+R_o)$ respectively. We next obtain predictions about the how the rates of emigration for independent and organizational inventors will vary with changes in IPRs.

The impact of stronger IPRs at home

The effect of TRIPS on IPRs in the home country is twofold. First, the inventor's share of the value of the invention rises: $d\delta/dIPR > 0$. The inventor's share is small when appropriability is weak. This could be due to high risk of imitation by competitors (Gans and Stern, 2003) or due to the disclosure problem.[24] Stronger IPRs reduce the risk of imitation and mitigate the disclosure problem and thus increase the inventor's share. Second, a strengthening of IPRs is expected to reduce the cost disadvantage of developing and patenting the idea at home. With weak IPRs in the home country, inventors are less likely to be able to successfully convert their ideas to the commercialization stage because of the risk of imitation, and incur higher costs to find alternative ways to protect the idea under development from the risk of imitation. This effect is expected to be particularly strong for individual inventors, who in comparison to organizations have reduced access to complementary assets that enable alternative mechanisms of protecting their IPRs. This implies that $-d\varphi_i/dIPR > -d\varphi_o/dIPR$. For simplicity, we assume that $d\varphi_o/dIPR = 0$ and $-d\varphi_i/dIPR > 0$.

Figure 2 (on the right) displays a schematic of this framework and the impact of an increase in the strength of IPRs. The impact of a reduction in the cost disadvantage of developing the invention at home is illustrated by the blue (dashed) line, the impact of an increase in the inventor's share

[24] The strategic value of the invention is uncertain to the organization (the buyer of intellectual property) but the inventor (the seller of the intellectual property) is reluctant to disclose it because of fears that the knowledge will be expropriated (Anton and Yao, 1994, 2002, 2004).

of the value of the invention is illustrated by the red (solid) line .

The model predicts that a strengthening of IPRs in the home country will reduce the emigration rate of individual inventors, relative to the emigration rate of organizational inventors. The two effects of IPRs considered in this simple framework are consistent in this prediction.

First, when the cost disadvantage of developing the invention at home falls for the individual inventor, the emigration rate of individual inventors, $E_i/(E_i + R_i)$, falls. This is because the area E_i, which is given by the set of (C_i, C_o) for which emigration for individual inventor is optimal in Figure 2 shrinks; while the area $E_i + R_i$ remains unchanged. At the same time, the emigration rate of organizational inventors, $E_o/(E_o + R_o)$, does not change, because the cost disadvantage of developing the invention at home does not change for the organizational inventor.

Secondly, when the inventor's share of the value of the invention rises, the emigration rate of individual inventors, $E_i/(E_i + R_i)$, falls. This is because the increase in δ increases δV, the horizontal intercept of the equation $C_o = \delta V$ (the zero profit condition for commercializing with an organization) and expands the range of C_o over which an inventor will pursue commercialization. Independent commercialization occurs when C_i is below the margin which is equal to $(1-\delta)V + Co$. As the margin for C_o rises when δ rises, the margin for C_i also rises. The range of costs at which commercialization is profitable expands, increasing the total amount of commercialization represented by the sum of all four areas in Figure 2. An increase in δ increases both E_i and $E_i + R_i$, but the area E_i rises proportionately less. At the same time, the opposite is true for the emigration rate of organizational inventors, $E_o/(E_o + R_o)$: it rises, because the area E_o rises more to the area $E_o + R_o$.

Summarizing, the simple conceptual framework outlined above has predictions relevant for our empirical analysis. Most importantly, it predicts that as IPRs strengthen in the home country, there will be a notable decline in the emigration rate of individual inventors, relative to organizational inventors. This prediction stems from the following two considerations:

1. *Cost Disadvantage:* Stronger IPRs in the home country can mitigate the cost disadvantage faced by individual inventors, making it more feasible for them to commercialize their inventions domestically.

2. *Inventor's Share of Value:* Robust IPRs can increase the inventor's share of the value created by their invention in the market for ideas, as stronger protection reduces the risk of imitation and mitigates disclosure problems.

With a reduced cost disadvantage and increased share of value, individual inventors may have a diminished incentive to emigrate, as the domestic environment becomes more conducive to commercializing their intellectual property. The predicted decline in the emigration rate is specific to individual inventors and is expected to be more pronounced compared to the emigration rate of organizational inventors.

4 Data and Methodology

4.1 Data Description

Our full sample consists of 103 countries of origin, all of which are EDCs. The World Bank assigns EDCs into one of the three income groups: upper middle income (39 countries), lower middle income (37 countries), and low income (27 countries).[25] Out of 27 low income countries, 24 are recognized by the WTO as LDCs.[26] Our sample of countries of origin thus excludes high-income economies, as defined by the World Bank.

We use the data on migratory patterns of inventors collected by the WIPO and documented in Miguelez and Fink (2013, 2017). These data are extracted from international patent applications filed under the PCT. The dataset contains information on the counts of inventors included in the PCT patent applications, with the counts disaggregated along three dimensions: the country/territory of nationality of the inventors; the country/territory of current residence of the migrant inventors;[27] and the year of priority filing.[28]

The PCT-based inventor immigration dataset has four principal advantages over alternatives. First, it focuses on inventors—a specific class of high-skilled workers who create knowledge, as distinct from other tertiary educated workers. Second, it relies upon residence and nationality information disclosed by inventors themselves in their patent applications, which arguably makes it more current and precise than, for example, inferring migration history from the cultural origin

[25]The assignment is based on gross national income (GNI) per capita for the year 2012.

[26]The list of LDCs is available here: https://www.wto.org/english/thewto_e/whatis_e/tif_e/org7_e.htm.

[27]The PCT system stipulates that only applicants or applicant-inventors who are nationals or residents of a PCT contracting state are eligible to submit PCT applications. In order to verify compliance with this criterion, the PCT collects information on nationality and residence of each applicant. Moreover, until 2012, if a PCT application listed the United States as a designated state, all inventors involved in the application were obliged to be listed as applicants and provide their nationality and residence details. Historically, the majority of PCT applications before 2004 included the United States as a designated state. Since 2004, all PCT applications have automatically encompassed all PCT member states, including the United States, as designated states.

[28]The year of priority filing is the initial year when the patent application was filed in any patent office worldwide; it may be different from the year of PCT filing.

of inventors' names (e.g., Foley and Kerr, 2013). Third, the PCT-based data allow for easier cross-country comparisons, because the PCT operates in nearly all countries and implements a uniform application procedure and process. And since the cost of filing abroad can be substantial, the inventions represented by applications filed under the PCT system are likely to have a greater commercial significance than the inventions of applications filed domestically. Finally, the data cover as many as 241 countries/territories from 1978 to 2012.

There are three main limitations of the dataset to keep in mind when interpreting the results. First, the data are collected from the patent applications filed, without adjusting for the actual grants of the patents. Secondly, the dataset does not contain information on the inventors' country of birth, only their nationality, which can change over time. Lastly, we do not observe the actual counts of migrant inventors, only the counts of inventors whose names are included in patent applications. These counts are by patent number, without a single identifier for each inventor or applicant-inventor. The unit of analysis is *inventor/applicant-inventor name-patent number pair*. An increase in the count of inventors' or applicant-inventor' names could thus reflect an increase in the number of inventors or an increase in the number of PCT patent applications associated with each inventor, or both.

Miguelez and Fink (2013) report that as many as 2,361,455 PCT applications were submitted in total by the end of 2012. This amounted to 6,112,608 of "inventor/applicant-inventor name-patent number" records, with both nationality and residence information available for 4,928,076. This implies a coverage rate of 81 percent, across all countries and years.

The rate of inventor emigration from country j in year t is given by the share of non-resident inventors from that country included in PCT patent applications filed in that year. It is defined as follows:

$$ER_{jt} = \frac{Emigrants_{jt}}{Emigrants_{jt} + Residents_{jt}},$$

where $Emigrants_{jt}$ is the aggregate count of non-resident inventors who are nationals of country j but currently reside in one of the 31 OECD destination countries in our list;[29] and $Residents_{jt}$ is the count of inventors who reside in country j. The count of $Residents_{jt}$ includes immigrant inventors residing in country j. Defined this way, the emigration rate is referred to as the *brain-drain* rate in the migration literature.[30]

[29] The OECD destinations are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea Rp., Luxemburg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, UK, and USA. This list excludes Mexico and Chile, which are in our list of the EDCs.

[30] In the migration literature, the brain-drain rate is calculated using data on tertiary-educated individuals. But our focus is on inventors, a specific class of high-skilled workers who create knowledge.

We calculate the emigration rate for three distinct sectors (i.e., types of inventors): individual patentees, corporations, and academic/public institutions (universities and public research institutes). These data cover the period of 1993-2012 but since the coverage has dropped significantly across all countries in 2012, we use 2011 as the last year in our analysis.[31]

The emigration rate of inventors is likely to be correlated with a number of country characteristics. We use a number of variables from different sources to control for the countries' level of development, institutional strength and capacity, and effectiveness of governance. Population data are from the World Bank, *World Development Indicators* (2010). Data on real gross domestic product (GDP), the capital stock measure and the human capital index are from the *Penn World Tables* version 9.0 (Feenstra, Inklaar and Timmer, 2015).[32] Data on the average years of tertiary schooling attained and the percentage of complete tertiary schooling attained in population are from Barro and Lee (2013). The index of financial openness is from Chinn and Ito (2006). This index measures a country's degree of capital account openness, based on the binary variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). We also use six indices of political risk from the International Country Risk Guide (ICRG): external conflict, internal conflict, democratic accountability, socioeconomic conditions, corruption, and government stability. The data on the total number of low-skill emigrants (age 25+) are from the IAB brain-drain dataset (Brücker et al., 2013).

To assess whether the rate of inventor emigration is associated with the overall strength of IPRs, we incorporate data on the Ginarte and Park (1997) index of patent rights, updated in Park (2008). The Ginarte-Park (GP) index measures the strength of countries' patent rights, based on five measures of patent laws: coverage, membership in international patent treaties, provisions against losses of protection, enforcement mechanisms, and duration of protection. The GP index in our sample spans from 1990 to 2010, in five-year increments.

Table 1 provides summary statistics of the variables used in the analysis for the 103 EDCs over the entire period of 1993-2011. The sample includes 3,102 observations, with fewer observations for some independent variables.[33] The mean number of patents filed by both residents and emigrants

[31]The coverage has dropped significantly in 2012 due to the United States enacting changes to its patent laws under the Leahy-Smith America Invents Act (AIA), which effectively removed the requirement that inventors also be named as applicants. The AIA was signed into law on September 16, 2011 and came into effect on September 16, 2012. PCT applicants in the United States are free to name inventors without disclosing their nationality and residence.

[32]We use expenditure-side real GDP at chained PPPs. Capital stock is at constant 2011 national prices, in mil. 2011US$. The human capital index is based on the average years of schooling from Barro and Lee (2013).

[33]The dataset is an unbalanced panel. Table A2 in the Appendix reports the number of observations by year and sector for the full sample of 103 EDCs. The data coverage is relatively poor in the first two years of our sample,

in our sample is relatively low compared to patent counts for higher-income countries: an average of 93.8 patents filed per year by residents of our sample countries, and 48.7 patents per year by emigrants. These counts are also highly variable across countries and over time, with high standard deviations relative to the mean. The average emigration rate is 0.626, implying that for a typical country and year in our sample, 62.6% of PCT applications by a country's nationals are filed by those living outside the home country. This suggests the importance of studying policies that might influence the retention of inventors in the home country.

4.2 Descriptive Cross-Country Evidence on Inventor Emigration

We begin by examining cross-country patterns of emigration and resident patenting using the GP index as a measure of the strength of IPRs. We relate the GP index in country j in year t to the rate of inventor emigration from that country j in years $t, ..., t+4$. So for example, the GP index in the year 1990 is used to explain the rate of inventor emigration in each year from 1990 to 1994.

Table 2 shows the results of OLS estimation using a sample of 60 EDCs for which the GP index is available, over the period of 1993-2011. The outcome variable is the rate of inventor emigration. Robust standard errors in parentheses are clustered at the country level. The results show that countries with higher values of the GP index—which corresponds to stronger IPRs—have lower rates of inventor emigration, controlling for a wide range of covariates. These control variables include home country income and population (both of which are also significantly correlated with emigration rates), human capital, governance, and other variables. Importantly, we control for the rate of unskilled emigration, so the results in this table reflect the relationship between the strength of IPRs and inventor emigration after controlling for factors affecting the overall rate of emigration.

Columns (1)-(4) show that on average, there is a negative correlation between the strength of IPRs and inventor emigration, with the largest coefficient observed in column (2) which is focused on individual inventors. The regression in this column suggests that a one percent increase in the GP index is associated with a decrease of 0.35 in the rate of inventor emigration, all else equal.

In the regressions in columns (1)-(4), we control for year fixed effects to account for worldwide changes in migration propensities in a given year; but we do not control for country fixed effects, since there is little year-to-year variation in the GP index with the exception of major changes such as TRIPS. When we add country fixed effects in columns (5)-(7), we find that the coefficient

1993-1994, with fewer than 30 observations (i.e., countries) per year for the sector of individual patentees. The coverage is better after 1994.

on the GP index is statistically significant (at the 10% level) only in the regression focused on individual inventors (implying an approximately 0.32 reduction in the emigration rate for a 1% increase in the GP index). The regressions in columns (8)-(10), where we control for country fixed effects and country-specific linear trends, show a similar result: the coefficient on the GP index is negative (-0.401) and statistically significant at the 5% level only in column (8), for individual inventors.

While these regressions are informative, they are based on mostly cross-sectional variation across countries in the strength of IPRs and emigration rates. Although we have controlled for many important covariates, innovator migration and IPRs may be jointly determined for reasons not accounted for in these regressions. First, it is possible that there is an omitted confounder that is correlated with both the emigration rate and the strength of IPRs. Countries with weak institutions, for example, typically have high emigration rates and weak IPRs. Consequently, IPRs may be associated with migration even if migration does not depend on IPRs.

Moreover, one could conceive of potential reverse causality in which emigration leads to stronger IPRs, as McAusland and Kuhn (2011) demonstrate. Emigrants may positively influence source country institutions, as in Spilimbergo (2009), which showed that foreign-educated individuals promote democratic values in their home countries. To attempt to account for these potential sources of endogeneity, we turn to evidence from the exogenous introduction of TRIPS in 2000 to identify the impact of stronger IPRs on emigration of inventors.

4.3 TRIPS compliance

The data on the timing of TRIPS compliance are from Delgado, Kyle, and McGahan (2013).[34] Table 3 reports the years of TRIPS compliance across 103 EDCs in our sample, by income groups.

The last year in the inventor migration data is 2011. From Table 3, 70 countries achieved TRIPS compliance by this year, 44 of which fully adopted TRIPS by the year 2000. Of the remaining 33 countries that did not comply with TRIPS by the year 2011, one country complied with TRIPS in 2012 and the rest - in 2016.

Of the 70 countries that achieved TRIPS compliance by 2011, 53 countries self-designated as 'developing' when they joined the WTO in 1995.[35] The majority of these countries (39) fully

[34] Table A1b in Delgado, Kyle, and McGahan (2013) details on the classification criteria for a country's TRIPS compliance.

[35] The 17 countries that are not in this list, either because they did not self-designate as 'developing' or because they joined the WTO after 1995, are: South Africa (1995), Bulgaria (1996), Panama (1997), Mongolia (1997),

adopted TRIPS by the year 2000, and the rest did so between 2001 and 2006. Among countries that complied with TRIPS in 2016, 24 are LDCs.

Furthermore, 23 countries in our sample have joined the WTO after 1995. Of these countries, 16 have complied with TRIPS upon joining (Bulgaria in 1996; Mongolia and Panama in 1997; Kyrgyzstan in 1998; Latvia in 1999; Albania, Georgia and Jordan in 2000; China, Lithuania and Moldova in 2001; Armenia and Macedonia FYR in 2003; Tonga in 2007; Ukraine in 2008; and Russian Federation in 2012) while the others complied with a delay (Ecuador, Fiji, and Grenada joined the WTO in 1996 and complied with TRIPS in 2000; and Papua New Guinea, St. Kitts and Nevis, Congo Rp., and Viet Nam joined the WTO in 1996, 1996, 1997, and 2007, respectively, and complied with TRIPS in 2005, 2000, 2000, and 2008, respectively).

From the last two rows in Table 1, the average value of the $Post\text{-}TRIPS_{jt}$ variable is 0.55 across all 103 countries and 0.66 across 70 countries that achieved TRIPS compliance by 2011 (which are TRIPS-compliant in our sample). This variable is equal to one for the year when country j has complied with TRIPS and all years thereafter and is equal to zero otherwise.

Figure 3 shows that, among upper middle income countries (UMICs) and countries with lower-middle and low income (LMICs) that complied with TRIPS in 2000, counts of corporate patents filed by by nationals located in other countries (the "emigrants") match or even exceed patents filed by residents. It is also in these countries where individual inventors play a particularly important role. In UMICs, patents filed by resident individual inventors rose substantially over our sample period, while emigrant patenting by individual inventors was flat. And in LMICs, the trends for corporate and individual inventors run in opposite directions: among corporate patents the only growth is in emigrant patenting, while for individual inventors the growth in patenting comes from residents, with the divergence occurring mostly after 2000.[36]

It is also important to note that the number of patents filed is quite low in some countries, particularly LMICs. In the most extreme case, Figure 3 shows that independent emigrant LMIC nationals file only 1-2 PCT patent applications per year on average, while independent residents of LMICs file a slightly higher but still low number of applications compared to higher-income countries. Since PCT patent applications are on inventions destined for an international market, this likely represents an underestimate of the total number of inventions occurring in LMICs.

