Free Movement of Inventors: Open-Border Policy and Innovation in Switzerland*

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Abstract

We study the innovation effects of the Agreement on the Free Movement of Persons, signed by Switzerland and the European Union in 1999. We exploit a quasi-experimental setting created by Switzerland's implementation of the treaty, which initially eased entry restrictions only for commuters from neighboring countries, thereby inducing a large inflow of "cross-border inventors" in regions close to the border. We find that the treaty increased patenting in such regions relative to comparable ones farther away from the border. We find no evidence indicating the displacement of native inventors or a reduction in the patenting activity of Switzerland's neighboring countries. We also find that incumbent inventors in regions next to the border increased their productivity, thanks to patents in collaboration with cross-border inventors. We provide evidence suggesting that cross-border inventors contributed to Swiss patenting by enabling R&D laboratories to enlarge, albeit without increasing the productivity of local peers outside direct collaborations.

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1. Introduction

The international migration of skilled workers is historically linked to innovation. In early modern Europe, itinerant craftsmen served as the main agents for diffusing technical knowledge (Cipolla 1972; Belfanti 2004; Hilaire-Pérez and Verna 2006), and the forced relocation of religious minorities after the Reformation significantly contributed to technological progress in host countries (Scoville 1952a,b; Luu 2005; Hornung 2014). Similar patterns have been observed in more recent times, such as with the flight of Jewish scientists from Nazi Germany (Moser et al. 2014) and Russian emigration following the collapse of the Soviet Union (Borjas and Doran 2012; Ganguli 2015).

Today, foreign-born individuals make up a large share of science, technology, engineering, and mathematics (STEM) workers across many advanced economies (Kerr 2008; Miguelez and Fink 2017), in a context of revived global migration (Kerr et al. 2016) and of rising importance of teamwork in R&D activities (Wuchty et al. 2007; Jones 2009; Agrawal et al. 2016). A growing literature investigates the effects of immigration on innovation in destination countries, mostly in the United States and often focusing on the implications of policy changes (Kerr and Lincoln 2010; Hunt and Gauthier-Loiselle 2010; No and Walsh 2010; Hunt 2011; Stuen et al. 2012; Kerr et al. 2015; Burchardi et al. 2020; Doran et al. 2022; Glennon 2024). Related research examines productivity spillovers between immigrants and natives (Bernstein et al. 2021) and the possibility of displacement effects due to substitutability and competition (Borjas and Doran 2012, 2015).

In this paper, we study the innovation effects of the Agreement on the Free Movement of Persons (AFMP), a treaty signed by Switzerland and the European Union (EU) in 1999. The treaty prescribed the elimination of most worker mobility restrictions between Switzerland and the EU as part of a broader economic liberalization. Its application in Switzerland was gradual and varied across regions and immigrant permit types. In particular, regions very close to the border experienced a disproportionate increase in cross-border commuters, the first category of visa holders for which restrictions were removed, thus generating a quasi-experimental setting (Beerli et al. 2021). We exploit this setting to study the treaty's effect on innovation at both the regional and individual levels, using patent and inventor data matched to administrative records on immigrants.

Despite its small size, Switzerland is both an innovation powerhouse and a leading destination of international high-skilled workers, making it a highly relevant case study. In recent years, Switzerland has consistently ranked among the top countries worldwide for patent applications per capita and for full-time R&D employees relative to population (?EPO 2020). Many of these employees are immigrants. For example, patent data between 2001 and 2010 indicate that one-third of inventors residing in Switzerland were foreign nationals (versus 12% in the UK and 16% in the US; see Miguelez and Fink 2017). However, up until the AFMP treaty was signed, and notwithstanding the importance of European workers for its economic system, Switzerland did not lower its entry barriers from the EU, which were also binding for highly skilled individuals (Piguet 2009).

We rely on an original dataset comprising 67,869 patent applications filed at the European Patent Office (EPO) between 1990 and 2012 to protect inventions resulting from Swiss-located R&D activities. By comparing the personal and company addresses reported on patent applications, we identify a large number of "cross-border inventors", namely inventors living in commuting zones across the border but working in Switzerland. For the years 2002–2012, we verify this patent-based definition of cross-border inventors by comparing it to one based on administrative data, using personal records on immigrant permit holders from the Swiss Central Migration Information System (ZEMIS). The database covers the entire immigrant population in Switzerland since 2002 and provides valuable information on immigrants' age, entry date, and other personal characteristics.

We first find that the AFMP led to a large increase in cross-border inventors but only for regions close to the border. We argue that this differential effect is not due to any unobserved trend affecting both innovation and immigration. This creates a powerful treatment-control setting, which we exploit to study the effects of immigration on innovation. Using an event study approach, we estimate an annual increase in patenting between 15% and 54% in the treated regions during the first eight years following the AFMP's ratification. The temporal evolution of our estimates indicates that those inventions would have remained unrealized absent the AFMP.

Our results do not depend exclusively on very large multinational conglomerates, which could have anticipated the AFMP, but also and predominantly on large- and medium-sized patent applicants. Nor do they depend on new firms or firms moving to the treated regions to profit from the increased supply of inventors, owing instead to incumbent firms increasing their patenting activity. They are largely driven by patents in the instruments, chemicals, and pharmaceuticals fields, which collectively account for over half of our sample and represent the main patented technologies from regions close to the international border.

We do not find evidence suggesting that the policy-induced inflow of cross-border inventors occurred to the detriment of Swiss inventors, whose number does not appear to have decreased in treated regions, relative to control ones, after the AFMP's introduction. Nor do we detect adverse effects on the inventive output of regions close to the Swiss border in France, Germany, or Italy, where the number of patent filings does not appear to have declined relative to that of other areas in the same countries.

We next conduct our analysis at the individual level, first focusing on incumbent inventors. These are Swiss and foreign residents whose patenting activity began before the AFMP's signing and whose location and specialization decisions can be assumed to be exogenous to the treaty. We find that, relative to those in control regions, incumbent inventors in treated ones increased their annual patent filings by 17%–46% in the post-AFMP period, with most of the additional patents resulting from new collaborations with cross-border inventors. Several pieces of evidence suggest that this outcome is due to the availability of more skilled cross-border workers as collaborators, with a profile complementary to that of the incumbents.

First, we observe that the newly arrived cross-border inventors tend to be rather young, with no previous patenting experience, while many incumbents are more experienced and possibly in positions of responsibility within their R&D labs. Second, we find that incumbent inventors in treated regions increase the number of distinct co-inventors they team up with in the post-AFMP period, relative to those in control regions. Third, we show that cross-border inventors bring with them some distinctive knowledge assets, but not enough to generate major knowledge transfer effects, capable of changing the direction of R&D of the firms they join. In particular, we find that incumbent inventors in treated regions increase their citations to patents from cross-border inventors' countries in the post-AFMP period and that this effect is entirely due to patents in collaboration with cross-border inventors. At the same time, these patents do not introduce novel terms in the text of their abstract, relative to the stock of Swiss patents accumulated before the AFMP introduction, nor they substantially depart from the technological classes where incumbent inventors patented before.

In the second part of our individual-level analysis, we focus on more junior Swiss resident inventors. Identifying the effects of the AFMP on those who started patenting after its ratification is particularly challenging. Their decisions to become inventors and their location choices are unlikely to be exogenous to the treaty, and we cannot observe them before the date of their first patent. As a partial remedy, we focus on Swiss residents who started patenting right before the AFMP's introduction but whose subsequent activity occurred entirely in the post-AFMP context, in both the treated and control regions. We adopt a difference-in-differences strategy and compare their patenting record to that of similar inventors of previous cohorts, whose activity took place entirely in the pre-AFMP context. Our estimates suggest that the AFMP's introduction positively affected the productivity of junior inventors in treated regions (similar in magnitude, albeit in fewer years than incumbent inventors), once again in the absence of major knowledge transfers from cross-border inventors.

We conclude our investigation by examining the outcomes of incumbent "R&D locations," a patent-based proxy of firms' R&D laboratories, which we cannot directly observe. Our results indicate that R&D locations in treated regions experienced an increase in active inventors, both Swiss residents and cross-border, following the AFMP's introduction. However, there were no significant changes in the average size or experience of their inventor teams. This suggests that the increased availability of cross-border inventors allowed R&D locations in treated regions to increase their patenting productivity by expanding laboratory capacity, but it did not produce any major organizational change.

Our paper complements and extends the evidence on the effects of the AFMP's introduction provided by Beerli et al. (2021), whose study was the first to exploit the treaty's introduction as a natural experiment. They show that the increased supply of cross-border workers post-AFMP did not harm Swiss workers' employment and wages; and, based on survey data, that it increased the propensity of Swiss firms to patent. We provide novel evidence in many respects. First, by using the full set of patents filed by Swiss firms at the EPO, we can better quantify and qualify the AFMP's innovation effects. Second, we establish a direct link between the AFMP-induced supply shock of foreign inventors and the increase in patenting. Third, we extend the analysis to Switzerland's neighboring countries. Fourth, we study individual inventors' productivity and collaborations, using information on inventor teams. Fifth, we examine the patents' textual and technological content.

More generally, our findings contribute to the literature examining the relationship between immigration and innovation. To the best of our knowledge, ours is one of the few studies available on the innovation effects of the Free Movement of Workers principle, which is a pillar of the EU and the main source of migration to many of its member countries (Kahanec et al. 2016; Dustmann and Preston 2019; Dorn and Zweimüller 2021). Our analysis at the individual inventor level is also original with respect to prior studies on migration and innovation in the European context, which mostly focus on variations in immigrants' share of the workforce or population and their association with various measures of innovation (Ozgen et al. 2013; Parrotta et al. 2014; Bosetti et al. 2015; Nathan 2015; Ferrucci and Lissoni 2019).

Our results differ from those of comparable studies for the United States. Kerr and Lincoln (2010) find that more H-1B visa admissions of foreign high-skilled workers increased patenting by foreign inventors in highly H-1B-dependent locations, without positive productivity effects on natives. In contrast, we find a positive effect on the productivity of Swiss resident incumbents.

Compared to Moser et al. (2014) and Ganguli (2015), who study immigration events involving established scientists and inventors, we find no evidence of major knowledge transfer effects. We attribute this to the relatively young age profile of most cross-border inventors in our study, whose main impact consisted of allowing incumbent inventors to undertake more R&D projects, easing previous constraints.

This mechanism also differs from prior research on peer effects in R&D teams, which finds that positive effects are mainly driven by either high-standing scientists (Azoulay et al. 2010; Oettl 2012) or the slow accumulation of team-specific capital between frequent collaborators (Jaravel et al. 2018; Bernstein et al. 2021).

Last, unlike Borjas and Doran (2012), who show that the influx of Soviet mathematicians to the US after the Soviet Union's collapse negatively affected the careers of their American junior peers, we do not find adverse effects of immigration on the productivity of the younger domestic inventors. This can be attributed to the higher elasticity of labor demand in industrial R&D relative to the academic labor market. In our setting, companies can expand their R&D laboratories to absorb new foreign workers without displacing their domestic counterparts, whereas academic positions in research universities are more rigid.

The rest of the paper proceeds as follows. Section 2 provides background information on Swiss immigration laws, before and after the AFMP. Section 3 describes our data collection methodology and the resulting dataset. Section 4 outlines our quasi-experimental setting and describes the cross-border inventors' supply shock. Sections 5 and 6 present the results of our regional- and inventor-level analysis, respectively. Section 7 provides additional results at the R&D location level, and Section 8 concludes.

2. The Swiss Immigration System and the AFMP

The inflow of foreign workers in Switzerland is regulated by a "demand-based" system, where only those with a job offer can apply for an immigrant permit. Due to the peculiar geography of Switzerland, which is surrounded by the three largest EU countries and Austria, with some densely populated agglomerations on both sides of the border, permits for cross-border workers are as important as those for resident immigrants.

Resident immigrants are foreigners who work and reside anywhere in Switzerland. Their entry permit can be either a "B," which is valid for 5 years, or an "L," which is valid for 1 year. After 5 years of uninterrupted stay in Switzerland (10 years for non-EU citizens), they can request a permit "C" with unlimited validity. Cross-border workers are foreigners who reside in neighboring countries' areas close to the Swiss border and commute to nearby Swiss cities for work. They hold a "G" permit, which has been historically regulated by bilateral treaties.

Until 2002, these treaties included some geographical restrictions, as they indicated the cross-border-designated areas inside Austria, France, Germany, and Italy where foreign workers had to reside to be eligible for the permit, as well as the Swiss "border regions" in which the permit allowed them to work.[1]

On June 21, 1999, Switzerland and the EU signed the AFMP. Gradually implemented over the following years, this treaty lifted most restrictions to workers' immigration from the EU to Switzerland (and vice versa). Its negotiations were part of a comprehensive series addressing the relationship between the EU and Switzerland. They began in 1994, two years after Swiss voters rejected, with a referendum, their government's proposal to join the European Economic Area. Their result remained uncertain until common ground was established in 1998, and the AFMP's introduction became certain only after the positive outcome of another referendum held on May 21, 2000. Swiss entrepreneurs could scarcely anticipate its introduction nor make plans based on it.

Before the AFMP's implementation, the concession of work permits for both cross-border workers and resident immigrants was subject to many limitations. Sponsoring employers had to go through a costly and time-consuming application process, which included showing that they had searched and failed to find a native worker with the required skills. Although cross-border workers were not subject to immigration quotas like resident immigrants, they faced multiple restrictions. For example, they were required to have resided in the cross-border-designated areas for at least six months before applying for a G-permit, and had to commute back to their countries of residence every day. Additionally, their work permits had to be renewed annually and were tied to a specific employer, and they could only work in a border region corresponding to their G-permit-designated area.

These restrictions were progressively lifted during the AFMP's implementation. Immediately after the treaty's signing in 1999, the procedures for firms to obtain G-permits were informally simplified. Then, after its official introduction on June 1, 2002, the duration of G-permits was extended to five years and no longer tied to a specific employer. In addition, the compulsory daily commute was transformed into a weekly one, and the six-month residence requirement to be eligible for a G-permit was eliminated (workers were still required to reside

[1]The treaties were signed in 1928 with Italy, 1946 with France, 1970 with Germany, and 1973 with Austria. The treaties with Germany and Austria indicate precisely in which cities and/or districts within these two countries the commuters must reside and in which ones in Switzerland they can work. For France and Italy, the treaties simply mention the obligation to reside at no more than 10 km behind the border and to work at no more than 10km beyond it. Appendix Table B6 reports the specific administrative units in Austria, France, Germany, and Italy corresponding to a G-permit-designated area, based on information from the State Secretariat for Migration (`https://www.sem.admin.ch/sem/de/home/publiservice/weisungen-kreisschreiben/auslaenderbereich.html`, last visit: August 2025). Figure 1 shows them on a map. For the Swiss border regions, we rely on the list used by Beerli et al. (2021).

in a G-permit-designated area after obtaining the permit). In 2004 all residual restrictions for G-permit holders in Swiss border regions were dropped, while the non-border regions still remained under a separate regime.

Finally, in 2007, nationals of EU15 (EU member countries in 2004) and EFTA (the European Free Trade Area, which in 1999 included Iceland, Liechtenstein, and Norway) gained full freedom to work in Switzerland without distinction between border regions and non-border regions, regardless of their working permit.[2]

In summary, the AFMP's introduction laid down the conditions for a geographically heterogeneous labor supply shock: stronger in the border regions, to which cross-border workers were admitted, and weaker in the non-border regions, which admitted only resident immigrants. As we discuss below, the shock was also asymmetric within the border regions, with the new cross-border inventors working almost exclusively in locations within a short commute from a border crossing point. This provides us with a quasi-experimental setting, which we return to in Section 4.

3. Data

Our main data source is the Worldwide Patent Statistical Database (Patstat), version 2017b.[3] Despite their well-known limitations, patent statistics are a key innovation measure in R&D-intensive economies like Switzerland (Griliches 1990; Nagaoka et al. 2010). Patent documents provide rich information on both the inventions they protect and their inventors (the physical persons who have produced the ideas described and protected by the patent) and applicants (mostly the inventors' employers, with the main exception of independent inventors who file their own applications).[4]

We extract from Patstat all the patent applications filed at the EPO, whether granted, under examination, or rejected (for ease of exposition, we refer to all of them simply as "patents"). One reason why we focus on EPO patents is because they contain accurate information on the address of both inventors and applicants, which we need for geocoding purposes (Breschi and Lissoni 2004). At the same time, filing through the EPO represents a convenient way for Swiss companies to obtain patent protection at the continental level and beyond (via international extension).

As for the choice of using patent applications instead of granted patents, this is common practice when dealing with EPO data, as the EPO has always published them 18 months after

[2]Appendix Figure A1 illustrates the AFMP implementation timeline, by region and immigrant category. Note that potential resident immigrants also experienced a gradual relaxation of immigration restrictions, starting in 2002, but with no differences across regions.