Kyrgyzstan (1998), Latvia (1999), Albania (2000), Ecuador (2000), Georgia (2000), Jordan (2000), Romania (2000), Lithuania (2001), Moldova (2001), Armenia (2003), Tonga (2007), Ukraine (2008), and Viet Nam (2008).

[36]By contrast, among OECD countries, patents filed by residents significantly outnumber patents filed by emigrant inventors. Furthermore, the data reveal reveal a strong rise in resident patents filed over time for both corporate and individual patents.

4.4 Identification Strategy

The treatment timing is differential across countries in our sample, and time-varying treatment effects estimated with two-way fixed effects can generate a severe bias (De Chaisemartin and D'Haultfœuille, 2024). To make sure that this bias does affect our results, we limit our group of TRIPS-compliant countries to 44 countries that fully adopted TRIPS by the year 2000, and compare it to the group of 32 countries that did not comply with TRIPS during our sample period (but eventually complied by 2016).

The basic statistical model for the observed outcomes is specified as follows:

$$ER_{jkt} = \alpha + \beta_0 \; Post\text{-}TRIPS_{j,2000} + \beta_1 \; Post\text{-}TRIPS_{j,2000} \times Ind + X'_{jt}\delta + \alpha_{jk} + \alpha_t + \varepsilon_{jkt}, \quad (1)$$

where the outcome variable ER_{jkt} is the emigration rate of inventors from country j (to the group of 31 OECD destination countries) in sector k in year t. We consider three distinct sectors (i.e., types of inventors): individual patentees, corporations, and academic/public institutions (universities and public research institutes). The key variable of interest is the interaction term $Post\text{-}TRIPS_{j,2000} \times Ind$, which is the product of the post-TRIPS dummy variable and the indicator for individual patentees. The variable $Post\text{-}TRIPS_{j,2000}$ is equal to one for the year 2000 and all years thereafter for country j that fully adopted TRIPS by 2000 and is equal to zero otherwise. The variable Ind is equal to one when the sector k is individual patentees and is equal to zero otherwise. Next, the vector X_{jt} contains time-varying country controls, discussed in Section 4.1. The model also includes fixed effects for each country-sector pair (α_{jk}) and year (α_t).[37] The year fixed effects capture temporal changes in inventor migration patterns common to all EDCs and sectors, while the country-by-sector fixed effects allow for any unobserved differences that are constant over time but vary across countries within each sector and across sectors within each country. Last, α is the constant term and ε_{jkt} is the stochastic error term.

In the specification (1), the omitted sector group is "organizational" inventors. This group includes both corporate and academic/public inventors, as the distinction between these two types is somewhat blurred in the data. Miguelez and Fink (2013) notes in this respect that some academic inventors may assign their patents to corporations; and when assigning each patent to an applicant type, all research institutions or universities with names not appearing in the keyword list were automatically classified as corporations. Consequently, the number of inventors from universities and public research institutes is underestimated in the data, particularly prior to 2004. For sensitivity analysis, we allow inventors from corporations and academic/public institutions to

[37] In Section 6, we examine the robustness of our findings to the inclusion of country-specific time trends ($\alpha_j t$).

be impacted differently by TRIPS, but find no statistically significant difference in the impact.

The variable Ind does not appear in (1) by itself because the model includes fixed effects for each country-sector pair, α_{jk}. These country-by-sector specific effects allow the baseline emigration rates to vary across countries for a given inventor type in the absence of TRIPS implementation. Their inclusion ensures that the coefficient on the interaction term $Post\text{-}TRIPS_{j,2000} \times Ind$ is identified solely from changes in the relative emigration rates of individual versus organizational inventors around the timing of TRIPS adoption in 2000 for treated countries, compared to control countries.

Consistent with the predictions of the conceptual framework, we expect $\beta_1 < 0$. That is, we expect that in EDCs, the behavior of individual inventors is most sensitive to national adjustments of IPR systems mandated by the TRIPS Agreement. We discuss the evidence for this prediction in the following section.

5 Results

Table 4 shows the results of estimating model (1) using the sample of 76 countries, of which 44 are TRIPS-compliant (i.e., fully adopted TRIPS by the year 2000) and the other 32 are non-compliant (i.e., did not comply with TRIPS during our sample period, but eventually complied in 2016).

In columns (1)-(2), the omitted sector group is organizational inventors. The estimated coefficient on $Post\text{-}TRIPS_{j,2000} \times Ind$ measures how the emigration rate of individual inventors, relative to organizational inventors, changed following TRIPS compliance in 2000. In columns (3)-(4), we add the interaction term $Post\text{-}TRIPS_{j,2000} \times Public$, which is the product of the post-TRIPS dummy variable and the indicator for academic/public inventors. The omitted group is now limited to corporate inventors. We include fixed effects for each country, sector and year in all columns and also add country time-varying controls in columns (2) and (4). Robust standard errors are clustered at the country level in all regressions in the paper.

Table 4 shows that the estimated coefficient β_1 on the variable $Post\text{-}TRIPS_{j,2000} \times Ind$ is negative and statistically significant at the 5% level in all columns. The estimate is quite stable across the specifications. Its magnitude rises (in absolute value) when we add time-varying country controls, but this change could be due to changes in the sample when observations with missing values on some controls are dropped. In column (2), the estimated coefficient β_1 is equal to -0.134. This result implies that compared to organizational inventors, the emigration rate of individual inventors has fallen by 13.4 percentage points following TRIPS compliance in 2000. The estimated coefficient β_0 on $Post\text{-}TRIPS_{j,2000}$ is positive (0.062) but not statistically significant at the 5% level, suggesting that the emigration rate of organizational inventors did not change following TRIPS compliance in 2000.

When we allow the impact of TRIPS to differ across inventors from corporation and academic/public institutions in columns (3)-(4), we find no statistically significant difference in the impact. The estimated coefficient on $Post\text{-}TRIPS_{j,2000} \times Public$ is not statistically different from zero in both columns, while the estimated coefficient on $Post\text{-}TRIPS_{j,2000} \times Ind$ is still largely the same in magnitude and statistical significance.

Table 5 offers deeper insight into the above results. Column (1) replicates the results of column (3) in Table 4, while columns (2)-(5) consider individual components of the emigration rate. The outcome variable is *Emigrants* in columns (2)-(3) and *Residents* in columns (4)-(5), transformed using either the inverse hyperbolic sine *(ihs)* or the logarithmic *(log)* transformation. The *log* transformation allows us to measure the impact on the intensive margin (IM), focusing on positive counts of inventors before and after TRIPS, while the *ihs* transformation also incorporates the extensive margin (EM) effect.[38] To ensure comparability of results, we keep the sample size consistent across all columns (unless *log* is applied): 1,436 observations for which the value of *ER* is defined.[39] We see that the relative decline in the emigration rate of individual inventors (relative to organizational inventors) following TRIPS is primarily driven by the relative decline in the number of emigrant individual inventors. With respect the number of resident individual inventors, the results are mixed and depend on the transformation used. We find evidence of a differential impact of TRIPS on resident individual inventors on the IM, but not when we allow for both the IM and EM using *ihs*.[40]

In absolute terms, the impact of TRIPS on organizational inventors is measured by the coefficient on $Post\text{-}TRIPS_{j,2000}$ while the impact on individual inventors is measured by the sum of the coefficients on $Post\text{-}TRIPS_{j,2000}$ and $Post\text{-}TRIPS_{j,2000} \times Ind$ in Table 5. Figure 4 shows the resulting estimates together with the 95% confidence intervals. The outcome variables *Emigrants* and

[38]Chen and Roth (2024) highlights that average treatment effects estimated for log-like transformations, such as the *ihs* transformation, can arbitrarily depend on the units of measurement used for the outcome variable and should not be interpreted as approximating percentage effects. This issue is particularly problematic when the treatment affects the extensive margin, i.e., when it changes the probability of the outcome being zero. To address this concern, we also use Poisson regression for *Emigrants* and *Residents*. We report these results in Section 6.

[39]For 1,063 observations, the value of *ER* is undefined, because the denominator ($Emigrants_{jt} + Residents_{jt}$) is equal to zero. We show in Table A3 in the Appendix that our results are very similar when we re-estimate specifications with the *ihs* transformation using the full sample, which does not exclude these 1,063 observations.

[40]The Poisson QMLE results in Table 9 provide evidence of a differential impact of TRIPS on both emigrant and resident individual inventors.

Residents are transformed using *(ihs)*.[41] Both *Emigrants* and *Residents* rose following TRIPS, leaving ER unchanged, in the sector of organizational inventors; but in the sector of individual inventors, we see no growth in *Emigrants*.

In the last five columns of Table 5, we further examine whether the impact of TRIPS compliance differs across country income groups. We augment specifications in columns (1)-(5) by adding two interaction terms: the variables $Post\text{-}TRIPS_{j,2000}$ and $Post\text{-}TRIPS_{j,2000} \times Ind$ interacted with the $LMIC$ dummy variable, which is the indicator for countries with lower middle or low income (including LDCs). Among 44 countries that fully complied with TRIPS by 2000, $LMIC$ is equal to one for 17 countries: 16 with low middle income and 1 with low income. In this augmented specification, the omitted group is organizational inventors in UMICs.

From the first two rows in Table 5, it is apparent that the results for UMICs in columns (6)-(10) are similar to the aggregate results in columns (1)-(5). The number of both emigrant and resident organizational inventors rose in UMICs following TRIPS compliance: the coefficient on $Post\text{-}TRIPS$ is positive and highly statistically significant in the last four columns. The effects on *Emigrants* and *Residents* are similarly strong so that there is no corresponding change in the ER of organizational inventors in UMICs: the coefficient on $Post\text{-}TRIPS$ in column (6) is positive (0.051) but not statistically significant at the 5% level. The first set of bars in Figure 5 confirms these results.[42] For individual inventors in UMICs, the number of *Emigrants* shows a strong negative differential response, as evidenced by the negative and highly statistically significant coefficient on $Post\text{-}TRIPS \times Ind$ in columns (7)-(8). The number of *Residents* also shows a negative differential response that is highly statistically significant in column (10). In the absolute value, we find that the number of resident individual inventors in UMICs rose after TRIPS: the sum of the coefficients on $Post\text{-}TRIPS$ and $Post\text{-}TRIPS \times Ind$ is positive and statistically significant at the 5% level, as confirmed by the second set of bars in Figure (5). At the same time, we find no evidence that TRIPS compliance affected the number of emigrant individual inventors (in absolute terms) in UMICs.

From the third row in Table 5, we observe that the impact of TRIPS on organizational inventors is smaller LMICs compared to UMICs. The coefficient on the interaction term $Post\text{-}TRIPS_{j,2000} \times LMIC$ is negative and highly statistically significant in columns (7)-(10). In LMICs, corporate participation in patenting and innovation activities is generally lower compared to more developed economies. This limited corporate involvement might explain why the strengthening of IPRs under the TRIPS agreement had a less pronounced impact on organizational inventors in these countries.

[41] Applying a logarithmic transformation instead yields similar results.

[42] The outcome variables *Emigrants* and *Residents* are transformed using *(ihs)* in Figure 5. Applying a logarithmic transformation instead yields similar results.

The third set of bars in Figure 5 further shows that, in absolute terms, the impact of TRIPS on organizational inventors in LMICs is not statistically different from zero. However, in the individual inventor sector, the pattern of changes in the number of emigrant and resident inventors in LMICs resembles that observed in UMICs. In both income groups, the TRIPS agreement contributed to growth in the number of resident individual inventors (as evidenced by the results from the *ihs* transformation of *Residents*), but did not change the number of emigrant individual inventors.

6 Threats to validity and robustness checks

In this section, we discuss several potential threats to the validity of the identification strategy described above. Tables 6-9 present alternative specifications used as robustness checks.

6.1 Timing of adoption of the PCT by country and variation in use of international patents

Our data on inventor migration flows are extracted from PCT filing data, and the propensity to patent through the PCT route differs across countries, affecting the selection of inventors included in our dataset. Permanent cross-country differences in inventor migration flows (due to the country differences in the propensity to patent under the PCT, or other reasons) are absorbed by country fixed effects. However, it is possible that residents and nationals of countries that adopted the PCT around the same time as TRIPS could have increased their rates of patenting via the PCT rather than other routes. If this were the case, we would overestimate the increase in invention in PCT-adopting countries because we would measure an increase in patents that in the absence of the PCT would have been filed via another route (e.g. filing directly at the USPTO). We would expect this to show up primarily in our counts of resident patents, since diaspora inventors in OECD countries can file PCT patents based on their country of residence. Thus, concerns about PCT accession contaminating our results are most valid for results based on the emigration rate rather than those based on the total amount of emigrant patenting.

Table A5 in the Appendix reports the PCT accession years.[43] Countries that complied with TRIPS in 2000 are highlighted in bold, and countries that did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016) are italicised. Countries in our

[43]The dates on which state became bound by the PCT are available here: https://www.wipo.int/pct/en/pct_contracting_states.html.

sample joined the PCT system in different years. Out of 44 countries that fully complied with TRIPS in 2000, only 15 accessed the PCT before 1999; from the remaining countries, 20 accessed the PCT between 1999 and 2011 (inclusive), two accessed after 2011 (the last year in our sample), and 7 are not bound by the PCT. Out of 32 countries that fully complied with TRIPS in 2016, 17 accessed the PCT before 1999; from the remaining countries, 5 accessed the PCT between 1999 and 2011 (inclusive), two accessed after 2011 (the last year in our sample), and 8 are not bound by the PCT.

We approach this issue in the following ways. First, we include in the regressions shown in Table 6 Panel A a dummy variable equal to one in the year in which country j became bound by the PCT and all years thereafter and equal to zero in prior years. By including this variable as a control, we ensure that any change in PCT patenting activity within a country around its PCT accession year does not confound the impact of TRIPS implementation. In Panel B, we exclude countries not bound by the PCT from our sample. In Panel C, we exclude countries that acceded to PCT in or after 1999. In the Appendix, we provide results based on an alternative emigration rate based on imputed estimates of resident patent counts.

Panel A of Table 6 shows that belonging to the PCT is indeed associated with a lower inventor emigration rate, as evidenced by the negative and statistically significant coefficient on *Post PCT entry* in column (1). As expected, this is not driven by a reduction in the absolute amount of emigration (columns 2-3), but by an increase in resident patenting associated with PCT accession (column 4-5). However, we find that including this control does not change the prior finding that the emigration rate of individual inventors falls most relative to organizational inventors post-TRIPS.

The regressions in Panel B show that excluding countries that have not yet adopted the PCT during our time period[44] does not change the main results, although the coefficient on $Post\text{-}TRIPS_{j,2000} \times Ind$ is less precisely estimated in column (1). The regressions in Panel C exclude countries adopting the PCT in 1999 or later. Here, the statistical precision of the coefficient on $Post\text{-}TRIPS_{j,2000} \times Ind$ is further reduced. Interestingly however, our main finding of a decline in the emigration rate of individual inventors relative to organization inventors is preserved or even enhanced when we isolate the impact on UMICs: the coefficients on $Post\text{-}TRIPS_{j,2000}$ and $Post\text{-}TRIPS_{j,2000} \times Ind$ go from 0.051 and -0.108, both statistically insignificant at the 5% level, in column (6) of Table 5 to 0.322 and -0.230, now both statistically significant at the 5% level, in column (6), Panel C of Table 6. Meanwhile, the standard errors of the coefficients on the TRIPS terms increase noticeably in columns (7)-(10), where the number of emigrant or resident patents is

[44]These countries are Argentina, Bolivia, Fiji, Guyana, Jamaica, Jordan, Mauritius, Suriname, and Venezuela.

the outcome variable. Our estimates of the impact of TRIPS on resident inventors are particularly sensitive to controlling for PCT accession, and the estimates of the impact on emigrant inventors in LMICs are also sensitive. This suggests that we should be cautious in interpreting the results based on the counts of resident patents, as some of the larger impacts of TRIPS may be driven by an increase in patenting associated with PCT adoption around the same time as TRIPS.[45] In the Appendix, we use data on USPTO patenting to impute resident patent counts of non-PCT member countries, and use this to compute an alternative emigration rate. This approach does not require dropping countries from the sample, which leads to a reduction in statistical power. Results based on this variable are similar to those in panel A of Table 6.

6.2 Potential underestimation of the count of resident inventors

A related potential source of bias comes from the fact that our dataset prevents us from measuring all inventors, as it only captures inventors who file patents. In countries with weak IPRs, researchers may refrain from patenting their inventions, resulting in their exclusion from resident inventor counts. These researchers might opt to emigrate and become inventors in countries with stronger IPR protections. This scenario could artificially inflate the worldwide count of national inventors, as the total number of emigrants increases when an researcher emigrates, while the resident count remains stable, potentially causing a downward bias in the measured emigration rate.

If this phenomenon is at work, then when a country strengthens its IPR protections, the number of resident inventors may increase as researchers become more inclined to patent their innovations at home. This increase in resident inventors could lead to an apparent decline in the emigration rate, even if the actual distribution of inventors across countries remains unchanged.