[3]See `https://www.epo.org/searching-for-patents/business/patstat.html` (last accessed August 2025).

[4]For more details on the distinction between inventors and applicants, see Appendix B1.

filing, irrespective of the outcome of the examination process (in contrast, in the United States the Patent & Trademark Office started publishing non-granted patents only after 2011, making it impossible to have a long time series of applications).[5] We date each application with its first filing year worldwide.[6]

3.1. Sampling, Disambiguation, and Geolocation

We consider all patents with first filing years ranging between 1990 and 2012. This time frame ensures a decade or so of observations both before and after the AFMP's signing. Since we only want to focus on the output of R&D labs located in Switzerland, we proceed as follows. First, we retain all patents that include at least one inventor with a Swiss address regardless of the applicant's address. To these, we add the patents filed by applicants with a Swiss address and no inventors with a Swiss address, but at least one inventor with an address in a G-permit-designated area in Austria, France, Germany, or Italy.

Second, we disambiguate inventors and applicants. Although Patstat data provide unique identifiers for inventors and applicants, inconsistencies such as simple spelling mistakes or address changes can result in the same person (or firm) receiving multiple identifiers across different patents. Therefore, we must further disambiguate these entries to accurately track both individuals and firms over time and across locations. For inventors, we use the identifiers produced by the algorithm of Pezzoni et al. (2014). For applicants, we use the identifiers produced by Du Plessis et al. (2009), which we improve by manually checking all applicants in our data with at least 20 patents (accounting for roughly 56% of all patents in our dataset) to verify their company or group affiliation.

Third, we assign each patent to the location where the inventive activity presumably occurred and filter out those originating from outside of Switzerland. Patent data do not explicitly report the address of the R&D laboratories (or other facilities) that sourced the inventions they protect, only those of applicants and inventors. Hence, we must deduce the presumed location of the invention source (henceforth "R&D location") from either one or both of sets of addresses.

Regarding the applicant's address, the larger the company, the more likely the address coincides with that of the company's headquarters or intellectual property division. These may be located in different cities or, in the case of multinationals, even in different countries than those hosting the R&D laboratories.[7] As for the inventors' address, the most common practice

[5] Besides data availability, there are a number of technical reasons for preferring application data to granted patent data, which we discuss in Appendix B1. Nevertheless, we obtain similar results for all our main estimates when using only granted patents in a series of robustness checks.

[6] In legal terms, this is more precisely defined as the "priority year." For details, see Appendix B1.

[7] For example, the municipality of Rüschlikon (Zurich) hosts one of IBM's 12 global research labs. Out of all IBM's 603 patents in our dataset, only one mentions it in the applicant's address, while the others indicate IBM's headquarters in Armonk, New York. In contrast, 80% of the inventors' addresses indicate municipalities

followed by patent attorneys is to report that of their home, which we expect to be relatively close to their workplace. In this case, the inventor and applicant addresses differ. When they coincide, it is because the attorney preferred using the applicant address also for the inventors.

Based on these considerations, we infer each applicant's R&D location(s) from the distribution of its inventor addresses, with the applicant addresses playing an auxiliary role. We first use the Google Maps Geolocation API to geocode each Swiss address on our patents and assign it to a Swiss "spatial mobility region". For each applicant, we calculate the frequency distribution of all its inventor-patent instances across such regions, thus obtaining one or more candidate R&D locations.[8]

When applicants have just one candidate R&D location (22% of all patents in the dataset), we retain this as the only relevant one. When they have multiple candidate locations and at least 20 patents in their portfolios (58% of all patents), we extensively search the companies' websites and other online resources and retain only the candidate R&D locations that match them. For the remaining applicants with multiple candidate R&D locations but fewer than 20 patents (20% of total patents), we retain only the location that corresponds to the region with the highest number of inventor-patent instances. In this case, we do not perform systematic manual checking except for ambiguous cases (e.g., when the number of patents is closely matched across two or more candidate locations). We also filter out any false Swiss R&D location. This involves identifying applicants without a Swiss-based facility yet holding a few patents with one or more Swiss-based inventors. Such patents are typically due to collaborations between a Swiss academic and a foreign research institution or a Swiss-based inventor consulting internationally.[9]

Last, we identify inventors with a likely cross-border worker status ("cross-border inventors"). We distinguish them from inventors working and residing in Switzerland ("resident inventors"), whether Swiss nationals or not, and also from other inventors collaborating with a Swiss R&D lab from abroad, that is, with no connection to the Swiss labor market. We provide further details in Section 3.2.

around Zurich.

[8] Swiss spatial mobility regions, or "MS regions" from the French "mobilité spatiale", are defined by the Swiss Federal Statistical Office as travel-to-work areas for micro-regional analyses (Schuler et al. 2005). They consist of agglomerations of municipalities and are large enough to track our inventors' commutes to work. In addition, they are ideal units of analysis for our econometric exercises due to their heterogeneity in terms of G-permit holders' presence (see Section 4).

[9] We search and eliminate the former by looking at keywords such as "university" or "foundation" in the applicants' names (237 patents). As for the latter, we search online for corporate information and eliminate all those for which no Swiss-based R&D facility is ever mentioned (3,466 patents). We believe our method of identifying R&D locations to be accurate and necessary due to the need to remove the noise contained in the applicants' and inventors' addresses and to locate correctly within Switzerland the patents signed by local inventors and foreign resident ones. However, we also experiment with simpler methods, which do not require the use of personal judgment and external information. In one case we simply assign each patent and inventor to the applicant's spatial mobility region, alternatively we use the inventor's one.

Our final sample thus includes all patents by resident inventors and/or cross-border inventors, assigned to the Swiss location where the inventive activity presumably occurred. This amounts to 67,869 patents, 13,831 applicants, and 86,876 inventors. Around 91% of all patents in our dataset are filed by firms, 2% by universities and nonprofit research organizations, and 7% by independent inventors. Most patents originate either from applicants with just one R&D location or, for those with multiple R&D locations, from just one of them (47,108 patents, approximately 70% of all patents). In these cases, we treat all the inventors listed on the patent as employed in that location, even if their addresses are outside the corresponding spatial mobility region. As for the patents with multiple R&D locations, they may originate from multiple labs of the same company or from joint applications by different companies, each one with its own lab. In both cases, we assign each inventor to one or another R&D location (and the corresponding region) by simply picking the location closest to the their address, and assign patents fractionally to each location.

We complement our main dataset with an additional one that includes all patents filed in Austria, France, Germany, and Italy. This is specifically for testing any possible first-order effect of the AFMP on Switzerland's neighbor countries. We extract from Patstat all EPO patents filed between 1990 and 2012 that list at least one inventor with an address in one of these four countries. After discarding any patent filed or co-filed by applicants with a Swiss address or listing a cross-border inventor as a co-inventor, we assign each remaining patent to the NUTS-3 region where most of the inventor team is located. If no clear majority exists, we assign it to the applicant's location. The final sample consists of 28,253 patents for Austria, 161,132 for France, 429,198 for Germany, and 83,480 for Italy.[10]

In what follows, we illustrate the methodology we adopt to identify cross-border inventors, and describe their main characteristics. More details about our procedures for disambiguating inventors and applicants and assigning patents to their R&D locations is available in Appendix B.

3.2. Cross-Border and Resident Inventors

We define as cross-border inventors all inventors who, according to patent information, reside in a G-permit-designated area in Austria, France, Germany, or Italy and work in a nearby Swiss R&D location. For each G-permit-designated area, we consider as "nearby" all the Swiss spatial mobility regions in cantons with the same official languages of the country across the border. The only exceptions are the cantons of Bern, Fribourg, Grisons, and Valais, which have

[10]In Austria, NUTS-3 regions correspond to districts' aggregations, in France to departments, in Germany to districts, and in Italy to provinces. These are substantially larger geographical units than Swiss spatial mobility regions, making it less likely that their inventions will be misassigned to their R&D location.

two or more official languages, and those of Basel-Stadt and Basel-Landschaft, which share borders with both France and Germany. In those cases, we opt for a conservative definition strictly based on the G-permit-designated areas' geographic proximity. Appendix B4 reports the complete pairwise list of G-permit-designated areas and "nearby" regions.[11] We define as resident inventors all those with a Swiss address. In this way, we count 6,090 cross-border inventors associated with 10,348 patents and 56,457 resident inventors associated with 64,435 patents.