The fundamental concern in both scenarios is the potential inaccuracy in quantifying resident inventor populations. Our analysis addresses this issue through two key approaches. First, we compare inventor emigration rates across individual and organizational inventors. The sector-based approach ensures that measurement errors in resident inventor populations, which are common across sectors, do not significantly skew our results. Secondly, we perform a detailed examination of the individual components of the emigration rate. Our findings indicate that the relative decline in the emigration rate of individual inventors (compared to organizational inventors) following the implementation of TRIPS is predominantly driven by a reduction in the number of emigrant individual inventors, rather than an increase in the number of resident individual inventors (the

[45] There may also be concern that accession to the WTO could also contaminate our estimates. Out of 44 countries that fully complied with TRIPS in 2000, only three accessed the WTO in the same year. It is thus unlikely that our estimate of the impact of TRIPS picks up the effects of the WTO membership.

former declines while the latter is roughly constant, as seen in Figure 4).

6.3 Country-specific trends

Another possibility is that our results are driven by secular changes in countries that adopt TRIPS. For example, TRIPS adoption could be correlated with reaching a level of economic development consistent with a better environment for domestic commercialization of inventions (leading to a decline in the emigration rate of inventors). We next examine the robustness of our findings to the inclusion of country-specific time trends. Table 7 shows the revised estimates. We augmented the specifications with country-specific time trends and also included the *Post PCT entry* variable in all regressions. Notably, the overall findings remain consistent. However, a noteworthy observation is the diminished statistical precision in the estimated coefficient on $Post\text{-}TRIPS$ in columns (4)-(5) and (9)-(10), where *Residents* is the outcome variable. This suggests that the inclusion of country-specific time trends absorbs a considerable portion of the variation in the number of resident organizational inventors within UMICs, which represent the omitted group in these regressions. Consequently, the estimated coefficient on $Post\text{-}TRIPS$ in columns (1) and (6), where ER is the outcome variable, is now more precisely estimated (and larger in magnitude).

6.4 Alternative TRIPS compliance years and event study

As another robustness check, we confirm that our results are not specific to the group of countries that complied with TRIPS by 2000, nor do they pick up some other changes around the year 2000 that are specific to this country group. For this, we re-estimate the specifications using a different sample of TRIPS-compliant countries: TRIPS-compliant by the year 2005. This sample comprises two UMICs (Chile and Tunisia) and four LMICs (Nicaragua, Pakistan, Papua New Guinea, and Paraguay). We excluded India from this group, so that it does not overly influence the results. Table 8 shows the results.[46] Despite the limited number of TRIPS-compliant countries in both groups, our overall findings remain consistent. The coefficient on $Post\text{-}TRIPS \times Ind$ is statistically significant at the 5% level in columns (2)-(3), suggesting that the emigration of individual inventors has fallen, relative to organizational inventors, after TRIPS. Further from columns (7)-(8), we find that this differential decline in the number of individual emigrant inventors is observed in both UMICs and LMICs.

[46] As previously noted, the TRIPS-non-compliant group comprises 32 countries that did not comply with TRIPS during our sample period of 1993-2011.

Next, we study the timing of changes in emigration rates. We replace the $Post\text{-}TRIPS_{j,2000}$ variable in model (1) with a set of pre-TRIPS and post-TRIPS dummy variables (relative to the year 1999, for the group of TRIPS-complaint countries). The post-TRIPS dummy variable $TRIPS_{j,2000+n}$ is equal to one for n years after TRIPS and zero in all other years. We have 12 such variables, for $n = 0, ..., 11$. The pre-TRIPS dummy variable $TRIPS_{j,2000-n}$ is equal to one for n years before TRIPS and zero in all other years. We have 6 such variables, for $n = 2, ..., 7$. The dummy for the one year before TRIPS compliance (1999) is omitted and so, the coefficients on the TRIPS variables provide estimates relative to this year.[47]

Figure 6 plots the estimated coefficients (with the 95% confidence intervals) on the pre-TRIPS and post-TRIPS dummy variables. The coefficients have a differential interpretation.[48] The pre-TRIPS and post-TRIPS dummies appear by themselves (for the omitted sector of organizational inventors) in the top left graph; interacted with the Ind dummy (for individual patentees) in the top right graph; interacted with the $LMIC$ dummy in the bottom left graph; and interacted with both Ind and $LMIC$ dummies in the bottom right graph. The outcome variable is *Emigration Rate (ER)*, and the estimated specifications include time varying country controls (controlling for PCT accession year) and fixed effects for each country-sector pair and year.[49] The figure shows no evidence of pre-existing trends that might confound the impact of TRIPS.[50] The lack of such trends before TRIPS implementation supports the notion that the observed changes in emigration rates post-TRIPS are attributable to the TRIPS Agreement itself, rather than being influenced by other unobserved factors that were active prior to its implementation. The estimates further reveal a delayed negative impact of TRIPS compliance on the emigration rate of individual inventors in LMICs. The coefficient on $TRIPS_{j,2000+n} \times Ind \times LMIC$ turns negative and achieves statistical significance at the 5% level starting seven years post TRIPS implementation. This lag could stem from the time required for individual inventors in LMICs to adapt to the new intellectual property regulations introduced by TRIPS.

[47] Table A6 reports the number of observations by year and sector for the sample of 44 countries that complied with TRIPS in 2000.

[48] To obtain the estimated effect for individual inventors in LMICs in a given year (relative to the baseline year), for example, one would need to add all four estimates in Figure 6 for that year. For the year 2004 (relative to 1999), the estimated effect for individual inventors in LMICs is equal to $-0.058 + 0.119 - 0.024 - 0.412 = -0.375$, which is statistically significant at the 5% level.

[49] The sample used consists of 44 countries that fully complied with TRIPS in 2000 and 32 countries that did not comply with TRIPS during our sample period of 1993-2011. The year fixed effects are identified using data on TRIPS-non-compliant countries.

[50] Although the top right panel shows declining coefficients prior to 2000, these estimates are not statistically significantly different from zero at the 5% level. The test of joint significance of these coefficients has a p-value of 0.09.

6.5 Alternative econometric models for counts and rates

Furthermore, we checked the robustness of our findings to alternative estimation methods. Table 9 follows. In columns (1) and (4), which focus on the emigration rate of inventors as the outcome variable, we employed a fractional (logit) model, fitted using the quasi-maximum likelihood estimation (QMLE) technique.[51] This model is suitable for our analysis because the emigration rate is a bounded variable, constrained within the interval $[0, 1]$. Our analysis reaffirms the observed relative decline in the emigration rate (ER) of individual inventors compared to organizational inventors post-TRIPS implementation, with this effect being particularly pronounced in LMICs.

Next, in columns (2)-(3) and (4)-(5) of Table 9, where the counts of emigrant or resident inventors are the outcome variables, we employed Poisson QMLE.[52] The findings for $Emigrants$ are consistent with those in Table 6 Panel A, where the specific transformation used (ihs or log) did not significantly affect the results. With respect to $Residents$, the findings in column (3) of Table 9 show the differential decline in the number of individual inventors. This finding supports the result in column (5) of Table 6 Panel A, where the log transformation was applied to $Residents$.

6.6 Staggered treatment timing

Our analysis in the paper focused on two groups of countries with constant treatment timing: 44 countries that fully adopted TRIPS by 2000 and 32 countries that did not comply during our sample period. This approach simplified our estimation of the average treatment effect. We now expand our analysis to include all 103 countries in our dataset, of which 70 had adhered to TRIPS by 2011. The timeline for TRIPS compliance varied: 6 countries meet the criteria between 1995 and 1999, 44 countries complied in 2000, and 20 countries adopted TRIPS between 2001 and 2008. This comprehensive analysis strengthens our findings by showing that our aggregate estimate of TRIPS impact remains consistent even when accounting for different implementation timelines across countries.

First to validate our results, we estimate model (1) using two-way fixed effects (within) regression for two distinct samples: 103 countries with varying TRIPS implementation dates and 76 countries with with uniform TRIPS adoption timing, and compare the estimates. Table (10) presents the results, with estimates for differential treatment timing in columns (1)-(2) and con-

[51] The command in Stata is: *glm y x, family(binomial) link(logit) cluster()*.

[52] The command in Stata is: *glm y x, family(poisson) link(log) cluster()*. Alternatively, using the *ppml* command yields the same results.

stant treatment timing in columns (3)-(4).[53] This analysis reveals that the potential bias arising from estimating time-varying treatment effects with two-way fixed effects does not substantially impact our results. The estimated impact of TRIPS is largely robust across different sample compositions and implementation schedules. Our aggregate estimate of the impact of TRIPS is primarily driven by the cohort of countries that adopted TRIPS in 2000, for two key reasons: this group comprised a significant portion of our sample (44 out of 70 compliant countries), and the treatment year 2000 is centrally positioned within our 1993-2011 sample period.

The decomposition of the aggregate DiD parameter estimate into single 2×2 DiD estimates based on Goodman-Bacon (2021) further supports the above conclusion. Figure 7 shows these results. The horizontal line gives the average DiD estimate of $\hat{\beta} = -0.097$ obtained from the two-way fixed effects regression of ER_{ijt} on $Post\text{-}TRIPS_{it} \times Ind$. The vertical axis shows the magnitude of each 2×2 estimate and the horizontal axis shows its weight. Most of the -0.097 parameter estimate is coming from comparing the treatment country-sector pairs to a group of never-treated country-sector pairs.[54] The average DiD estimate for this *Treated vs. Never treated* group is -0.104 with a weight of 0.930.

Last, we employ the imputation estimator of Borusyak, Jaravel, and Spiess (2024). Figure 8 plots the staggered-adoption DiD estimates, along with 95% confidence intervals. It reports the weighted averages of treatment effects for the $h = 0/10$ horizon, where $h = 0$ is the treatment year, $h = 1$ is one year after treatment, etc. To allow for treatment effect heterogeneity by inventor type, separate effects are reported for organizational and individual inventors. The results indicate positive treatment effects for organizational inventors and negative effects for individual inventors, albeit with limited precision. To measure the differential impact, we use the *lincom* test to compute the difference in weighted average treatment effects between individual and organizational inventors for each horizon. Table 11 presents these results, revealing a consistently negative individual vs. organizational difference in treatment effect across all horizons, with statistical significance at the 5% level observed in the year of TRIPS compliance and 2, 3, 6, and 10 years after TRIPS. The overall treatment effect across all treated observations is highly statistically significant at -0.093.[55] Additionally, we conduct a parallel trends test using a separate regression on non-treated

[53] It is noteworthy that the estimates of the coefficients on $Post\text{-}TRIPS$ and $Post\text{-}TRIPS * Ind$ from two-way fixed effects (within) regression in columns (3)-(4) of Table (10) are identical in magnitude to those from HDFE linear regression in columns (1)-(2) of Table (4).

[54] The largest weight (above 0.4) is coming from comparing the individual sector to the organizational sector within the group of countries that complied with TRIPS in 2000. Figure A1 shows the decomposition results for the sample of countries that excludes those that complied with TRIPS in 2000. Importantly, the average DiD estimate remains much the same: $\hat{\beta} = -0.089$.

[55] This estimate is from the regression that excludes time-varying controls. When time-varying controls are included, achieving convergence of standard errors requires increasing tolerance to 0.001 and the maximum number of iterations to 1000. When we do so, the overall treatment effect across all treated observations is largely the same:

observations. Figure 8 plots the coefficients on the dummies for $1, ..., 10$ years before treatment. We find that the ten pre-trend coefficients are not jointly statistically significant ($p-value = 0.45$), which supports the validity of our DiD approach.

7 Discussion and Conclusion

This paper finds that the emigration rate of individual inventors declined relative to that of organizational inventors after countries adopted TRIPS in 2000. The finding that patent protection matters relatively more for individual inventors in less-developed economies has a strong support in the empirical literature. But it is also not surprising, given that individual inventors depend on the patent system in a fundamental way. First, such dependence arises because individual inventors in less-developed economies often lack the financial and legal resources to secure the returns from their innovative activities. For this, they thus must rely more heavily on the patent system. A patent enables the inventors to appropriate the returns from their inventions, because it provides effective monopoly protection to them. Further reinforcing this dependence is the fact that individual inventors have limited means of safeguarding their inventions against misappropriation through private channels. A patent protects the invention from misappropriation or copying that could arise once the invention is implemented or disclosed to others.

By contrast, corporate inventors have access to a broader range of complementary assets which make the marginal effect of a change in IPRs relatively less important. These results suggest that strengthening IPRs may increase the attractiveness of independent invention in home countries. Given prior findings on the greater importance of independent invention in EDCs, these results suggest the need for more research on how IPRs and other factors influencing the innovation ecosystem affect the decision to emigrate or stay in one's home country.

It is important to recognize the potential negative impacts of stronger IPRs in these countries. Stronger patent rights increase imitation costs, which may be another reason why individual inventors are more positively affected than firms. Individual inventors may be less likely than firms to benefit from commercializing imitative copies of foreign technologies. Thus, stronger IPRs may shift benefits away from established domestic firms and toward domestic individual inventors. More research is needed to understand this tradeoff. For instance, since the overall rate of patenting by individual inventors is quite low relative to organizational inventors, a decline in the rate of emigration of individual inventors must be weighed against increases in imitation costs.

highly statistically significant at -0.113.

Understanding the implications of the welfare benefits of the increased retention of independent inventors compared to the welfare losses of higher costs of imitation warrants further study.

From a policy perspective, our results suggest the importance of recognizing the potential benefits to individual inventors of stronger IPRs and instituting complementary policies to capitalize on this. For example, providing access to advice on scaling up businesses, business incubators, or legal services to support engagement in markets for technology may enable EDCs to ensure individual inventors reap the potential benefits of stronger IPRs. It is likely also important to ensure that other policies are in place to reduce transactions costs and increase the ease of doing business for these inventors.

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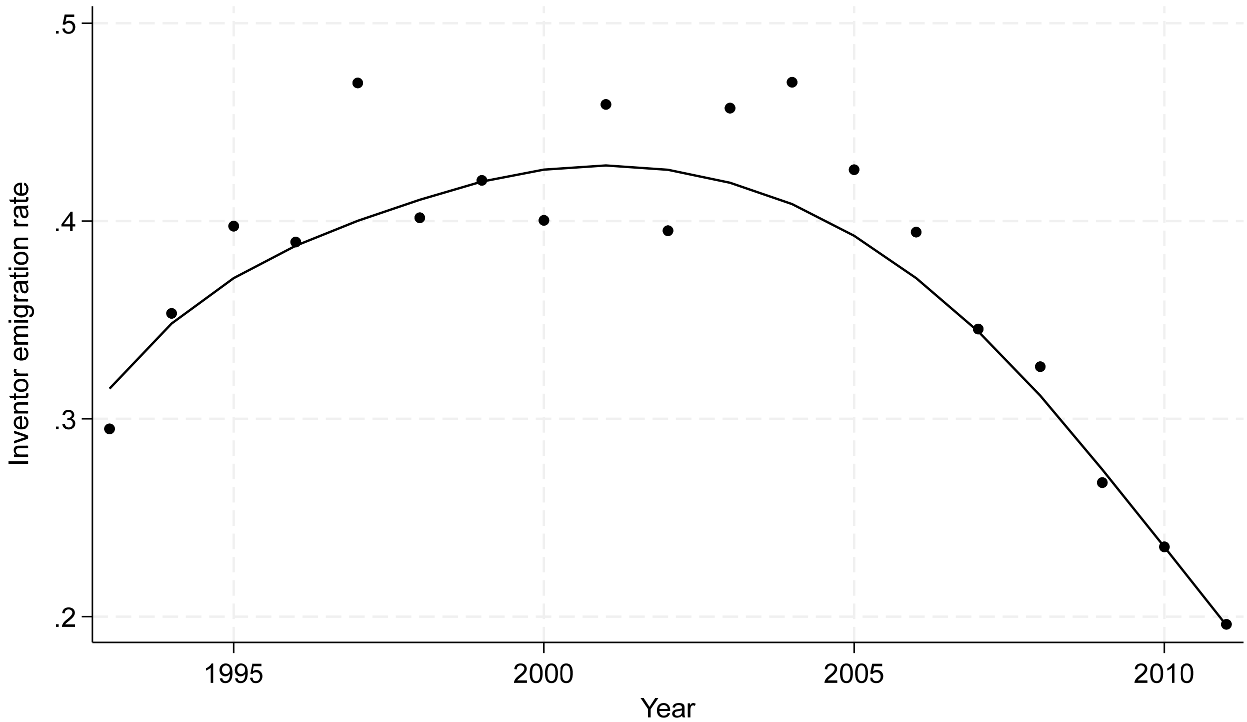


Figure 1: **The rate of inventor emigration from EDCs to OECD destinations by year**

Notes: For a given origin country j in year t, the emigration rate is defined as $Emigrants_{jt}/(Emigrants_{jt} + Residents_{jt})$, where $Emigrants_{jt}$ is the number of national inventors of country j residing abroad in year t and $Residents_{jt}$ is the number of inventors residing in country j (including national of country j and immigrants) in that year. The data used are from Miguelez and Fink (2013). To construct the emigration rate in this figure, we used aggregate measures of $Emigrants_t$ and $Residents_t$, obtained by aggregating data across 103 origin EDCs and 31 OECD destinations in each year. The EDCs are listed in Table 3. This list excludes high-income economies, as defined by the World Bank based on gross national income (GNI) per capita for 2012. The list of OECD destinations excludes Mexico and Chile, because they are classified as the EDCs. The plot displays the raw data together with a lowess line, created by conducting a locally weighted regression of the rate of inventor emigration against year.

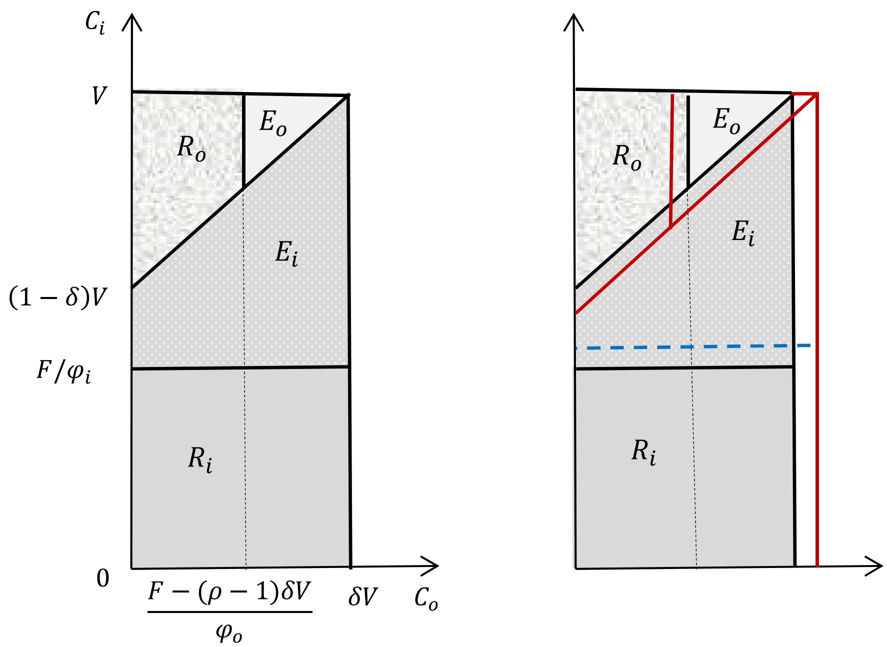


Figure 2: **Equilibrium allocation and the impact of stronger IPR**

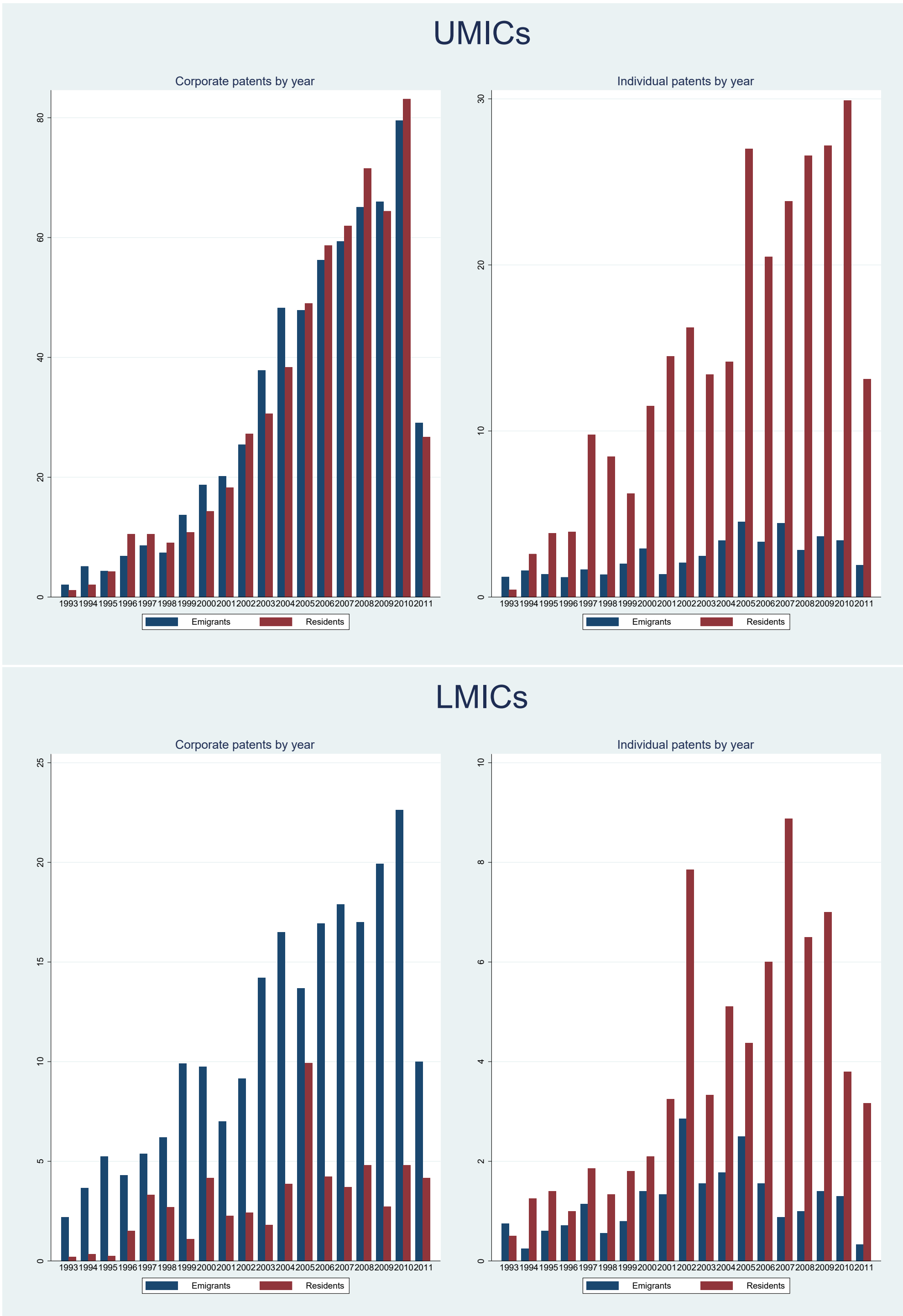


Figure 3: **Patents by diaspora and resident inventors in UMICs and LMICs countries TRIPS-compliant in 2000**

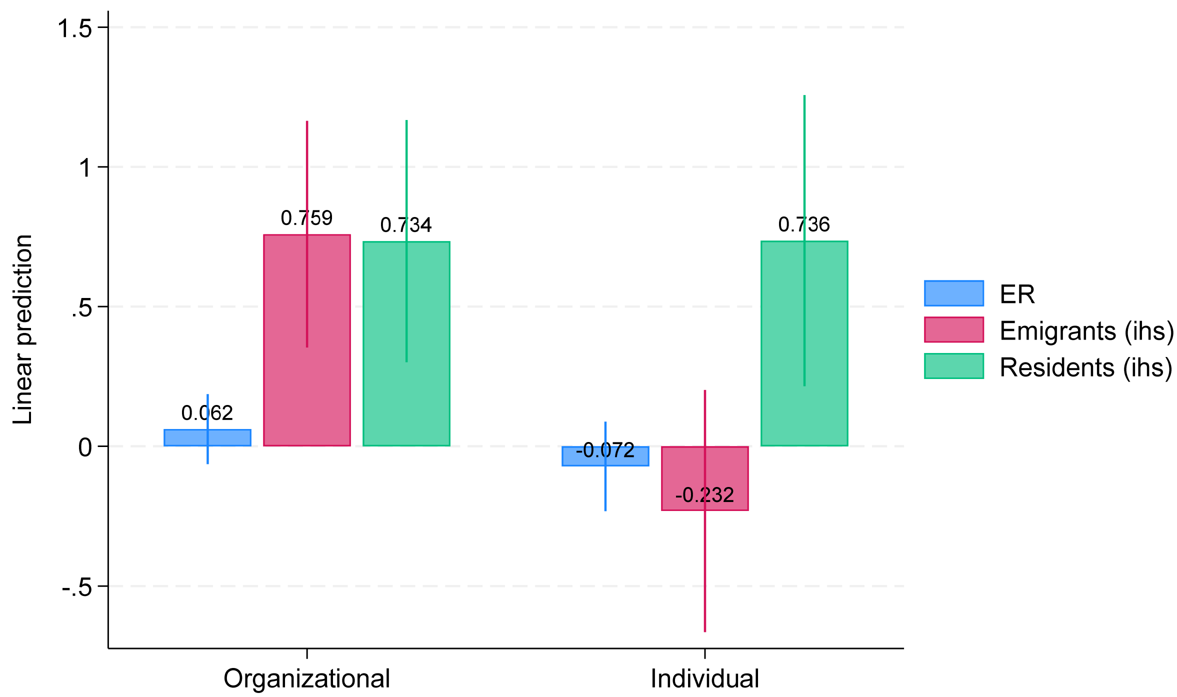


Figure 4: **The effect of TRIPS by inventor type**

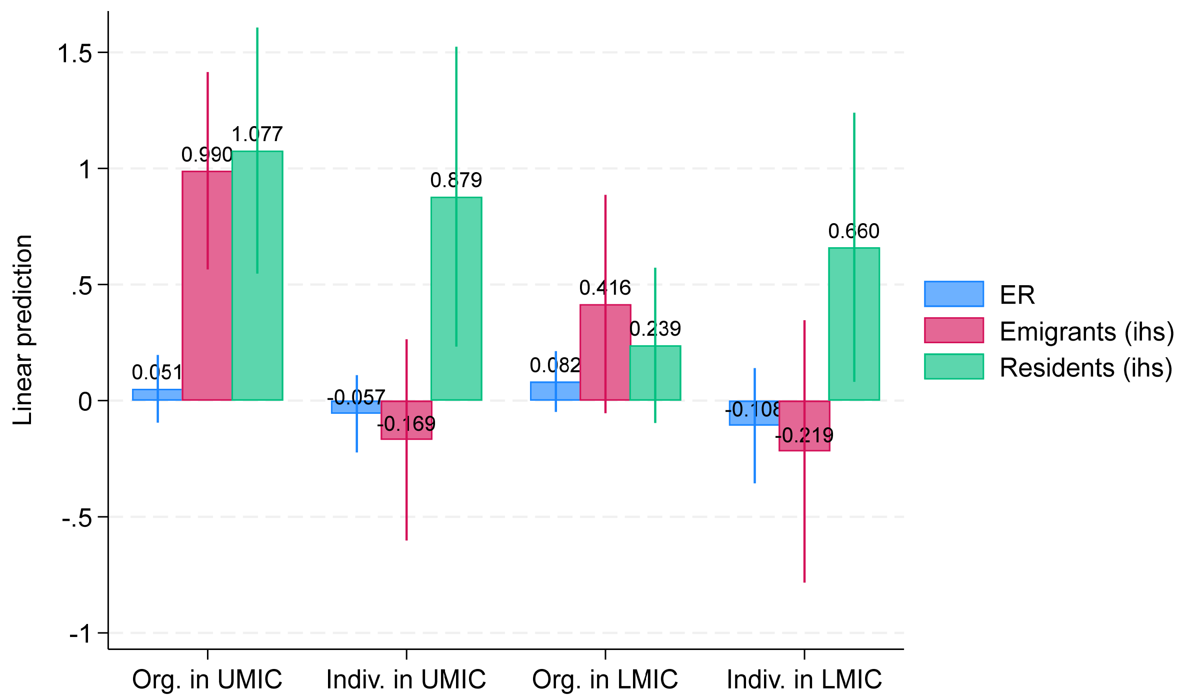


Figure 5: **The effect of TRIPS by inventor type and country groups**

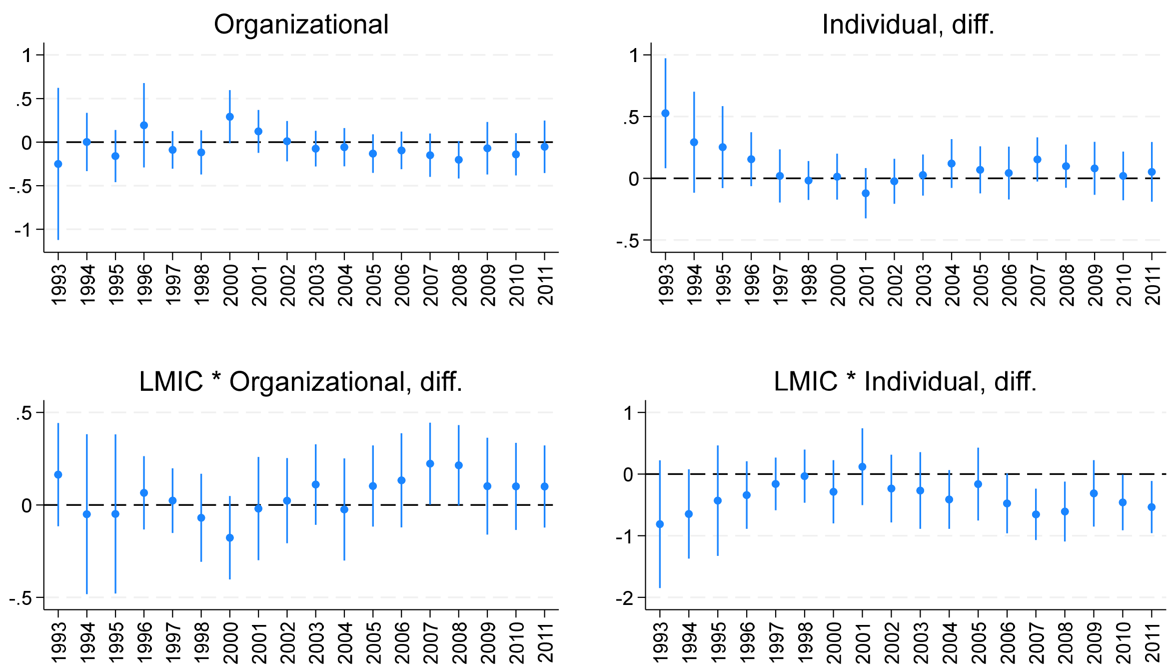


Figure 6: **Inventor emigration rate around TRIPS, in differential terms**

Notes: Figure plots the estimated coefficients (with the 95% confidence intervals) on the pre-TRIPS and post-TRIPS dummy variables (relative to the year 1999, for the group of TRIPS-complaint countries). The pre-TRIPS and post-TRIPS dummies appear by themselves (for the omitted sector of organizational inventors) in the top left graph; interacted with the Ind dummy (for individual patentees) in the top right graph; interacted with the $LMIC$ dummy in the bottom left graph; and interacted with both Ind and $LMIC$ dummies in the bottom right graph. The dummy for one year before TRIPS compliance (1999) is omitted. The outcome variable is *Emigration Rate (ER)*. The sample used consists of 44 countries that fully complied with TRIPS in 2000 and 32 countries that did not comply with TRIPS during our sample period of 1993-2011. The estimated specification includes time varying country controls (controlling for PCT accession year) and fixed effects for each country-sector pair and year. The year fixed effects are identified using data on TRIPS-non-compliant countries. Robust standard errors in parentheses are clustered at the country level.