Note that the resident inventors category does not distinguish between Swiss and foreign nationals (holders of B, C, or L permits). This is because EPO patents do not report any useful information in this regard. For this reason, when applicable, we focus on what we refer to as the EPO-PCT subsample, which consists of patents first filed at the EPO, from the 1990s to 2010, and then extended to the United States via the Patent Cooperation Treaty (PCT) procedure. For administrative reasons, explained by Miguelez and Fink (2017), patents in this subset contain information on the inventors' nationality, allowing us to fully distinguish between cross-border inventors, other foreign inventors, and Swiss inventors.

Figure 1 shows the distribution of cross-border inventors across Switzerland's neighboring countries. The colored areas indicate the municipalities where cross-border inventors reside, all of which are located close to the border. Those with the highest proportion of cross-border inventors are, in general, immediately adjacent to it. Germany hosts the largest share, followed by France, and, significantly behind, Austria and Italy.

For the 2002–2012 period, we verify our patent-based cross-border inventor definition by comparing it to one based on ZEMIS administrative records. These records provide data on all foreign nationals working and/or residing in Switzerland, including their permit types (with issue and renewal dates), addresses, nationality, and year of birth. Using a supervised machine learning strategy first proposed by Feigenbaum (2016), we match inventor and ZEMIS records and identify as cross-border inventors all matches holding a G-permit. We also classify all the matches with permits other than G as foreign resident inventors and all the non-matches as Swiss

[11] While cross-border inventors could also reside outside the G-permit-designated areas after 2007, we do not adapt our address-based definition to this change. This is because outside such areas, we cannot distinguish between inventors employed by a Swiss R&D lab and those who collaborate with a Swiss lab due to an international partnership (i.e., without being one of its employees and a cross-border commuter). The only exceptions are the very few cases in which we observe the same inventor on more than one patent, first with an address in a G-permit-designated area and then in a location further away from the Swiss border (most often in large cities such as Milan, Munich, and Stuttgart). As long as all the patents are filed by a Swiss-based applicant, we keep labeling the inventor as a cross-border inventor even after the change of address. We are aware that this methodology may lead us to underestimate the number of cross-border inventors after 2007, but a different choice would introduce too many false cross-border inventors in our sample. Nevertheless, using information from immigration records, we find few cross-border inventors residing outside G-permit-designated areas (Appendix Figure C4).

nationals. When comparing the spatial distribution of cross-border inventors identified with the two methods, we observe an almost complete overlap. When comparing their distribution over time, the overlap is once again almost complete from 2002 to 2008. After 2008, the figures diverge, with the ZEMIS-based cross-border inventor definition producing a higher count than the patent-based cross-border one. The gap is due to an increase in the number of patents listing inventors' work address rather than their residential one in the final years of our sample, which prevents the identification of cross-border inventors from patent data alone (Appendix C).[12]

The ZEMIS biographical information also allows us to better characterize cross-border inventors, albeit only for the post-AFMP period. Panels (a) and (b) of Figure 2 confirm that most cross-border inventors are either German or French citizens and are disproportionately active in chemical and pharmaceutical technologies. Panels (c) and (d) indicate that these inventors generally enter the Swiss innovation system early on in their inventor careers. Depending on their technology field, only 12% to 17% obtained the G-permit after having filed at least one patent abroad. Their average age at arrival in Switzerland is 33.7 years, and the median and modal age are both 32 years, all close to the average age of first-time inventors indicated by the literature (Jones 2009; Breschi et al. 2020; Kaltenberg et al. 2023).

When considering their entire observable patenting career, we find that cross-border inventors are more productive than resident inventors. We obtain this evidence by regressing an inventor's productivity measure on a dummy variable equal to 1 for cross-border inventors and 0 for resident inventors, and controlling for inventors' first patent cohort, technology field, and key applicant and co-inventors' characteristics (panel (e) of Figure 2). Our results do not change much when excluding independent inventors and cross-border inventors who already patented before moving to a Swiss employer.

We also find that patents filed by inventor teams including at least one cross-border inventor generally cite more patent literature from Switzerland's neighboring countries than patents filed by teams including only Swiss nationals. Panel (f) of Figure 2 provides evidence supporting this, based on estimations where we regress the number of citations to patents filed in Switzerland's neighboring countries on an indicator for cross-border inventors' patents, plus filing year, spatial mobility region, applicant, and technology field fixed effects.[13]

[12] Appendix B5 describes the inventor-ZEMIS matching procedure in detail. While using ZEMIS records would have been the ideal way to define cross-border inventor status for the entire database, we could not adopt it as the ZEMIS was created only after the AFMP's signing. We report the full results of the comparison between the two methods for defining cross-border inventors in Appendix Figure C1 and Figure C2. Appendix Figure C3 shows the increase of patents reporting inventors' work address starting in 2005.

[13] For more information on the estimates in panels (e) and (f) of Figure 2, see Appendix Table D1 and Table D2, respectively. When we run our regressions for panel (f), switching to citations to the patent literature of non-neighboring countries, such as the United States, we do not detect any significant difference between the patents

Last, we find that most cross-border inventors employed in Switzerland in the post-AFMP period reside in G-permit-designated areas, and that the majority of Austrian, Italian, and, to a lesser extent, German ones were also born there or nearby (Appendix C). This suggests that the majority of post-AFMP cross-border inventors originate from G-permit-designated areas and did not move there from other locations far from the Swiss border. In the case of France, the pattern is less clear cut, as nearly half of cross-border inventors were not born in a G-permit-designated area.

4. Quasi-Experimental Setting

As discussed in Section 2, G-permit holders were the first immigrant category to experience a progressive relaxation of immigration restrictions after the AFMP was signed. In addition, until 2007, G-permits were only granted to employees of firms located in border regions. Thus, the most intuitive empirical approach would be to compare border regions to non-border regions, before and after the AFMP. This strategy would exploit the exogenous exposure of border regions to cross-border inventors' influx, entirely determined by a legal change rather than by any economic force simultaneously driving local performance and the influx of cross-border inventors. However, a close look at the data reveals that most cross-border inventors work predominantly in a subset of the border regions, specifically those located within very short commuting times from their residences in neighboring countries.

Figure 3 shows the relationship between driving distances from the closest border crossing and the share of cross-border inventors relative to total inventors, for both border and non-border regions, before and after the AFMP ratification. The relationship is strongly negative, with the border regions located up to 10 minutes from the border crossing exhibiting the largest shares of cross-border inventors, both before and especially after the AFMP. We find a similar pattern in regions located up 10 to 20 minutes from the border crossing. In contrast, the cross-border inventor shares in more distant border regions, as well as in all the non-border regions, are both low and unaffected by the AFMP.[14]

These descriptive statistics suggest that distance from the border is a more relevant source of exogenous geographic variation in the presence of cross-border inventors than the administrative distinction between border and non-border regions. We thus restrict our analysis only to the border regions and designate as the "treated regions" all those within a 20-minute drive from the border. All the other border regions, at more than 20 minutes from the border, constitute

of cross-border inventors and those of Swiss residents or nationals (Appendix Table D3).

[14]Each spatial mobility region's driving time is defined as the average driving time between its municipalities and their closest border crossing. All driving times are calculated with the Google Maps Distance Matrix API. We obtained the border crossings' locations from Hennerberger and Ziegler (2011).

the "control regions" (see the map in Figure 4). We include non-border regions in the control group only in robustness checks, whose results are reported in Appendix D (with no meaningful change in the results).[15]

One key advantage of this identification strategy is that, in contrast to comparisons between border and non-border regions, all border regions—whether treated or not—are very similar in terms of innovation activities. Both include several top Swiss innovation hubs, while non-border regions contain none. As an example, consider the four largest Swiss cities: Zurich, Geneva, Basel, and Lausanne. All of them fall into a border region, with Basel and Geneva right on the border (and therefore treated) and Zurich and Lausanne both at approximately 30-minute drives from the closest border crossing (controls). These four cities are Switzerland's leading economic centers, concentrate most of its patenting activity, and host its top research universities. Table 1 provides more general evidence and shows how, in the pre-AFMP period, the control regions were very close to the treated ones in terms of average number of patent filings and inventors, while the non-border regions reported much lower values.

When examining trends concerning the number of cross-border inventors active in treated and in control regions, we see that they are parallel until the AFMP's ratification and then diverge. Figure 5 reports yearly figures for both groups of regions, including, for the sake of completeness, also non-border regions. Markers indicate, for validation, the same counts for the ZEMIS-based definition of cross-border inventors, when available. We observe that before 1999, the number of cross-border inventors in treated regions and those in control ones differ but increase at the same moderate pace. Between 2000 and 2003, the growth rate in treated regions increases sharply but does not change in controls. This diverging trend persists until 2005, when the number of cross-border inventors in treated regions starts declining.

Note, however, that this decline is visible only for the patent-based definition of cross-border inventors and not for the ZEMIS-based one, suggesting instead that the gap between treated and control regions, after increasing with the AFMP, does not revert. This is due to a measurement problem, which, as explained in Section 3.2, causes an underestimation of the number of cross-border inventors based solely on their address on patents in the last years of our sample. In general, the temporal evolution of active cross-border inventors suggests at least a one-year delay between the AFMP's signing and the first patent filings of any commuter benefiting from

[15] Our empirical strategy is equivalent to that of Beerli et al. (2021) except for different driving distance cutoffs (20 rather than 30 minutes). This difference is due to our use of spatial mobility regions as units of observation, rather than municipalities. Appendix Figure C7 shows that regions at an average driving distance within 20 minutes from the border encompass nearly all municipalities at up to 15 minutes from the border and the large majority of those between 15 and 30 minutes. Notice that some cross-border workers commute by ferry across Lake Léman and Lake Constance, with travel times between 20 and 35 minutes. This does not alter the assignment of the spatial mobility regions around Lausanne and Konstanz to the treated or control group.

the treaty's provisions, which is consistent with the literature on the gestation lags between R&D and innovation.[16]

In addition to the proximity to the commuters' residences, a factor potentially explaining the different increase in the number of cross-border inventors across the treated and control regions could be the influence of cross-border workers' personal networks. It is possible that information on how to access the Swiss labor market is passed on by commuters already working in Switzerland to prospective ones in their residential locations. Since most commuters worked in treated regions even before the AFMP's introduction, information about specific job openings in Switzerland might have been mostly related to firms in those locations, therefore attracting the majority of commuters hired after the AFMP was signed.[17]

5. Regional Analysis

For the regional analysis, we organize our dataset of Swiss-filed patents into a panel of spatial mobility regions, which we observe annually from 1990 to 2012. We then compare treated and control regions over time, based on an event study approach. Formally, we estimate the following equation:

$$E[y_{m,t}|X_{m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t\neq 1999}}^{2012} \beta_t \cdot I_{year=t} \times Treated_m + \gamma_m + \phi_t], \tag{1}$$

where $y_{m,t}$ is an innovation outcome for region m in year t; $I_{year=t}$ is an indicator equal to 1 in year t and 0 otherwise (with 1999 as the reference year); $Treated_m$ is a dummy variable equal to 1 for the treated regions and 0 for the control ones; γ_m are region fixed effects, which capture time-invariant characteristics of each region; and ϕ_t are year fixed effects, which account for time-variant shocks common to all regions. The parameters of interest are β_t, which measure the yearly difference in the conditional mean of y between the treated and control regions.

With one exception, our innovation outcomes always consist of patent counts. We expect the AFMP's effects to be detectable starting in 2000, which implies a one-year delay between the kick-off of at least some of the new R&D projects and the first patent filings. This is consistent with previously discussed gestation lags between R&D and innovation.

[16] The studies surveyed by Hall et al. (2010) estimate such lags to range between 2 and 6 years. However, since they define innovation as either the launch of a new commercial product or the occurrence of the first revenues, the lag to the first patent filing must necessarily be shorter (otherwise the invention would go unprotected). More recently, de Rassenfosse et al. (2019) estimate that in the United States, the lag from the signing of a public R&D contract to the patent filing is around 33 months, while the lag measured since the end of the contract is less than 6 months.

[17] This explanation follows an intuition similar to that adopted by studies exploiting the past geographic distribution of immigrants as an instrumental variable to address endogeneity problems in new immigrants' location choices (Altonji and Card 1991; Card 2001, 2009).

Our main identifying assumption is the parallel evolution of outcomes in the treated and control regions had the AFMP not been introduced. This assumption cannot be tested directly but appears reasonable whenever the estimated β_t for the pre-AFMP period do not significantly differ from zero. We follow other econometric studies of innovation and science (e.g., Henderson and Cockburn 1994; Blundell et al. 1995; Azoulay et al. 2019; Catalini et al. 2020) and produce pseudo-maximum-likelihood (PML) estimates based on Hausman et al. (1984)'s Poisson fixed effects model. Regarding inference, we report robust standard errors clustered at the spatial mobility region level (Liang and Zeger 1986).[18]

5.1. Patenting in Switzerland

Panel (a) of Figure 6 reports the estimation results for Equation 1, where $y_{m,t}$ equals the number of patents filed in region m at time t. The black circles and vertical dashed bars correspond, respectively, to the estimated β_t coefficients and their 95% confidence intervals. For $t < 2000$, all estimates are close to zero and display no particular trend, providing reassuring evidence in support of our parallel trends assumption. For $t \geq 2000$, the coefficients first increase and then also become statistically significant (starting in 2001). This trend reverts in 2008, when all regions finally implement the AFMP.

We interpret these results as evidence that after the AFMP was signed, the R&D locations in the treated regions progressively increased their patenting output relative to the control ones due to the inflow of cross-border inventors. The positive and statistically significant coefficients for the post-AFMP period imply large effects: compared to the control regions, the yearly increases in patenting in the treated regions from 2001 to 2007 range from 15% to 54%. For the mean spatial mobility region in 1999, this corresponds to an increase of 5 to 18 additional patents per year. Based on a two-period difference-in-differences estimate, the average increase for the 2001–2007 period is around 22% (Appendix D). This falls between the estimates of Kerr and Lincoln (2010) and of Moser et al. (2014), the former concerning the patenting effects of increased H-1B admissions in the US in the early 2000s, and the latter those of the inflow of German Jewish scientists in the US starting in the 1930s.

The temporal evolution of our estimates indicates that the AFMP's introduction did not permanently increase the patenting activity of the treated regions relative to the control ones. However, it suggests that the firms in the treated regions undertook some R&D investments that they would have not otherwise been able to make, lacking the necessary scientific and engineering workforce. These resulted in patented inventions that would not have materialized absent the AFMP, and not just in the acceleration of their research agenda. In fact, the positive

[18] We also estimate an equivalent fixed effects difference-in-differences regression, in which we compare two periods, pre- and post-AFMP (respectively, up to 1999 and from 2000). The results are reported in Appendix D.

and statistically significant coefficients we estimate up until 2007 gradually diminish to zero, rather than becoming negative, and offset the prior increase.

We also test whether the patenting increase is driven by firms setting up new R&D labs in the treated regions or relocating there from the control ones. This would raise an identification issue in our exercise, namely the impossibility of retaining our definition of treated and control regions over the entire study interval due to changes in the structural conditions caused by the AFMP itself. We also investigate whether the effects are only driven by a few very large companies, which might have lobbied in favor of the AFMP while preparing to recruit large numbers of cross-border inventors after its signing.

We first re-run our estimations for a reduced sample of "incumbent applicants," that is, those with at least one patent filed before the AFMP's ratification. While a small number of these applicants have or used to have R&D labs in both the treated and control regions, only three of them opened up a new lab after 2000 (with barely more than 100 patents attached). We then identify the "top" applicants in our sample as those in the 99.9th percentile of the inventive workforce distribution and re-run the regressions after dropping them.[19]

Panels (b) and (c) of Figure 6 report the event study results for the two reduced samples. The plot in panel (b) is strikingly similar to that in panel (a), suggesting that the results are more attributable to the incumbent firms in the treated regions than to any firms moving in after the treatment. Panel (c) shows that the results are robust to excluding the top applicants.

Turning our attention to the mechanisms underlying the patenting surge, we first observe that, before and after the AFMP, no less than 80% of cross-border inventors' patents were co-signed by a Swiss resident inventor, most often a Swiss national (see Appendix Figure C6). We then investigate how much of the cross-border inventors' impact on their host regions' patent output depends on such collaborations. To do so, we distinguish between patents by inventor teams including at least one cross-border inventor (*cross-border inventor in team*) and patents signed by teams with only resident inventors (*resident-only team*). We then run separate regressions for the two types of patents.

Panel (d) of Figure 6 reports the results. The black circles show the estimated coefficients for *cross-border inventor in team* patents, while the gray squares indicate patents from *resident-only* teams. We can see that it is mainly the coefficients for the former that become positive and significant after the AFMP's introduction. This suggests that the post-AFMP growth in patenting is mostly due to cross-border inventors' direct contribution.