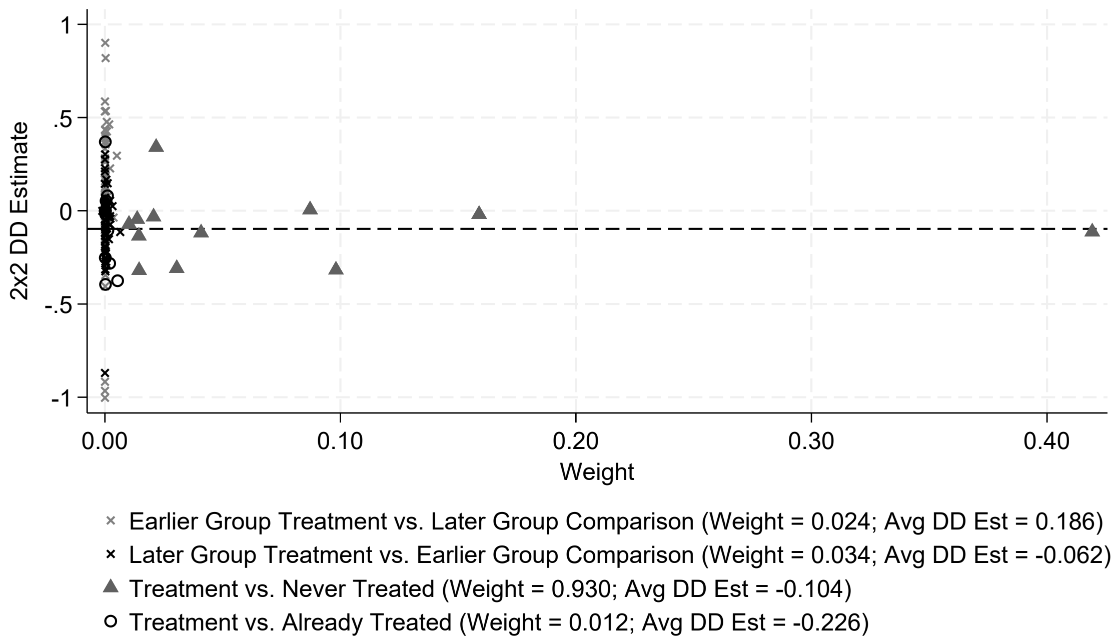


Figure 7: **Decomposition of a DiD estimator with variation in treatment timing**

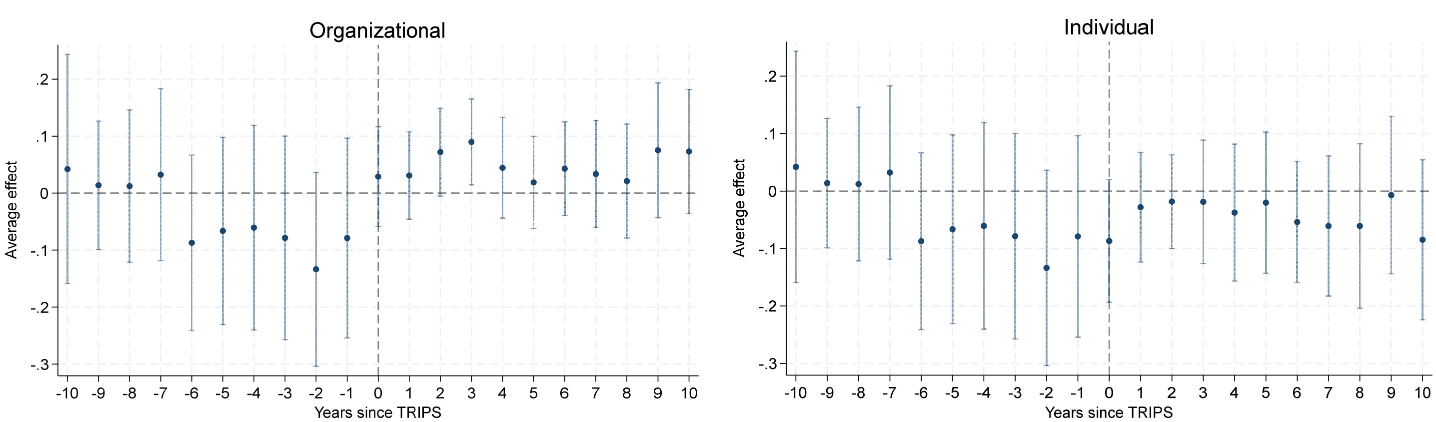


Figure 8: **The staggered-adoption DiD estimates, by inventor type**

Table 1: **Summary statistics**

Variable	Obs.	Mean	Std. Dev.	Min	Max
The rate of inventor emigration	3,102	0.626	0.393	0	1
Emigrants	3,102	48.746	331.585	0	5429
Residents	3,102	93.831	924.608	0	31232
Immigrants	3,102	2.533	23.518	0	753
Real GDP (in logs)	3,011	11.363	1.857	6.331	16.437
Population (in logs)	3,102	16.600	1.807	10.683	21.019
Human capital index (in logs)	2,832	0.779	0.247	0.076	1.198
Percentage of tertiary complete	2,787	5.788	5.374	0.011	26.591
Years of tertiary schooling	2,787	0.325	0.290	0.000	1.793
Financial openness	2,997	0.456	0.337	0.000	1
Capital stock (in logs)	3,011	12.566	1.908	7.292	17.705
External conflict	2,605	10.112	1.257	4.583	12
Internal conflict	2,605	8.979	1.664	2.958	12
Democratic accountability	2,605	3.826	1.412	0	6
Socioeconomic conditions	2,605	4.763	1.752	0	10
Corruption	2,605	2.370	0.866	0	5
Government stability	2,605	8.428	1.669	2.083	12
Total low-skill emigrants (in logs)	3,102	10.693	1.608	5.468	15.487
The index of PRs protection (in logs)	2,595	1.286	0.255	0	1.736
Post-TRIPS (all 103 countries)	3,102	0.546	0.498	0	1
Post-TRIPS (70 TRIPS-compliant countries)	2,584	0.655	.475	0	1

Table 2: **Descriptive results (correlations)**

VARIABLES	(1) All sectors	(2) Indiv	(3) Corp	(4) Public	(5) Indiv	(6) Corp	(7) Public	(8) Indiv	(9) Corp	(10) Public
Ginarte & Park Index (in logs)	-0.244***	-0.349**	-0.237***	-0.198**	-0.324*	-0.127	-0.107	-0.401**	0.036	0.061
	[0.071]	[0.152]	[0.071]	[0.085]	[0.179]	[0.096]	[0.136]	[0.151]	[0.101]	[0.159]
Corruption	-0.009	-0.030	0.002	-0.001	-0.032	-0.010	0.022	0.006	-0.002	0.025
	[0.015]	[0.024]	[0.016]	[0.021]	[0.022]	[0.013]	[0.023]	[0.025]	[0.016]	[0.026]
Capital Stock (in logs)	0.001	0.049	-0.005	-0.035	-0.101	-0.340***	-0.201*	0.242	-0.226	0.379
	[0.035]	[0.048]	[0.040]	[0.049]	[0.150]	[0.092]	[0.112]	[0.448]	[0.244]	[0.350]
Real GDP (in logs)	-0.170***	-0.204***	-0.180***	-0.133**	-0.124	0.005	0.045	-0.339*	-0.091	-0.093
	[0.040]	[0.059]	[0.042]	[0.066]	[0.131]	[0.063]	[0.109]	[0.185]	[0.092]	[0.159]
Population (in logs)	0.102***	0.086*	0.113***	0.106***	-0.617*	-0.053	-0.184	-2.015*	1.987*	2.078
	[0.027]	[0.043]	[0.033]	[0.035]	[0.333]	[0.178]	[0.353]	[1.143]	[1.099]	[1.492]
Human Capital Index (in logs)	0.075	-0.048	0.089	0.206	-0.354	0.284	0.502	-0.392	-0.438	1.269
	[0.096]	[0.181]	[0.104]	[0.157]	[0.853]	[0.357]	[0.811]	[1.486]	[0.835]	[1.478]
Percentage of Tertiary Complete	-0.002	-0.024**	0.012	0.003	-0.033	0.017	0.017	-0.053***	0.020	-0.013
	[0.007]	[0.010]	[0.010]	[0.011]	[0.023]	[0.020]	[0.039]	[0.019]	[0.022]	[0.027]
Years of Tertiary Schooling	0.071	0.380**	-0.197	0.081	0.591	-0.106	-0.529	1.006***	-0.302	0.033
	[0.131]	[0.185]	[0.178]	[0.207]	[0.422]	[0.416]	[0.787]	[0.324]	[0.494]	[0.568]
Financial Openness	0.051	0.025	0.080**	0.027	-0.086	0.114**	-0.047	-0.178*	0.162*	0.062
	[0.038]	[0.071]	[0.035]	[0.062]	[0.081]	[0.057]	[0.082]	[0.105]	[0.081]	[0.104]
External Conflict	-0.016	-0.039**	-0.003	-0.013	-0.002	-0.007	0.001	-0.016	0.001	0.015
	[0.012]	[0.017]	[0.013]	[0.021]	[0.022]	[0.009]	[0.023]	[0.025]	[0.011]	[0.023]
Internal Conflict	-0.003	-0.005	-0.002	-0.003	-0.006	-0.004	-0.002	0.003	-0.003	-0.006
	[0.006]	[0.013]	[0.008]	[0.010]	[0.014]	[0.009]	[0.012]	[0.011]	[0.008]	[0.014]
Democratic Accountability	-0.005	0.018*	-0.016*	-0.015	0.022	-0.004	-0.023	0.025	-0.009	-0.009
	[0.007]	[0.010]	[0.009]	[0.014]	[0.020]	[0.011]	[0.025]	[0.022]	[0.016]	[0.021]
Socioeconomic Conditions	-0.004	0.018	-0.002	-0.024*	-0.000	-0.016*	-0.009	0.010	0.013	0.003
	[0.007]	[0.013]	[0.008]	[0.012]	[0.014]	[0.009]	[0.017]	[0.016]	[0.010]	[0.017]
Government Stability	0.017**	0.024*	0.018**	0.010	-0.004	0.013*	0.006	-0.002	0.009	0.010
	[0.007]	[0.014]	[0.008]	[0.012]	[0.010]	[0.008]	[0.013]	[0.010]	[0.006]	[0.010]
Total Low-Skill Emigrants (in logs)	0.036***	0.010	0.047***	0.045**	0.182	0.096*	0.146	0.188	0.040	0.071
	[0.013]	[0.016]	[0.014]	[0.022]	[0.113]	[0.056]	[0.091]	[0.150]	[0.074]	[0.123]
Constant	0.916***	1.187**	0.616*	0.787*	12.636*	4.858	4.306	-17.889	1.405	72.361
	[0.330]	[0.509]	[0.326]	[0.409]	[6.551]	[3.105]	[6.030]	[39.632]	[29.805]	[51.911]
Sector fixed effects?	Yes									
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
Country fixed effects?					Yes	Yes	Yes	Yes	Yes	Yes
Country trends?								Yes	Yes	Yes
Observations	2,255	657	902	696	655	901	694	655	901	694
R-squared	0.459	0.288	0.412	0.251	0.523	0.591	0.456	0.611	0.653	0.557

Notes: OLS estimation using the sample of 60 countries over the period of 1993-2011. The outcome variable is the rate of inventor emigration. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table 3: **Countries by income and TRIPS compliance year**

TRIPS Year	Upper Middle Income	LM income	Low Income	LDC
1995	South Africa			
1996	Bulgaria			
1997	Panama	Mongolia		
1998			Kyrgyzstan	
1999	Latvia			
2000	Albania	Belize	Zimbabwe	
	Antigua and Barbuda	Bolivia		
	Argentina	Cameroon		
	Botswana	Congo Rp.		
	Colombia	El Salvador		
	Costa Rica	Fiji		
	Cuba	Georgia		
	Dominica	Guatemala		
	Dominican Rp.	Guyana		
	Ecuador	Honduras		
	Gabon	Indonesia		
	Grenada	Ivory Cst.		
	Jamaica	Morocco		
	Jordan	Nigeria		
	Malaysia	Philippines		
	Mauritius	Swaziland		
	Mexico			
	Namibia			
	Peru			
	Romania			
	St. Kitts and Nevis			
	St. Lucia			
	St. Vincent and the Grenadines			
	Suriname			
	Thailand			
	Turkey			
	Venezuela			
2001	Brazil	Moldova	Kenya	
	China			
	Lithuania			
	Uruguay			
2003	Macedonia FYR	Ghana		
		Armenia		
2005	Chile	India		
	Tunisia	Nicaragua		
		Pakistan		
		Papua New Guinea		
		Paraguay		
2006		Egypt		
2007		Tonga		
2008		Ukraine		
		Viet Nam		
2012	Russian Federation			
2016		Angola		Bangladesh
		Cabo Verde		Benin
		Lesotho		Burkina Faso
		Mauritania		Burma
		Senegal		Burundi
		Solomon Islands		Cambodia
		Vanuatu		Central African Rep.
		Zambia		Chad
				Congo Dem Rp. (Zaire)
				Guinea
				Guinea Bissau
				Haiti
				Madagascar
				Malawi
				Mali
				Mozambique
				Nepal
				Niger
				Rwanda
				Sierra Leone
				Tanzania
				The Gambia
				Togo
				Uganda

Table 4: **Emigration rate, 2000 vs. 2016 TRIPS compliance**

	(1)	(2)	(3)	(4)
Post-TRIPS	0.086*	0.062	0.094**	0.066
	[0.048]	[0.062]	[0.044]	[0.063]
Post-TRIPS * Individual	-0.120**	-0.134**	-0.128***	-0.138**
	[0.046]	[0.054]	[0.044]	[0.052]
Post-TRIPS * Public			-0.021	-0.012
			[0.051]	[0.060]
Corruption		-0.007		-0.007
		[0.016]		[0.016]
Capital Stock (in logs)		-0.287**		-0.287**
		[0.123]		[0.123]
Real GDP (in logs)		0.041		0.041
		[0.074]		[0.075]
Population (in logs)		-0.577***		-0.577***
		[0.205]		[0.204]
Human Capital Index (in logs)		0.637		0.638
		[0.610]		[0.608]
Percentage of Tertiary Complete		-0.000		-0.000
		[0.018]		[0.018]
Years of Tertiary Schooling		-0.060		-0.062
		[0.388]		[0.392]
Financial Openness		-0.012		-0.013
		[0.050]		[0.051]
External Conflict		-0.001		-0.001
		[0.012]		[0.012]
Internal Conflict		-0.005		-0.005
		[0.008]		[0.008]
Democratic Accountability		-0.013		-0.013
		[0.013]		[0.013]
Socioeconomic Conditions		-0.010		-0.010
		[0.009]		[0.009]
Government Stability		0.011		0.011
		[0.007]		[0.007]
Total Low-Skill Emigrants (in logs)		0.105*		0.105*
		[0.061]		[0.061]
Constant	0.662***	12.026***	0.662***	12.026***
	[0.025]	[4.192]	[0.026]	[4.192]
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes
Observations	1,918	1,436	1,918	1,436
R-squared	0.594	0.606	0.594	0.606

Notes: OLS estimation of model (1) for the sample of 76 countries, of which 44 fully complied with TRIPS in 2000 and 32 did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016). The outcome variable is the rate of inventor emigration from country j (to the group of OECD destination countries) in sector k in year t. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table 5: **Emigration rate by components and income groups**

	(1) *ER*	(2) *Emigr (ihs)*	(3) *Emigr (log)*	(4) *Resid (ihs)*	(5) *Resid (log)*	(6) *ER*	(7) *Emigr (ihs)*	(8) *Emigr (log)*	(9) *Resid (ihs)*	(10) *Resid (log)*
Post-TRIPS	0.062	0.759***	0.732***	0.734***	1.027**	0.051	0.990***	0.952***	1.077***	1.403***
	[0.062]	[0.201]	[0.219]	[0.215]	[0.409]	[0.072]	[0.211]	[0.220]	[0.263]	[0.428]
Post-TRIPS * Individual	-0.134**	-0.991***	-1.018***	0.002	-0.351**	-0.108*	-1.159***	-1.287***	-0.198	-0.451***
	[0.054]	[0.119]	[0.160]	[0.163]	[0.153]	[0.061]	[0.123]	[0.170]	[0.177]	[0.140]
Post-TRIPS * LMIC						0.031	-0.574***	-0.559***	-0.839***	-1.065***
						[0.064]	[0.178]	[0.184]	[0.237]	[0.287]
Post-TRIPS * Ind * LMIC						-0.083	0.524**	0.941***	0.620*	0.514
						[0.121]	[0.222]	[0.201]	[0.319]	[0.351]
Corruption	-0.007	-0.001	0.021	0.038	0.093	-0.007	-0.002	0.021	0.037	0.076
	[0.016]	[0.030]	[0.035]	[0.081]	[0.100]	[0.016]	[0.030]	[0.037]	[0.073]	[0.086]
Capital Stock (in logs)	-0.287**	-0.172	-0.188	0.759	1.256*	-0.289**	-0.091	-0.121	0.886*	1.438*
	[0.123]	[0.274]	[0.237]	[0.483]	[0.705]	[0.124]	[0.277]	[0.231]	[0.490]	[0.719]
Real GDP (in logs)	0.041	0.153	0.260	-0.225	-0.304	0.040	0.068	0.184	-0.364	-0.545*
	[0.074]	[0.200]	[0.186]	[0.310]	[0.310]	[0.074]	[0.177]	[0.153]	[0.293]	[0.307]
Population (in logs)	-0.577***	-2.079***	-1.330**	0.597	0.022	-0.578***	-1.866**	-1.207*	0.939	0.681
	[0.205]	[0.718]	[0.613]	[1.113]	[1.241]	[0.210]	[0.725]	[0.630]	[1.115]	[1.200]
Human Capital Index (in logs)	0.637	1.028	0.499	-0.403	-0.212	0.642	0.936	0.605	-0.536	0.222
	[0.610]	[1.315]	[1.076]	[2.632]	[2.454]	[0.604]	[1.157]	[0.909]	[2.589]	[2.193]
Percentage of Tertiary Complete	-0.000	0.028	0.089***	0.001	-0.072	-0.000	0.012	0.075**	-0.025	-0.110
	[0.018]	[0.046]	[0.028]	[0.103]	[0.117]	[0.019]	[0.055]	[0.033]	[0.106]	[0.128]
Years of Tertiary Schooling	-0.060	-0.480	-1.705***	0.447	1.739	-0.058	-0.243	-1.524**	0.834	2.375
	[0.388]	[0.976]	[0.572]	[2.254]	[2.549]	[0.403]	[1.118]	[0.641]	[2.261]	[2.757]
Financial Openness	-0.012	-0.207	-0.133	-0.378	-0.220	-0.011	-0.230*	-0.148	-0.413**	-0.196
	[0.050]	[0.131]	[0.117]	[0.237]	[0.231]	[0.050]	[0.136]	[0.125]	[0.205]	[0.185]
External Conflict	-0.001	-0.040	-0.029	-0.051	-0.006	-0.001	-0.035	-0.029	-0.042	0.019
	[0.012]	[0.027]	[0.023]	[0.034]	[0.047]	[0.012]	[0.027]	[0.022]	[0.036]	[0.041]
Internal Conflict	-0.005	-0.037	-0.032	-0.042	-0.079**	-0.005	-0.037	-0.032	-0.044*	-0.094***
	[0.008]	[0.028]	[0.026]	[0.027]	[0.035]	[0.009]	[0.026]	[0.024]	[0.025]	[0.028]
Democratic Accountability	-0.013	-0.003	-0.023	0.081	0.068	-0.013	0.014	-0.007	0.108*	0.109
	[0.013]	[0.036]	[0.032]	[0.059]	[0.082]	[0.013]	[0.031]	[0.028]	[0.059]	[0.089]
Socioeconomic Conditions	-0.010	0.074**	0.083***	0.153***	0.122***	-0.010	0.052**	0.063***	0.120***	0.089**
	[0.009]	[0.028]	[0.027]	[0.047]	[0.041]	[0.009]	[0.023]	[0.022]	[0.040]	[0.037]
Government Stability	0.011	0.013	0.009	-0.017	0.007	0.012	0.014	0.010	-0.016	0.008
	[0.007]	[0.018]	[0.017]	[0.042]	[0.040]	[0.007]	[0.017]	[0.016]	[0.041]	[0.038]
Total Low-Skill Emigrants (in logs)	0.105*	-0.128	-0.145	-0.600**	-0.364	0.105*	-0.147	-0.163	-0.631***	-0.448*
	[0.061]	[0.144]	[0.155]	[0.257]	[0.294]	[0.060]	[0.160]	[0.172]	[0.219]	[0.223]
Constant	12.026***	38.193***	24.656**	-9.288	-8.656	12.051***	34.805***	22.748*	-14.672	-18.984
	[4.192]	[12.661]	[11.006]	[20.907]	[21.912]	[4.260]	[12.690]	[11.277]	[20.725]	[21.284]
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,436	1,436	1,262	1,436	823	1,436	1,436	1,262	1,436	823
R-squared	0.606	0.845	0.854	0.807	0.806	0.606	0.848	0.858	0.812	0.814