[19] We define the inventive workforce as the total number of inventors associated with a given applicant over the entire investigation period. We thus identify 14 top applicants, which collectively have 45 R&D locations and account for around 23% of the total patents in our sample (15,530 patents). All of these applicants are very large multinationals.

When examining the AFMP's effects by technology field, we find them to be largely driven by patenting in instruments, chemicals, and pharmaceuticals (Appendix Figure D1), which jointly account for around 56% of the patents in our sample in the pre-AFMP period. The estimates for electric and mechanical engineering, as well as for all the residual fields combined, are always statistically indistinguishable from zero.[20]

Last, we test whether the post-AFMP patenting increase is mainly driven by inventive activities in the Basel and Geneva agglomerations, which are the main innovation hubs in the treated regions (with, respectively, around 42% and 13% of patents filed in such regions in the post-AFMP period, and around 13% and 4% of all Swiss patents). To do so, we replicate the results of panel (a) of Figure 6 after excluding from the sample the regions associated with the Basel and/or Geneva agglomerations. When dropping only Geneva, the results do not change. When we exclude Basel, either alone or with Geneva, the size of the estimated coefficients slightly diminishes, implying a patenting increase of 24%–42% between 2005 and 2007 compared to the 36%–54% increase based on the full sample estimates. All the coefficients remain positive, statistically significant, and with the same temporal pattern of our baseline estimates. This suggests that the post-AFMP patenting increase is due to the inventive activities located across all the treated regions and not only in Basel and Geneva (Appendix Figure D3).

All of these results pass several robustness checks, reported in detail in Appendix D. First, we include non-border region regions in the control group. Second, we re-estimate the model including NUTS-2-specific time trends to account for potentially unobserved regional-specific shocks. Third, we test different methods for assigning patents to spatial mobility regions, using either only the inventors' residential address or only the applicant's address. Fourth, we examine the results' sensitivity to an alternative statistical model, based on OLS estimates and a logarithmic transformation of the dependent variable. Finally, we re-estimate our model using only granted patents instead of patent applications.

The first three checks return the same results of our main exercises. The same applies to the fourth, with just one main difference: when considering only incumbent applicants, the post-AFMP coefficients remain positive but lose significance. As for the last check, when performing it, the estimated coefficients keep their sign, significance, and temporal patterns but become slightly smaller.

5.2. Displacement and Brain Drain Effects

The growth in patenting induced by the AFMP's introduction could have come with two adverse effects. First, native inventors could have been displaced, suggesting some degree of

[20] For the distribution of Swiss patents by technology field, see Appendix C.

substitutability, rather than complementarity, between foreign and native inventors. Second, there could have been a brain drain of scientists and engineers from across the border into Switzerland, possibly resulting in a decline of patenting in the residence regions of cross-border inventors. The presence of either effect would imply that the innovation gains for Switzerland might have come at some loss for its native inventors or its neighboring countries.

To investigate displacement, we re-estimate Equation 1 with $y_{m,t}$ equal to the number of resident inventors active in each region and year. Panel (a) of Figure 7 reports the results. The estimated β_t are positive and statistically significant in the period immediately after the AFMP's signing and are very close to zero afterwards. This suggests that resident inventors did not experience any displacement. If anything, there are signs of a moderate but short-lived crowding-in effect.

However, our main sample of resident inventors includes both Swiss nationals and foreign residents, and a decline in the former might have been possibly compensated by an increase in the latter. For this reason, we replicate the exercise using the EPO-PCT subsample, which includes information on inventors' nationality. We then set $y_{m,t}$ equal to the number of inventors with Swiss nationality active in each region and year. Panel (b) of Figure 7 shows that the post-AFMP coefficients are either positive or close to zero until 2006, at which point they turn negative, although never statistically significant. While any indication of a possible crowding-in effect disappears, the results exclude any displacement of native inventors during the period immediately after the AFMP's introduction.

To investigate the brain drain hypothesis, we re-estimate once more Equation 1, this time with NUTS-3 regions in each of Switzerland's neighboring countries (Austria, France, Germany, and Italy) as our units of observation. The dependent variable $y_{m,t}$ is now equal to the yearly patent output of foreign region m in year t, from 1990 to 2012. $Treated_m$ is an indicator for the regions where the pre-AFMP legislation required G-permit holders to reside. As for control regions, in the baseline regression we consider as such all other NUTS-3 regions.

Figure 8 reports the results. Panel (c) shows the β_t estimates for Germany, where both the pre- and post-AFMP estimated coefficients are all close to zero and display no trend. The results for France in panel (b) are very similar except the coefficients are negative after 2007 but mostly not statistically significant. Panel (d) reports the results for Italy. Unlike France and Germany, most coefficients for the post-AFMP period are negative but close to zero and not statistically significant. The results are not as conclusive for Austria in panel (a). The estimated coefficients are negative but not statistically significant in 2002 and 2003, while they are positive and mostly statistically significant from 2004 onward. We interpret this result with caution, given a possible diverging trend between the treated and control regions' patenting before the AFMP's signing, as evidenced by the coefficients for the years 1990–1999.[21]

The lack of negative effects on the regions of origin for cross-border inventors' suggests that the increase in patenting observed in Switzerland post-AFMP represents a net gain in global innovation. While studying the mechanisms that made this gain possibly goes beyond the scope of this paper, it is worth observing that three non-mutually exclusive factors may have played a role. First, by increasing the openness of the Swiss labor market, the AFMP may have improved the matching between foreign STEM graduates and a larger set of R&D-intensive firms. This could have enabled them to either secure inventor jobs they otherwise would not have obtained or become more productive inventors than they otherwise would have been. Second, internal migration within the large French, German, and Italian national labor markets may have provided replacements for inventors or potential inventors now relocated into the Swiss labor market. Third, the presence of internal migrants among commuters, particularly in the case of France, may have reduced the severity of scientists' and engineers' emigration.

6. Inventor-Level Analysis

To explore the interactions between resident and cross-border inventors, we shift our focus from regions to individuals. Identifying any causal effect of the AFMP is only possible for incumbent resident inventors, those who patented at least once before the AFMP's introduction. These are the only individuals we can observe both before and after the AFMP's introduction, whose decision to become inventors and location choices pre-date the policy change and can therefore be considered exogenous to it. This cannot be said for any inventor who filed their first patent post-AFMP. Nevertheless, we can provide additional evidence for an intermediate group of inventors, the incumbents whose careers began just before the AFMP but took off afterwards. We examine the two types of inventors in turn.

6.1. Incumbent Inventors

For each incumbent inventor, we track the patents filed in each year, pre- and post-AFMP. Because some inventors might have responded to the treaty's introduction by changing their workplace, we fix each inventor's location after 1999 in the spatial mobility region where they were last observed patenting up to and including that year, irrespective of their real location afterwards. We thus obtain an unbalanced panel of 14,200 incumbent inventors observed be-

[21] Because these results could be sensitive to the choice of different control groups, we run two robustness checks. First, we exclude from the regressions the NUTS-3 areas immediately bordering the treated ones. We do this because the AFMP might have affected them indirectly, for example, by inducing internal migration, which would introduce a bias in the estimates. Second, we experiment with an alternative control group based on Mahalanobis matching, similar to Hafner (2021). In neither case, our results change in any meaningful way (Appendix D).

tween 1990 and 2012, out of which 4,917 are active in the treated regions and 9,283 are active in the control regions (plus 4,200 in the non-border regions).

We then estimate the following event study specification:

$$E[y_{i,m,t}|X_{i,m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t\neq 1999}}^{2012} \beta_t \cdot I_{year=t} \times Treated_m + \theta_i + \gamma_m + \phi_t], \tag{2}$$

where $y_{i,m,t}$ is the patenting output of inventor i located in region m in year t, $I_{year=t}$ is an indicator equal to 1 in year t and 0 otherwise (with 1999 as the reference year), $Treated_m$ is a dummy variable equal to 1 if inventor i is in a treated region, and ϕ_t are year fixed effects. Inventor fixed effects θ_i control for any unobserved time-invariant characteristics of inventor i, while region fixed effects γ_m account for time-invariant region heterogeneity. We cluster standard errors at the spatial mobility region level. Similar to the regional analysis, we assume that the outputs of treated and control inventors would have followed the same trends absent the AFMP.

Panel (a) of Figure 9 reports the results. The estimated β_t coefficients in the pre-AFMP period follow a flat trend and are mostly close to zero. Starting from 2002, many of them become positive and statistically significant. This result indicates that incumbent inventors in the treated regions significantly increased their productivity following the AFMP, with the number of patents signed from 2002 to 2011 growing by 17%–46% per year. For the average incumbent inventor active in 1999, this corresponds to an increase of 0.22 to 0.60 additional patents per year. Our two-period difference-in-differences estimates suggest an average annual increase of approximately 16% throughout the entire post-AFMP period (Appendix D).