Notes: OLS estimation of model (1) for the sample of 76 countries, of which 44 fully complied with TRIPS in 2000 and 32 did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016). The outcome variable is *Emigration Rate* in columns (1) and (6), *Emigrants* in (2)-(3) and (7)-(8), and *Residents* in (4)-(5) and (9)-(10), with the inverse hyperbolic sine *(ihs)* or logarithmic *(log)* transformation applied to *Emigrants* and *Residents*. The sample used in all regressions excludes 1,058 observations for which the value of *ER* is undefined, because the denominator ($Emigrants_{jt} + Residents_{jt}$) is equal to zero. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table 6: **Robustness to PCT accession**

	(1) *ER*	(2) *Emigr (ihs)*	(3) *Emigr (log)*	(4) *Resid (ihs)*	(5) *Resid (log)*	(6) *ER*	(7) *Emigr (ihs)*	(8) *Emigr (log)*	(9) *Resid (ihs)*	(10) *Resid (log)*
Panel A: Controlling for PCT accession years										
Post-TRIPS	0.084	0.773***	0.740***	0.594***	1.105***	0.069	0.997***	0.955***	0.957***	1.498***
	[0.063]	[0.196]	[0.213]	[0.190]	[0.384]	[0.072]	[0.205]	[0.216]	[0.237]	[0.386]
Post-TRIPS * Individual	-0.133**	-0.991***	-1.019***	-0.002	-0.364**	-0.109*	-1.159***	-1.288***	-0.191	-0.438***
	[0.054]	[0.119]	[0.160]	[0.162]	[0.151]	[0.062]	[0.123]	[0.170]	[0.180]	[0.140]
Post-TRIPS * LMIC						0.041	-0.570***	-0.556***	-0.904***	-1.090***
						[0.063]	[0.180]	[0.187]	[0.224]	[0.283]
Post-TRIPS * Individual * LMIC						-0.077	0.526**	0.944***	0.581*	0.422
						[0.121]	[0.221]	[0.200]	[0.318]	[0.345]
Post PCT entry	-0.093**	-0.057	-0.032	0.578***	0.603***	-0.093**	-0.037	-0.016	0.617***	0.636***
	[0.039]	[0.078]	[0.066]	[0.153]	[0.155]	[0.039]	[0.076]	[0.064]	[0.137]	[0.134]
Observations	1,436	1,436	1,262	1,436	823	1,436	1,436	1,262	1,436	823
R-squared	0.609	0.845	0.854	0.813	0.814	0.610	0.848	0.858	0.819	0.823
Panel B: Excluding countries not bound by the PCT										
Post-TRIPS	0.077	0.879***	0.932***	0.536**	0.980***	0.062	1.155***	1.190***	0.979***	1.396***
	[0.081]	[0.212]	[0.196]	[0.202]	[0.346]	[0.087]	[0.222]	[0.204]	[0.266]	[0.331]
Post-TRIPS * Individual	-0.110*	-0.972***	-0.921***	-0.034	-0.409**	-0.073	-1.144***	-1.183***	-0.247	-0.500***
	[0.059]	[0.134]	[0.162]	[0.182]	[0.175]	[0.066]	[0.146]	[0.187]	[0.202]	[0.164]
Post-TRIPS * LMIC						0.039	-0.616***	-0.588***	-0.971***	-1.242***
						[0.061]	[0.191]	[0.195]	[0.237]	[0.296]
Post-TRIPS * Individual * LMIC						-0.106	0.504**	0.822***	0.628*	0.498
						[0.125]	[0.234]	[0.211]	[0.332]	[0.367]
Post PCT entry	-0.081**	-0.030	-0.009	0.545***	0.568***	-0.081**	-0.015	0.002	0.572***	0.572***
	[0.037]	[0.088]	[0.077]	[0.140]	[0.142]	[0.038]	[0.085]	[0.072]	[0.126]	[0.122]
Observations	1,191	1,191	1,035	1,191	699	1,191	1,191	1,035	1,191	699
R-squared	0.624	0.846	0.856	0.819	0.827	0.625	0.850	0.860	0.826	0.837
Panel C: Excluding countries that accessed PCT in or after 1999										
Post-TRIPS	0.245**	1.570***	1.544***	0.424	1.528***	0.322***	1.916***	1.944***	0.636	1.389**
	[0.112]	[0.166]	[0.212]	[0.311]	[0.459]	[0.104]	[0.218]	[0.306]	[0.470]	[0.568]
Post-TRIPS * Individual	-0.170	-1.081***	-1.101***	-0.062	-0.380	-0.230**	-1.317***	-1.322***	-0.106	-0.367
	[0.103]	[0.184]	[0.194]	[0.258]	[0.264]	[0.096]	[0.178]	[0.246]	[0.308]	[0.292]
Post-TRIPS * LMIC						-0.126	-0.550**	-0.634*	-0.301	0.339
						[0.095]	[0.246]	[0.313]	[0.384]	[0.354]
Post-TRIPS * Individual * LMIC						0.143	0.564	0.730**	0.102	-0.103
						[0.221]	[0.330]	[0.264]	[0.497]	[0.425]
Post PCT entry	-0.236**	-0.188	-0.154	0.922**	0.754**	-0.237**	-0.190	-0.168	0.927**	0.759**
	[0.083]	[0.202]	[0.185]	[0.409]	[0.324]	[0.086]	[0.190]	[0.167]	[0.394]	[0.320]
Observations	537	537	480	537	289	537	537	480	537	289
R-squared	0.676	0.890	0.895	0.904	0.912	0.678	0.891	0.897	0.904	0.912

Notes: See notes under Table (5). All regressions include time-varying country controls and fixed effects for each country-sector pair and year, as in Table (5). We control for PCT accessions years in Panel A and also exclude countries that are not bound by the PCT (in Panel B) or countries that accessed PCT in or after 1999 (in Panel C).

Table 7: **Robustness to country time effects**

	(1) *ER*	(2) *Emigr (ihs)*	(3) *Emigr (log)*	(4) *Resid (ihs)*	(5) *Resid (log)*	(6) *ER*	(7) *Emigr (ihs)*	(8) *Emigr (log)*	(9) *Resid (ihs)*	(10) *Resid (log)*
Post-TRIPS	0.183***	0.836***	0.778***	0.139	0.636	0.203***	0.960***	0.924***	0.189	0.662
	[0.059]	[0.160]	[0.173]	[0.153]	[0.908]	[0.067]	[0.168]	[0.183]	[0.174]	[0.903]
Post-TRIPS * Individual	-0.138**	-0.984***	-1.082***	-0.001	-0.189	-0.119*	-1.148***	-1.325***	-0.191	-0.313*
	[0.057]	[0.124]	[0.164]	[0.182]	[0.174]	[0.065]	[0.130]	[0.175]	[0.195]	[0.163]
Post-TRIPS * LMIC						-0.067	-0.413**	-0.483**	-0.157	-0.252
						[0.076]	[0.175]	[0.185]	[0.227]	[0.297]
Post-TRIPS * Individual * LMIC						-0.061	0.524**	0.917***	0.607	0.504
						[0.125]	[0.223]	[0.199]	[0.361]	[0.436]
Corruption	0.001	-0.062*	-0.048	0.010	0.090	-0.002	-0.070*	-0.057	0.012	0.082
	[0.017]	[0.033]	[0.044]	[0.049]	[0.062]	[0.018]	[0.036]	[0.049]	[0.049]	[0.066]
Capital Stock (in logs)	-0.105	0.166	-0.510	0.465	-1.038	-0.033	0.388	-0.226	0.451	-0.907
	[0.225]	[0.601]	[0.774]	[0.735]	[1.015]	[0.245]	[0.577]	[0.706]	[0.759]	[1.096]
Real GDP (in logs)	-0.151	-0.446*	-0.022	0.141	-0.107	-0.158	-0.456**	-0.020	0.150	-0.130
	[0.096]	[0.222]	[0.246]	[0.274]	[0.292]	[0.095]	[0.223]	[0.244]	[0.270]	[0.306]
Population (in logs)	1.719***	0.303	-1.643	-3.701*	-4.487*	1.725***	0.426	-1.622	-3.617*	-4.225
	[0.543]	[1.859]	[1.820]	[2.044]	[2.501]	[0.584]	[1.739]	[1.774]	[2.092]	[2.636]
Human Capital Index (in logs)	1.142	-0.905	-1.488	-3.667*	-1.115	1.127	-0.912	-1.846	-3.629*	-0.831
	[0.823]	[2.117]	[2.017]	[2.026]	[3.470]	[0.798]	[2.062]	[2.036]	[2.018]	[3.587]
Percentage of Tertiary Complete	-0.017*	0.028	0.056**	0.067	-0.020	-0.020*	0.023	0.048*	0.071	-0.018
	[0.009]	[0.042]	[0.023]	[0.067]	[0.077]	[0.010]	[0.044]	[0.027]	[0.063]	[0.076]
Years of Tertiary Schooling	0.262	-1.102	-1.592***	-1.644	-0.214	0.332	-0.987	-1.412**	-1.743	-0.273
	[0.178]	[0.842]	[0.486]	[1.398]	[1.673]	[0.208]	[0.886]	[0.584]	[1.315]	[1.640]
Financial Openness	0.005	-0.195*	-0.193	-0.198	-0.148	0.010	-0.166	-0.159	-0.188	-0.122
	[0.056]	[0.115]	[0.147]	[0.175]	[0.164]	[0.056]	[0.119]	[0.154]	[0.175]	[0.181]
External Conflict	-0.015	-0.004	0.015	0.029	0.033	-0.014	-0.003	0.012	0.028	0.037
	[0.015]	[0.029]	[0.027]	[0.031]	[0.041]	[0.014]	[0.028]	[0.025]	[0.030]	[0.039]
Internal Conflict	-0.003	-0.012	-0.022	-0.005	-0.036	-0.003	-0.010	-0.021	-0.004	-0.038
	[0.007]	[0.019]	[0.022]	[0.023]	[0.030]	[0.007]	[0.019]	[0.023]	[0.023]	[0.032]
Democratic Accountability	-0.001	0.025	-0.004	0.045	0.011	0.001	0.027	0.001	0.043	0.011
	[0.013]	[0.028]	[0.027]	[0.036]	[0.042]	[0.014]	[0.026]	[0.026]	[0.035]	[0.042]
Socioeconomic Conditions	0.012	0.037*	0.037	-0.019	0.016	0.010	0.029	0.028	-0.021	0.017
	[0.008]	[0.021]	[0.026]	[0.029]	[0.036]	[0.008]	[0.020]	[0.025]	[0.029]	[0.036]
Government Stability	0.011	0.013	-0.001	-0.005	0.006	0.012	0.013	0.001	-0.007	0.005
	[0.007]	[0.018]	[0.017]	[0.025]	[0.034]	[0.007]	[0.017]	[0.017]	[0.025]	[0.034]
Total Low-Skill Emigrants (in logs)	0.132	0.251*	0.164	-0.191	-0.258	0.119	0.217	0.125	-0.185	-0.290
	[0.088]	[0.147]	[0.157]	[0.163]	[0.253]	[0.090]	[0.149]	[0.159]	[0.174]	[0.273]
Post PCT entry	-0.044	0.013	0.009	0.365***	0.425***	-0.039	0.022	0.014	0.359***	0.429***
	[0.038]	[0.088]	[0.082]	[0.105]	[0.127]	[0.039]	[0.088]	[0.078]	[0.108]	[0.129]
Constant	-27.504***	-2.285	35.423	60.660*	96.820**	-28.321**	-6.683	32.130	59.271*	90.996*
	[10.092]	[31.272]	[29.431]	[34.398]	[47.273]	[10.845]	[29.784]	[29.872]	[35.195]	[49.908]
Country-specific trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,436	1,436	1,262	1,436	823	1,436	1,436	1,262	1,436	823
R-squared	0.645	0.863	0.869	0.851	0.850	0.646	0.864	0.871	0.852	0.851

Notes: See notes under Table (5).

Table 8: **Robustness to TRIPS timing**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ER	*Emigr (ihs)*	*Emigr (log)*	*Resid (ihs)*	*Resid (log)*	*ER*	*Emigr (ihs)*	*Emigr (log)*	*Resid (ihs)*	*Resid (log)*
Post-TRIPS	0.027	0.289**	0.041	0.468***	0.544	-0.059	0.331***	0.097	0.956***	0.199
	[0.040]	[0.138]	[0.121]	[0.152]	[0.324]	[0.056]	[0.108]	[0.092]	[0.181]	[0.346]
Post-TRIPS * Individual	-0.163*	-1.082***	-1.164***	-0.245***	-0.260	-0.246	-1.386***	-1.372***	-0.208*	-0.011
	[0.093]	[0.186]	[0.189]	[0.083]	[0.288]	[0.146]	[0.067]	[0.031]	[0.100]	[0.298]
Post-TRIPS * LMIC						0.176*	-0.097	-0.123	-1.016***	1.552**
						[0.096]	[0.248]	[0.217]	[0.270]	[0.566]
Post-TRIPS * Individual * LMIC						0.208	0.711*	0.422	-0.152	-1.245
						[0.157]	[0.345]	[0.396]	[0.108]	[0.696]
Post PCT entry	0.000	-0.161	-0.145	0.271	0.800***	0.015	-0.156	-0.152	0.202	0.678***
	[0.101]	[0.182]	[0.152]	[0.254]	[0.185]	[0.105]	[0.178]	[0.148]	[0.251]	[0.207]
Constant	-15.184*	11.673	28.102	80.515***	22.973	-12.306	12.854	28.021	67.440***	33.216
	[8.288]	[21.750]	[18.126]	[23.068]	[61.627]	[7.543]	[21.683]	[18.081]	[21.313]	[53.393]
Observations	479	479	434	479	161	479	479	434	479	161
R-squared	0.579	0.802	0.830	0.755	0.807	0.586	0.803	0.831	0.763	0.814

Notes: See notes under Table (5). All regressions include time-varying country controls and fixed effects for each country-sector pair and year, as in Table (5). TRIPS-compliant country group comprises 6 countries that fully complied with TRIPS by 2005. TRIPS-non-compliant group comprises 32 countries that did not comply with TRIPS during the period of 1993-2011.