Next, we investigate the extent to which this productivity growth is due to direct collaborations with cross-border inventors rather than indirect effects, such as localized spillovers driven by physical proximity. To this end, we again estimate Equation 2 after excluding from $y_{i,m,t}$ all patents listing a cross-border co-inventor. We report the estimated β_t as black circles in panel (b) of Figure 9. Compared to those in panel (a), the estimated coefficients in panel (b) appear to be generally smaller and less often significant. When further excluding from the baseline sample all patents in which the inventors report their work address instead of their home one to correct for the underestimation of cross-border inventors, we find null results (gray squares).[22] We obtain comparable evidence from the two-period difference-in-differences specification.

These findings indicate that only incumbent inventors collaborating with cross-border inventors increased their productivity, with the additional patents being exclusively due to these

[22] See the discussion of Figure 5 in Section 4.

collaborations. This suggests that cross-border inventors have distinctive characteristics that make them complementary to incumbents. At the time of the AFMP's introduction, many such incumbents were senior enough to be lab directors or project leaders, with the potential to pursue a greater number of R&D projects by assembling more inventor teams, provided they could find the right human capital. Cross-border inventors would suit them for this purpose. As explained in Section 3.2, most of these inventors enter Switzerland at the beginning of their career, possessing distinctive knowledge assets and skills, as evidenced by their higher career productivity and greater propensity to cite patents from their home countries relative to Swiss inventors. At the same time, it seems unlikely that they could significantly extend their influence beyond their immediate collaborators or change their companies' research agenda right upon entry.

We test this interpretation by re-estimating Equation 2 with two new outcomes: first, the number of distinct co-inventors with whom each incumbent inventor collaborates yearly and, second, the number of citations from the incumbent inventors' patents to earlier patents filed in cross-border inventors' home countries.[23] Panels (c)–(f) of Figure 9 show the results. When the dependent variable is the number of distinct co-inventors (panel (c)), the pre-AFMP coefficients are never significant and follow an overall flat trend. The post-AFMP period coefficients start increasing in 2002 and then become positive and mostly statistically significant. When the dependent variable is the number of citations to patents from the home countries of cross-border inventors (panel (e)), the post-AFMP coefficients progressively increase in size and become statistically significant in the few, final years of the observed period.

The results change when we exclude from the dependent variable the co-inventors and citations on patents that list at least one cross-border inventor. In panel (d), the post-AFMP coefficients are positive although less frequently statistically significant when using the baseline sample (black circles) and statistically indistinguishable from zero when using the sample excluding patents with the inventors' work address (gray squares). Similar observations apply to panel (f). This indicates that the inflow of cross-border inventors induced by the AFMP increased the number of potential collaborators for incumbent inventors as well as their access to foreign inventions, but only when collaborating with a cross-border inventor.

We further deepen our analysis by studying the contents of incumbent inventors' patents and whether cross-border inventors may have changed them. To do so, we analyze both the patents' abstracts and technological classifications. For the abstracts, all of which are in English,

[23]We find cited patents from the cross-border inventors' home countries based on the addresses of their applicants and inventors. We first drop all patents with at least one Swiss address for either an inventor or an applicant. Then we retain any cited patent that has at least one inventor from Austria, France, Germany, or Italy.

we first parse their texts by removing all natural language stop words and by tokenizing and lemmatizing each word. Next, we create a vector of terms describing the main features of each patent, along with a cumulative repertoire of all terms representing the state of the art in Swiss-patented inventions for each year. Then, for each incumbent inventor and year, we count all patents that introduce a novel word in their abstract, relative to the state of the art in the previous year, and re-estimate Equation 2 with this count as the new dependent variable.[24]

Regarding the patents' technological classification, we consider all IPC codes at the class, subclass, group, and subgroup level appearing on each patent.[25] Then, for each incumbent inventor and year, we count all the patents that introduced a novel IPC code relative to the inventor's patent stock up to the previous year. We repeat the exercise four times, each with an increasingly stringent classification level, ranging from technology classes down to subgroups. This generates four sets of dependent variables, which we use to re-estimate Equation 2 an equal number of times. Our goal is to assess the degree to which incumbent inventors' new patented inventions diverge technologically from their previous body of patented work.

Panel (a) in Figure 10 reports the results for novelties in abstracts and panel (b) those for new IPC classes and subclasses. Virtually all the estimated coefficients are not statistically significant. Panel (c) reports the estimates for new IPC groups or subgroups. The estimated coefficients are close to zero and statistically insignificant in the pre-AFMP years, progressively becoming positive and statistically significant for several years after 2000, particularly at the subgroup level. Overall, these results indicate that incumbent inventors increased their patenting activity in the same domains in which they had been active pre-AFMP, albeit with some novel applications, as measured by IPC groups and subgroups. We interpret these results as further evidence of the positive effects of the availability of a greater number of collaborators with useful and complementary skills, absent any major knowledge transfer. We come back to this interpretation in Section 7.

Last, we expand our analysis by examining whether the inventor-level effects we have found so far may be heterogeneous across technology fields and locations (results in Appendix D). With respect to technologies, in line with our regional-level results, we find that incumbent inventors' increase in productivity is concentrated in the chemical and pharmaceutical fields. As for

[24]Iaria et al. (2018) use a similar word-based approach to study the effects of World War I on the publications of scientists from Central Empires.

[25]IPC stands for International Patent Classification, a classification system used by the patent offices of more than 100 countries, including the EPO. It consists of a hierarchical system of language-independent codes composed of up to 10 digits (letters and numbers, for a total of over one million codes). IPC classes refer to the first three digits, subclasses to the first four, and groups to the first six, while the entire code indicates a subgroup. Each patent can be classified in multiple classes, groups, and subgroups, depending on the complexity of the invention it protects. More details can be found at https://www.wipo.int/classifications/ipc/en/ (last accessed August 2025).

locations, we test event studies where we exclude inventors based in the agglomerations of Basel and Geneva, which account for, respectively, 50% and 10% of all incumbent inventors in the treated regions (63% and 15% for the chemicals and pharmaceutical field). Our estimates remain unchanged when we drop Geneva. However, when we exclude Basel, most of the coefficients become smaller and lose statistical significance, except for the year 2005. This contrasts with our findings at the regional level, which did not change considerably when excluding Basel. On the one hand, this may indicate that the micro-level mechanisms behind the patenting surge differed between Basel and the other Swiss areas close to the border. On the other hand, it may simply be that any effect at the inventor level is more difficult to detect without considering Basel due to the severe cut of our sample size that comes with it.

6.2. Junior Inventors

The choice of focusing on incumbent Swiss resident inventors, while motivated by identification issues, comes at a price. It limits us to study the interaction of cross-border inventors with the more senior researchers (some of them already active before 1990) and not with the junior ones, especially those starting their inventive career post-AFMP. As a partial remedy, we examine the patenting activity over the first eight years of career (years from the first patent) of two cohorts of inventors: those first patenting in 1999–2000 and those first patenting in 1990–1993. For inventors in both cohorts, we can assume that the decision to start an R&D career in a given location was exogenous with respect to the AFMP's introduction and the subsequent inflow of cross-border inventors. But in the case of inventors in the 1999–2000 cohort, their entire career occurred after the policy shock, while for the 1990–2003 cohort, the first eight years of their career occurred before it.[26]

We adopt a difference-in-differences strategy and compare the activity of inventors in the treated regions to those in the control ones, for both inventor cohorts, in each year since their first patent. Formally, for each year of inventors' activity $\tau \in \{1, 2, 3, 4, 5, 6, 7, 8\}$, we estimate the following specification:

$$E[y_i|X_i] = exp[\alpha + \beta\tau(AFMP_{c(i)} \times Treated_{m(i)}) + \gamma_{m(i)} + \phi_{t(i)} + \lambda_{k(i)}], \tag{3}$$

where y_i represents an outcome for inventor i, from cohort c, located in region m, active in

[26]Eight years is the average lag between the first and fourth patent by inventors in our sample. In other words, it is a reasonable time window to examine the early career patenting activity of new inventors. We also consider inventors first patenting in 2000 in order to enlarge our sample of junior inventors. We think that their location choices can also be considered exogenous to the AFMP: their first patents were filed right when the confirmatory referendum was held such that their selection of employer and region is very likely to have occurred before the AFMP. Note that we do not consider the cohorts from 1994 to 1998 because the first eight years of their career span across both the pre- and post-AFMP periods.