Table 9: **Robustness to alternative estimators**

	(1) *ER*	(2) *Emigrants*	(3) *Residents*	(4) *ER*	(5) *Emigrants*	(6) *Residents*
Post-TRIPS	1.555	0.491**	0.496	1.423	0.558**	0.697
	[1.125]	[0.218]	[0.558]	[1.135]	[0.231]	[0.551]
Post-TRIPS * Individual	-0.861***	-0.925***	-0.462**	-0.762**	-1.086***	-0.520***
	[0.295]	[0.151]	[0.188]	[0.340]	[0.138]	[0.194]
Post-TRIPS * LMIC				0.416	-0.349*	-1.665***
				[0.375]	[0.207]	[0.237]
Post-TRIPS * Individual * LMIC				-0.390	0.822***	0.949**
				[0.673]	[0.269]	[0.447]
Corruption	-0.106	-0.018	-0.002	-0.100	-0.018	-0.025
	[0.095]	[0.040]	[0.067]	[0.091]	[0.045]	[0.048]
Capital Stock (in logs)	-2.625***	-0.437	3.249***	-2.649***	-0.408	3.069***
	[0.836]	[0.321]	[1.087]	[0.824]	[0.314]	[0.963]
Real GDP (in logs)	0.122	0.511**	-0.323	0.186	0.450**	-0.535*
	[0.477]	[0.241]	[0.372]	[0.478]	[0.219]	[0.320]
Population (in logs)	-3.594***	-0.805	-0.259	-3.739***	-0.852*	0.176
	[1.375]	[0.532]	[1.241]	[1.312]	[0.517]	[0.891]
Human Capital Index (in logs)	3.667	-0.033	8.849**	3.629	0.264	8.379**
	[3.308]	[2.274]	[4.375]	[3.246]	[2.001]	[3.638]
Percentage of Tertiary Complete	-0.020	0.089***	-0.016	-0.007	0.084***	-0.025
	[0.078]	[0.018]	[0.046]	[0.074]	[0.018]	[0.046]
Years of Tertiary Schooling	-0.292	-1.430***	0.548	-0.498	-1.359***	0.683
	[1.659]	[0.237]	[1.069]	[1.576]	[0.246]	[1.110]
Financial Openness	-0.065	0.088	-0.296*	-0.056	0.084	-0.211*
	[0.301]	[0.121]	[0.175]	[0.279]	[0.135]	[0.122]
External Conflict	-0.005	-0.092**	0.064	-0.014	-0.078**	0.109
	[0.088]	[0.041]	[0.091]	[0.091]	[0.035]	[0.084]
Internal Conflict	-0.007	0.027	-0.010	-0.004	0.022	-0.039
	[0.055]	[0.028]	[0.044]	[0.054]	[0.027]	[0.036]
Democratic Accountability	-0.023	0.023	0.072*	-0.034	0.025	0.056*
	[0.084]	[0.023]	[0.041]	[0.081]	[0.024]	[0.033]
Socioeconomic Conditions	-0.042	0.065***	0.012	-0.028	0.059***	0.005
	[0.054]	[0.016]	[0.035]	[0.055]	[0.018]	[0.021]
Government Stability	0.054	0.015	-0.012	0.054	0.016	-0.009
	[0.041]	[0.012]	[0.025]	[0.041]	[0.012]	[0.027]
Total Low-Skill Emigrants (in logs)	0.727*	0.013	-0.378	0.753*	-0.036	-0.597***
	[0.438]	[0.125]	[0.251]	[0.412]	[0.122]	[0.152]
Post PCT entry	-0.468*	0.045	0.625***	-0.473**	0.059	0.686***
	[0.240]	[0.039]	[0.095]	[0.236]	[0.039]	[0.086]
Constant	79.495***	10.745	-36.328***	81.093***	12.206	-35.782***
	[23.379]	[8.850]	[13.690]	[22.473]	[8.798]	[11.808]
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,441	1,441	1,441	1,441	1,441	1,441

Notes: Fractional Logit estimation in columns (1) and (4), for the rate of inventor emigration as the outcome variable. Poisson Quasi-Maximum Likelihood Estimation (QMLE) in columns (2)-(3) and (4)-(5), for the counts or emigrant or resident inventors as the outcome variables. The sample comprises 76 countries, of which 44 fully complied with TRIPS in 2000 and 32 did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016). Robust standard errors in parentheses are clustered at the country level. $***$ $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10: **Emigration rate, differential vs. constant treatment timing**

	(1)	(2)	(3)	(4)
	Differential timing		*Constant timing*	
Post-TRIPS	0.006	0.020	0.086*	0.062
	[0.026]	[0.034]	[0.048]	[0.062]
Post-TRIPS * Individual	-0.095***	-0.117***	-0.120**	-0.134**
	[0.033]	[0.039]	[0.046]	[0.054]
Constant	0.688***	6.100*	0.804***	12.129***
	[0.039]	[3.211]	[0.050]	[4.149]
Time-varying country controls		Yes		Yes
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes
Observations	3,102	2,417	1,939	1,441
R-squared	0.016	0.057	0.023	0.067

Notes: Two-way fixed effects estimation of model (1), for the sample of 103 countries with differential treatment timing in columns (1)-(2) and the sample of 76 countries with constant treatment timing in columns (3)-(4). The outcome variable is the rate of inventor emigration from country j (to the group of OECD destination countries) in sector k in year t. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table 11: **Individual vs. organizational difference in ATT**

Horizon (years since TRIPS)	Estimate	Std. Error	p-value
$h = 0$	-0.116**	0.053	0.029
$h = 1$	-0.059	0.054	0.275
$h = 2$	-0.090**	0.043	0.034
$h = 3$	-0.108**	0.054	0.043
$h = 4$	-0.082	0.052	0.115
$h = 5$	-0.039	0.055	0.479
$h = 6$	-0.097**	0.049	0.046
$h = 7$	-0.094*	0.056	0.089
$h = 8$	-0.082	0.064	0.204
$h = 9$	-0.082	0.056	0.139
$h = 10$	-0.158**	0.066	0.017
Overall	-0.093***	0.032	0.004

Notes: The *lincom* test of the difference in the weighted averages of treatment effects between organizational and individual inventors ($tau\_ind - tau\_org$), for each horizon. The test was implemented after the *did_imputation* command with the *hetby()* option. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Appendix

1. The Conceptual Framework Predictions

Define $ER_i \equiv E_i/(E_i + R_i)$ and $ER_o \equiv E_o/(E_o + R_o)$. We have:

$$R_i = \alpha_i \delta V; \qquad E_i = \left(1 - \frac{\delta}{2}\right) \delta V^2 - \alpha_i \delta V; \qquad R_o = \alpha_o \delta V - \frac{\alpha_o^2}{2}; \qquad E_o = \frac{1}{2}(\delta V - \alpha_o)^2,$$

where $\alpha_i \equiv F/\varphi_i$ and $\alpha_o \equiv [F - (\rho - 1)\delta V)]/\varphi_o$.

First, $(\partial ER_o/\partial \varphi_o)/(d\varphi_o/dIPR) = 0$, since $d\varphi_o/dIPR = 0$.

Secondly, $(\partial ER_i/\partial \varphi_i)/(d\varphi_i/dIPR) = 0$, since $\partial E_i/\partial \varphi_i = \alpha_i \delta V/\varphi_i > 0$ and $\partial(E_i + R_i)/\partial \varphi_i = 0$.

Next, we have $d\delta/dIPR > 0$. It follows that $(\partial ER_i/\partial \delta)/(d\delta/dIPR) < 0$ if $\partial ER_i/\partial \delta < 0$, which requires that $E_i^{'}(E_i + R_i) < (E_i + R_i)^{'} E_i$, where

$$E_i^{'} \equiv \frac{\partial E_i}{\partial \delta} = V\left[(1 - \delta)V - \alpha_i\right] > 0 \quad \text{and} \quad (E_i + R_i)^{'} \equiv \frac{\partial (E_i + R_i)}{\partial \delta} = (1 - \delta)\, V^2 > 0.$$

Using these derivatives, we simplify $E_i^{'}(E_i + R_i) < (E_i + R_i)^{'} E_i$ to obtain: $\delta < 2\delta$, which is true.

Last, it follows that $(\partial ER_o/\partial \delta)/(d\delta/dIPR) > 0$ if $\partial ER_o/\partial \delta > 0$, which requires that $E_o^{'}(E_o + R_o) > (E_o + R_o)^{'} E_o$, where

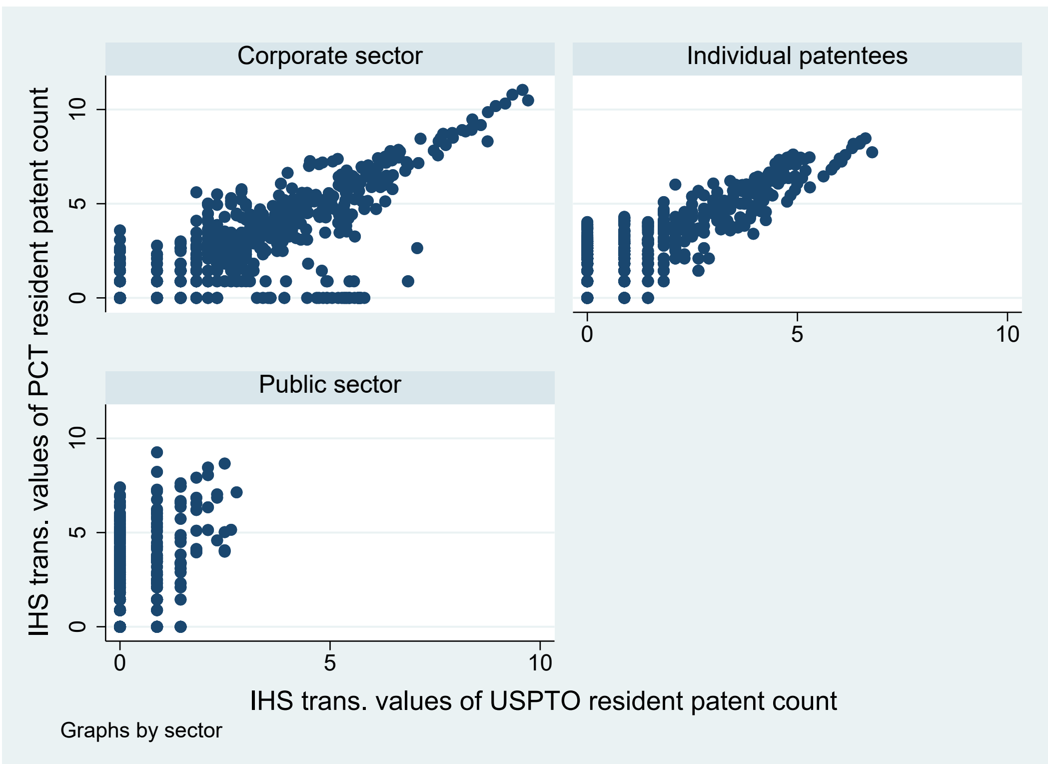
$$E_o^{'} \equiv \frac{\partial E_o}{\partial \delta} = (\delta V - \alpha_o)V\left(1 + \frac{\rho - 1}{\varphi_o}\right) > 0 \quad \text{and} \quad (E_o + R_o)^{'} \equiv \frac{\partial (E_o + R_o)}{\partial \delta} = \delta V^2 > 0.$$

Using these derivatives, we simplify $E_o^{'}(E_o + R_o) > (E_o + R_o)^{'} E_o$ to obtain: $(\rho - 1)\delta V + \alpha_o \varphi_o > 0$, which is true.

2. Alternative Emigration Rates using Imputed Patent Counts

In Table 6, we present results that drop non-PCT member countries. While this is a useful conservative robustness check, it reduces the number of observations substantially and drops many lower-income countries, making it difficult to test hypotheses about varying effects by income level. As an alternative robustness check against biases associated with PCT membership that does not require the dropping of non-PCT member countries, we impute the number of PCT patents in non-member countries using US patent data. To do this, we incorporate data from the Patentsview on the number of granted USPTO patents with inventors with an address in sample countries, by application year and sector. To identify the sector of USPTO patents, we use Patentsview's "assignee type" code. We classify patents as individual if the patent is not assigned to an organization or if the assignee type is recorded as either a US or foreign individual (codes 4 or 5). We classify the patent corporate if the assignee is a US or foreign corporation (codes 2 or 3); and as a public sector patent if the patent is assigned to a government entity (codes 6-9). USPTO patent counts are an imperfect measure of resident patenting since they do not capture inventions that do not seek protection in the US. However, since the US is one of the world's most important export markets, we expect USPTO patent data to capture the majority of a country's export-oriented patents. To confirm that USPTO patent counts are a reasonable measure of resident patent counts, we examine correlations for PCT-member countries. The overall correlation between IHS-transformed USPTO and PCT patent counts among individual inventors in PCT member countries in our sample is 0.87, for organizational inventors the correlation is 0.82, and for public sector inventors it is 0.56. Scatter plots displaying the relationship between PCT and USPTO patents are below:

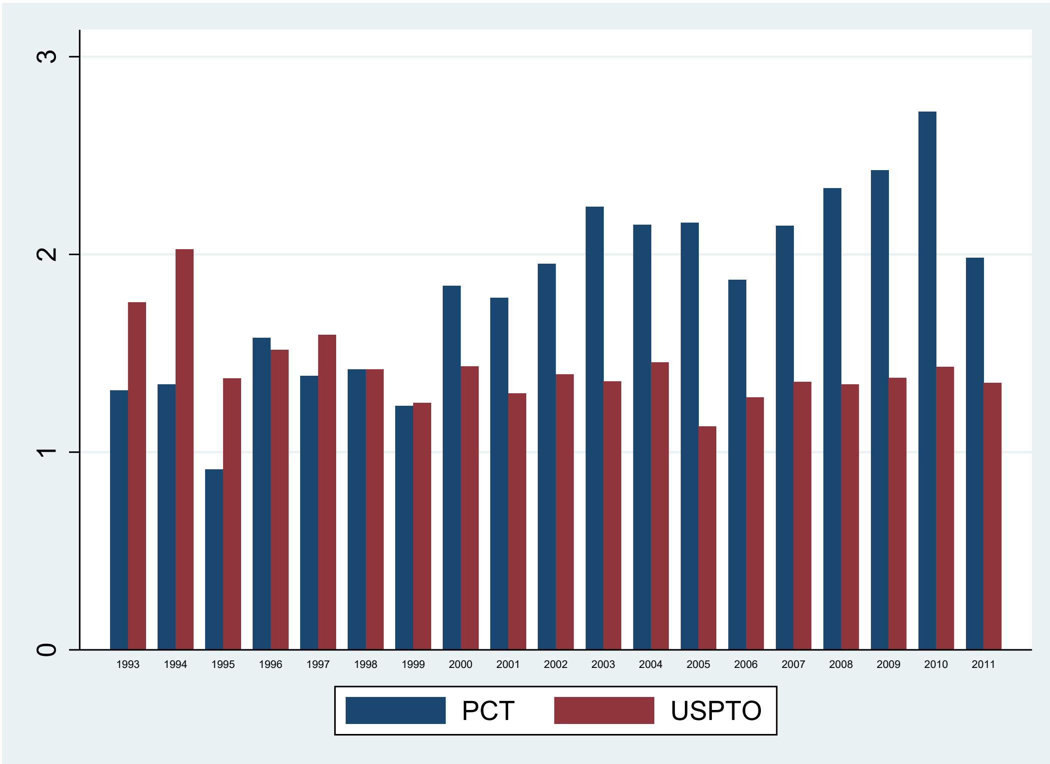
Figure A.1: PCT and USPTO patents filed by residents (IHS transformed) for PCT member countries



Restricting to PCT member countries in our sample who adopted TRIPS in 2000 or 2016, the correlations between PCT and USPTO patents are 0.80 for individual inventors, 0.64 for corporate inventors, and 0.20 for public inventors. If we restrict the sample to countries that had been PCT members for at least 5 years, these correlations are 0.88, 0.82 and 0.59 respectively.

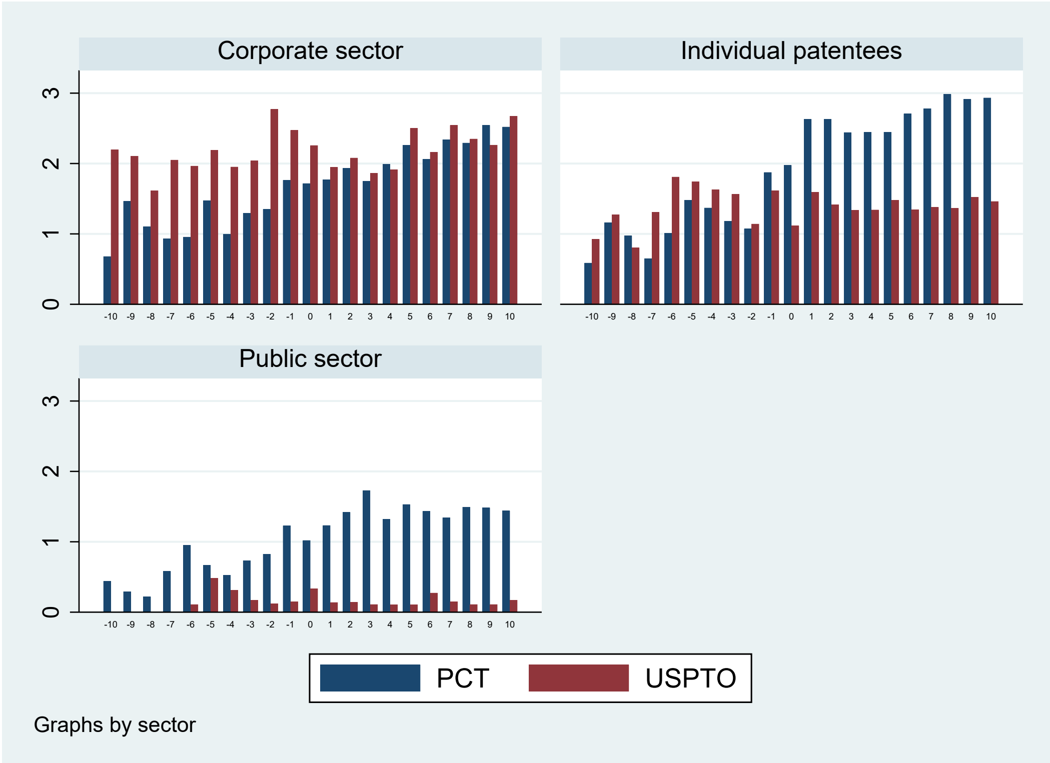
Separately, consider the figure below, which displays the counts of PCT and USPTO patents by application year for countries that acceded to the PCT in 1999 (CR, DM, MA, TZ), 2000 (AG, BZ, MZ), or 2001 (CO, EC, PH, ZM). Note that USPTO patent counts exceed PCT counts in the early years, but the gap narrows after 1999 and in the later years PCT counts often exceed USPTO counts.

Figure A.2: Average annual resident PCT and USPTO patent counts (IHS transformed) in countries adopting the PCT in 1999, 2000 or 2021



The next figure displays IHS transformed counts of PCT and USPTO patents by sector and year - year of PCT accession (where year of PCT accession = 0). This and the previous figure suggest that prior to adopting the PCT, residents of non-member countries tend to file foreign-oriented patents at the USPTO, but that after joining the treaty, the rate of patent filing via the PCT increases.

Figure A.3: Average annual resident PCT and USPTO patents (IHS transformed) by number of years relative to joining PCT (t = year − year joined PCT), by sector, countries that adopted PCT by 2009



The relative rate of PCT filing appears to increase most among individual and public inventors. Corporate inventors may be less sensitive to PCT membership because they are more likely to co-invent with team members who are residents of a PCT member country. Public-sector patents are not as well represented by the USPTO patent counts, possibly because the USPTO assignee classification makes it difficult to identify public research institutes and universities. The results in Table A1 below are robust to grouping public and corporate sector patents into a single category (e.g., "organizational" inventors).

To allow for the possibility that the count of resident patents is underestimated in countries that have yet to adopt the PCT, we thus construct an alternative measure of the emigration rate. We impute the resident patent count for non-PCT-member countries by regressing PCT resident patent counts for PCT member countries on the inverse hyperbolic sine of the country's USPTO patent count and a dummy for the sector, dummies (using Poisson regression to deal with zero values in the left hand side variable). We then compute fitted values for the whole sample. This generates a counterfactual resident patent count based on the relationship between USPTO resident patent counts and the PCT patent counts of member countries. We then use the imputed PCT resident patent count to calculate an alternative emigration rate in which imputed resident patent counts are used as the denominator for non-PCT member countries. The first two columns of Table A1 contain results from the specification used in columns 1 and 6 of Table 5, using the imputed patent count described above to construct the emigration rate. As an alternative (used in columns 3 and 4 of Table A.1 below), we impute PCT patents using IHS-transformed USPTO patent counts and sector-by-year interactions. A third method used in columns 5-6 imputes resident patent counts using IHS-transformed USPTO patents, sector and year dummies, the logs of GDP and population, and a dummy for lower-middle income countries.

Consistent with the main results in Tables 4 and 5, we continue to estimate significantly lower emigration rates for individual inventors post-TRIPS (columns 1, 3 and 5). The differential effect for LMIC individual inventors is negative but not significant at the 5% level in columns 2, 4 or 6).

Table A1: **Core results using alternative emigration rates with imputed resident counts**

	(1)	(2)	(3)	(4)	(5)	(6)
Post-TRIPS	0.099*	0.088	0.086	0.074	0.103**	0.107*
	[0.055]	[0.056]	[0.055]	[0.056]	[0.051]	[0.055]
Post-TRIPS * Individual	-0.217***	-0.175***	-0.192***	-0.150***	-0.204***	-0.156***
	[0.043]	[0.043]	[0.043]	[0.044]	[0.050]	[0.054]
Post-TRIPS * LMIC		0.037		0.038		0.002
		[0.060]		[0.063]		[0.066]
Post-TRIPS * Individual * LMIC		-0.136		-0.134		-0.153
		[0.095]		[0.091]		[0.105]
Country-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,436	1,436	1,436	1,436	1,436	1,436
R-squared	0.739	0.740	0.735	0.735	0.716	0.717
Fixed effects in imputation	sector	sector	sectorXyear	sectorXyear	sector, year, LMIC	sector, year,LMIC
Additional controls in imputation	none	none	none	none	GDP,pop	GDP,pop

Notes: OLS estimation of model (1) for the sample of 76 countries, of which 44 fully complied with TRIPS in 2000 and 32 did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016). The outcome variable is the rate of inventor emigration from country j (to the group of OECD destination countries) in sector k in year t. Additional controls include all the control variables included in Table 4. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table A2: **Number of observations by year and sector, 103 countries**

Year	Individual	Corporate	Public
1993	28	36	15
1994	27	45	23
1995	39	49	28
1996	40	49	29
1997	36	58	37
1998	41	61	43
1999	47	64	44
2000	46	73	52
2001	55	70	50
2002	44	71	53
2003	56	82	53
2004	53	75	63
2005	50	82	56
2006	57	82	61
2007	55	86	63
2008	58	81	57
2009	59	77	62
2010	57	82	69
2011	45	73	55
Total	893	1296	913

Notes: The sample comprises 103 countries.

Table A3: **Emigration rate by components and income groups, full sample**

	(1)	(2)	(3)	(4)	(5)	(6)
	ER	*Emigr (ihs)*	*Resid (ihs)*	*ER*	*Emigr (ihs)*	*Resid (ihs)*
Post-TRIPS	0.062	0.661***	0.582***	0.051	0.805***	0.835***
	[0.062]	[0.160]	[0.155]	[0.072]	[0.215]	[0.231]
Post-TRIPS * Individual	-0.134**	-0.917***	0.065	-0.108*	-0.964***	-0.041
	[0.054]	[0.089]	[0.106]	[0.061]	[0.128]	[0.140]
Post-TRIPS * LMIC				0.031	-0.302	-0.535**
				[0.064]	[0.210]	[0.201]
Post-TRIPS * Individual * LMIC				-0.083	0.124	0.275
				[0.121]	[0.164]	[0.203]
Corruption	-0.007	0.014	0.041	-0.007	0.015	0.044
	[0.016]	[0.036]	[0.053]	[0.016]	[0.034]	[0.048]
Capital Stock (in logs)	-0.287**	-0.265	0.107	-0.289**	-0.235	0.157
	[0.123]	[0.255]	[0.265]	[0.124]	[0.264]	[0.275]
Real GDP (in logs)	0.041	0.022	-0.119	0.040	-0.010	-0.173
	[0.074]	[0.196]	[0.212]	[0.074]	[0.181]	[0.190]
Population (in logs)	-0.577***	-2.123**	-0.568	-0.578***	-1.990**	-0.341
	[0.205]	[0.797]	[0.918]	[0.210]	[0.796]	[0.908]
Human Capital Index (in logs)	0.637	2.024	1.156	0.642	1.784	0.747
	[0.610]	[1.583]	[1.910]	[0.604]	[1.583]	[2.006]
Percentage of Tertiary Complete	-0.000	-0.028	-0.001	-0.000	-0.041	-0.023
	[0.018]	[0.080]	[0.110]	[0.019]	[0.087]	[0.114]
Years of Tertiary Schooling	-0.060	0.925	0.642	-0.058	1.110	0.957
	[0.388]	[1.718]	[2.407]	[0.403]	[1.835]	[2.449]
Financial Openness	-0.012	-0.236	-0.372*	-0.011	-0.270	-0.430**
	[0.050]	[0.172]	[0.213]	[0.050]	[0.169]	[0.206]
External Conflict	-0.001	-0.046**	-0.047*	-0.001	-0.048**	-0.050*
	[0.012]	[0.021]	[0.026]	[0.012]	[0.021]	[0.027]
Internal Conflict	-0.005	-0.032*	-0.030	-0.005	-0.030	-0.026
	[0.008]	[0.019]	[0.018]	[0.009]	[0.018]	[0.017]
Democratic Accountability	-0.013	0.047	0.089**	-0.013	0.055*	0.104**
	[0.013]	[0.032]	[0.038]	[0.013]	[0.029]	[0.039]
Socioeconomic Conditions	-0.010	0.054**	0.129***	-0.010	0.037	0.100**
	[0.009]	[0.027]	[0.046]	[0.009]	[0.024]	[0.041]
Government Stability	0.011	-0.011	-0.053	0.012	-0.009	-0.049
	[0.007]	[0.019]	[0.035]	[0.007]	[0.019]	[0.033]
Total Low-Skill Emigrants (in logs)	0.105*	-0.205	-0.530***	0.105*	-0.191	-0.507***
	[0.061]	[0.135]	[0.174]	[0.060]	[0.142]	[0.161]
Constant	12.026***	40.075***	14.862	12.051***	37.916**	11.182
	[4.192]	[14.151]	[16.234]	[4.260]	[14.260]	[15.888]
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,436	2,499	2,499	1,436	2,499	2,499
R-squared	0.606	0.843	0.807	0.606	0.844	0.810

Notes: OLS estimation of model (1) for the sample of 76 countries, of which 44 fully complied with TRIPS in 2000 and 32 did not comply with TRIPS during our sample period of 1993-2011 (but eventually complied in 2016). The outcome variable is *Emigration Rate (ER)* in columns (1) and (4), *Emigrants* in (2) and (5), and *Residents* in (3) and (6). The inverse hyperbolic sine transformation was applied to *Emigrants* and *Residents*. The sample in columns (1) and (4) excludes 1,058 observations for which the value of *ER* is undefined, because the denominator ($Emigrants_{jt}+Residents_{jt}$) is equal to zero, while the sample in the other columns includes these zero observations on *Emigrants* and *Residents*. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table A4: **Emigration rate, OECD placebo**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	TRIPS in 1995		TRIPS in 1996		TRIPS in 2000		All OECD countries	
Post-TRIPS * Individual	0.007	0.004	0.033	0.102	0.001	-0.002	0.015**	0.015**
	[0.009]	[0.010]	[0.057]	[0.065]	[0.008]	[0.005]	[0.006]	[0.007]
Corruption		-0.001		0.059		-0.015		-0.002
		[0.004]		[0.046]		[0.007]		[0.003]
Capital Stock (in logs)		-0.066		0.033		-0.232		-0.068
		[0.052]		[0.375]		[0.129]		[0.044]
Real GDP (in logs)		-0.025		0.098		-0.149*		-0.001
		[0.038]		[0.192]		[0.053]		[0.035]
Population (in logs)		0.110		-1.585**		0.117		0.045
		[0.125]		[0.466]		[0.062]		[0.065]
Human Capital Index (in logs)		-0.020		-0.403		-0.240		-0.237
		[0.133]		[0.345]		[0.136]		[0.183]
Percentage of Tertiary Complete		0.003		-0.021		-0.001		0.002
		[0.005]		[0.014]		[0.003]		[0.003]
Years of Tertiary Schooling		-0.063		0.357		0.129**		-0.007
		[0.098]		[0.195]		[0.038]		[0.070]
Financial Openness		0.011		-0.115*		-0.031		0.021*
		[0.020]		[0.047]		[0.033]		[0.012]
External Conflict		-0.001		0.041*		-0.003		-0.001
		[0.003]		[0.015]		[0.001]		[0.002]
Internal Conflict		-0.000		0.006		-0.003		0.001
		[0.003]		[0.021]		[0.002]		[0.003]
Democratic Accountability		-0.001		-0.014		0.020*		0.002
		[0.004]		[0.010]		[0.007]		[0.003]
Socioeconomic Conditions		-0.001		-0.003		0.014		-0.001
		[0.002]		[0.009]		[0.006]		[0.002]
Government Stability		-0.000		-0.004		0.003		-0.000
		[0.002]		[0.008]		[0.004]		[0.001]
Total Low-Skill Emigrants (in logs)		-0.002		0.046		0.114*		-0.011
		[0.017]		[0.033]		[0.043]		[0.017]
Constant	0.516***	0.068	0.598***	22.358*	0.548***	2.479	0.530***	1.151
	[0.003]	[1.488]	[0.016]	[7.882]	[0.002]	[2.690]	[0.001]	[1.063]
Country-by-sector fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,303	1,226	221	205	221	209	1,745	1,640
R-squared	0.652	0.732	0.666	0.720	0.446	0.758	0.664	0.742

Notes: OLS estimation of model (1). The sample is limited to 23 OECD countries that complied with TRIPS in 1995 in columns (1)-(2), four OECD countries that complied with TRIPS in 1996 in columns (3)-(4), and four OECD countries that complied with TRIPS in 2000 in columns (5)-(6). In columns (7)-(8), the impact is evaluated around 2000 for the full sample of 31 OECD countries. The outcome variable is the rate of inventor emigration. Robust standard errors in parentheses are clustered at the country level. $***\ p < 0.01$, $^{**}\ p < 0.05$, $^{*}\ p < 0.1$.

Table A5: **PCT accession years**

PCT year	Countries
1978	Brazil, **Cameroon**, *Cent.Afr.Rep.*, *Chad*, **Congo Rp.**, **Gabon**
	Madagascar, *Malawi*, *Russian Federation*, *Senegal*, *Togo*
1979	**Romania**
1983	*Mauritania*
1984	Bulgaria, *Mali*
1987	*Benin*
1989	*Burkina Faso*
1991	Armenia, **Georgia**, *Guinea*, **Ivory Cst.**, Kyrgyzstan, Moldova, Mongolia, Ukraine
1993	Latvia, *Niger*, Viet Nam
1994	China, Kenya, Lithuania, **Swaziland**
1995	**Albania**, *Lesotho*, Macedonia FYR, **Mexico**, *Uganda*
1996	**Cuba**, **St. Lucia**, **Turkey**
1997	Ghana, *Guinea-Bissau*, **Indonesia**, *Sierra Leone*, *The Gambia*, **Zimbabwe**
1998	**Grenada**, India
1999	**Costa Rica**, **Dominica**, **Morocco**, South Africa, *Tanzania*
2000	**Antigua and Barbuda**, **Belize**, *Mozambique*
2001	**Colombia**, **Ecuador**, **Philippines**, Tunisia, *Zambia*
2002	**St. Vincent and the Grenadines**
2003	**Botswana**, Egypt, Nicaragua, Papua New Guinea
2004	**Namibia**
2005	**Nigeria**, **St. Kitts and Nevis**
2006	**El Salvador**, **Guatemala**, **Honduras**, **Malaysia**
2007	*Angola*, **Dominican Rp.**
2009	Chile, **Peru**, **Thailand**
2011	*Rwanda*
2012	Panama
2016	*Cambodia*
2017	**Jordan**
2022	*Cabo Verde*, **Jamaica**
.	**Argentina**, *Bangladesh*, **Bolivia**, *Burma*, *Burundi*, *Congo Dem Rp. (Zaire)*,
	Fiji, **Guyana**, *Haiti*, **Mauritius**, *Nepal*, Pakistan, Paraguay, *Solomon Islands*, **Suriname**
	Tonga, Uruguay, *Vanuatu*, **Venezuela**

Notes: PCT year is missing (.) for countries that are not bound by PCT. Countries that complied with TRIPS in 2000 are highlighted in bold. Countries that did not comply with TRIPS during our sample period of 1993-2011 are italicised.

Table A6: **Number of observations by year and sector, 44 countries**

Year	Individual	Corporate	Public
1993	13	20	4
1994	14	22	9
1995	18	24	17
1996	22	25	14
1997	16	29	15
1998	20	31	22
1999	27	31	21
2000	24	35	24
2001	28	35	23
2002	20	31	24
2003	26	37	25
2004	26	35	29
2005	21	40	24
2006	27	40	30
2007	26	40	30
2008	27	36	30
2009	27	38	28
2010	29	36	31
2011	21	35	26
Total	432	620	426

Notes: The sample comprises 44 countries that complied with TRIPS in the year 2000.

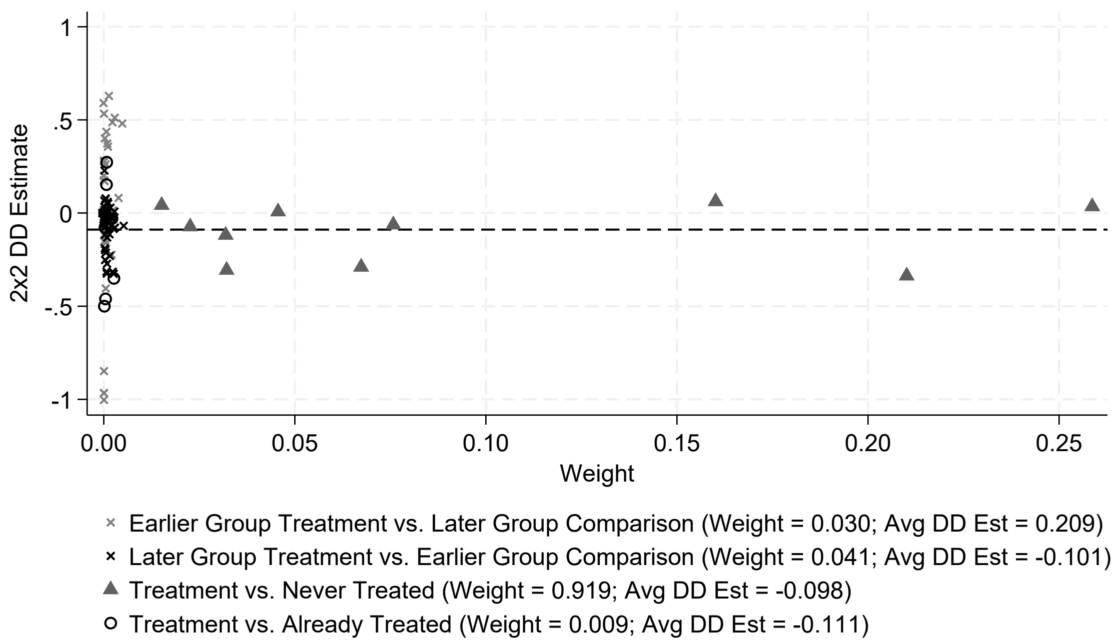


Figure A1: **Decomposition of a DiD estimator with variation in treatment timing**