year t, and in technology field k. As with incumbent inventors, the outcomes we include are the number of patents filed, the number of distinct co-inventors, and the number of citations to previous patented inventions. $AFMP_{c(i)}$ is an indicator equal to 1 for inventors in the 1999–2000 cohort. $Treated_{m(i)}$ is an indicator equal to 1 for inventors whose first patent occurred in a treated region. $\gamma_{m(i)}$, $\phi_{t(i)}$, and $\lambda_{k(i)}$ are region, calendar year, and technology field fixed effects, respectively. We cluster standard errors at the spatial mobility region level. $\beta\tau$ are our parameters of interest. For example, β_1 is the difference-in-differences estimate obtained by comparing the treated and control inventors in their first year of activity, β_2 is the estimate for the second year of activity, and so on.[27]

Our sample includes 7,452 inventors, of which 3,306 are in the 1999–2000 cohort and 4,146 are in the 1990–1993 cohort. Figure 11 reports the estimated $\beta\tau$. When we consider as dependent variable all patents filed in each year (panel (a)), we obtain positive estimated coefficients from the second patenting year onward, with only the coefficients for the third and seventh year being statistically significant. This implies an increase in patenting of, respectively, 20% and 51% (or about 0.26 and 0.67 additional patents relative to junior inventors' mean patenting output in those years). For the 1999–2000 cohort, the third to eighth patenting years correspond to the calendar years between 2001 and 2007. When we exclude from the dependent variable patents co-filed with a cross-border inventor (panel (b)), all the estimated coefficients are either negative or not statistically significant.

When we use as the dependent variable the number of distinct co-inventors in year τ, most of the estimated $\beta\tau$ are statistically indistinguishable from zero (panels (c) and (d)). When we replace it with the number of citations to the home countries of cross-border inventors, most of the estimated coefficients are not statistically significant (panels (e) and (f)).

These findings indicate that junior inventors who started patenting in the treated regions just before the AFMP's introduction experienced, like the incumbents, a productivity increase relative to their peers in the control regions. However, the effect is detectable in fewer years, right after the AFMP's introduction, and they did not experience a corresponding increase in the number of collaborators or in access to foreign patented inventions.

Taken together, the results of our inventor-level analysis suggest that the influx of cross-border inventors, triggered by the treaty's introduction, primarily benefited more senior inventors among the incumbents. These inventors were able to take on more projects and leverage the skills of the newly arrived cross-border inventors. The effects for more junior ones, those who started their patenting careers in the wake of the AFMP's introduction, appear to be more

[27] This empirical strategy is similar to those adopted in the literature on the persistent effects of initial labor market conditions (von Wachter 2020; Rothstein 2023).

limited.

7. R&D Location Analysis

The evidence for incumbent inventors suggests that they mostly benefited from the AFMP via the increasing availability of new collaborators with useful and complementary skills, absent any major knowledge transfer. We provide additional evidence in this sense by examining R&D locations. As explained in Section 3, while we do not observe the location and staffing of Swiss R&D laboratories, we can reconstruct their likely location from inventors' addresses. This mainly serves as a tool for assigning both patents and inventors to the different treated and control regions. However, we can also compare the outcomes of R&D locations as such, pre- and post-AFMP.

In particular, we focus on R&D locations already active in the pre-AFMP period and track their patenting activity between 1990 and 2012, estimating the following event study specification:

$$E[y_{j,m,t}|X_{j,m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t\neq 1999}}^{2012} \beta_t \cdot I_{year=t} \times Treated_{m(j)} + \xi_j + \phi_t], \tag{4}$$

where $y_{j,m,t}$ is an innovation outcome for R&D location j in region m and patenting in year t; $I_{year=t}$ is an indicator equal to 1 in year t and 0 otherwise (with 1999 as the reference year); $Treated_{m(j)}$ is a dummy variable equal to 1 for R&D locations in a treated region; ξ_j are R&D location fixed effects, which capture time-invariant characteristics of each R&D location; and ϕ_t are year fixed effects, which account for time-variant shocks common to all R&D locations. We cluster standard errors at the spatial mobility region level.

We examine four innovation outcomes. First, we calculate the average number of inventors in all teams patenting for R&D location j in year t, allowing us to assess changes in the organization of R&D teamwork. Second, we compute the average number of patents filed by all members of an inventor team by $t-1$, for all teams patenting in R&D location j and year t. This provides information on the average team experience of each location, for which we test whether any change occurred due to the AFMP. Third and fourth, we count, respectively, the total number of inventors and of cross-border inventors active in R&D location j and year t to study changes in the size of R&D locations.

Figure 12 shows the estimation results. When the dependent variable is the average team size (panel (a)), all estimated coefficients are close to zero and statistically insignificant, except for 2002. When examining the average team experience (panel (b)), we find that several of the estimated coefficients for the post-AFMP period are positive, although none of them are statistically significant. For the total number of active inventors per year (panel (c)), we find positive and statistically significant coefficients between 2002 and 2006. We find similar results for the number of active cross-border inventors (panel (d)), albeit with slightly larger estimated coefficients and standard errors.

These results suggest that incoming cross-border inventors increased the patent production of R&D laboratories in the treated regions by enabling them to expand their workforce, as indicated by the increase in the total number of inventors in the treated R&D locations. However, these laboratories did not alter their work organization, as suggested by the absence of changes in their teams' average size and experience. This aligns with the lack of major knowledge transfer effects, as discussed in Section 6.

8. Conclusion

In this paper, we study the innovation effects of the AFMP, a treaty signed in 1999 by Switzerland and the EU as part of the progressive extension of the Free Movement of Workers principle in Europe. To do so, we exploit the quasi-experimental regional variation in the influx of foreign inventors holding a cross-border worker permit (cross-border inventors), the first permit category to experience a relaxation of immigration restrictions during the AFMP's implementation phase (1999–2007).

We first find that after the AFMP's signing and introduction, the number of cross-border inventors sharply increased in regions very close to the Swiss border (treated regions) but not in those farther away (control regions). We also find that patenting activity in the treated regions increased relative to the control ones after the AFMP's introduction, primarily in the instruments, chemicals, and pharmaceuticals technology fields. We find no evidence of local inventors being displaced, nor of adverse effects on patenting in Switzerland's neighboring countries.

In the second part of the paper, we focus on Swiss resident inventors, in particular those who were already active before the AFMP's signing (incumbent inventors), finding that those located in the treated regions increased their productivity relative to those in the control ones. Four pieces of evidence suggest that this result is likely due to the availability of more collaborators with valuable and potentially complementary skills, in the absence of major knowledge transfers. First, based on a combination of inventor data and immigrant administrative records, we show that most cross-border inventors entered Switzerland at a relatively young age and with little or no prior patenting experience. This contrasts with the seniority of most incumbent inventors, as deduced from their patent records. Second, the productivity of incumbent inventors increased almost exclusively through patents co-signed with cross-border inventors, who expanded the number of distinct co-inventors with whom incumbents themselves could collaborate.

Third, patents co-signed by incumbent and cross-border inventors were more likely to cite patented inventions from the latter's countries, but the same does not hold for other incumbents' patents. Fourth, the rise in productivity among incumbent inventors was not due to patents that significantly diverged in their text content from the pre-AFMP Swiss patent stock, or in technological classification from their earlier patents. When focusing on inventors who started their patenting careers right before the AFMP's introduction, we still find positive effects, but they are more limited than those for more senior incumbent inventors.

We conclude by examining the outcomes of R&D locations. Our evidence shows that incumbent R&D locations in the treated regions experienced an increase in the total number of active inventors and cross-border inventors post-AFMP, without significant changes in the average size or experience of their inventor teams. This suggests that the increased availability of cross-border inventors allowed R&D locations in the treated regions to increase their patenting productivity by expanding laboratory capacity.

A joint reading of our results and those of Beerli et al. (2021) indicate that contemporary high-skilled immigration flows between advanced countries, such as Switzerland and its neighbors, can significantly increase the supply of knowledge workers in the receiving economies, with positive effects on their innovation activities. Our results also suggest that in a context of rising importance of R&D teamwork and division of labor (Wuchty et al. 2007; Jones 2009), these additional foreign STEM workers may both ease a supply shortage and complement established native ones. However, given their age and experience profile, most migrant STEM workers are not likely to open up new research pathways, as found by studies of migration episodes concerning experienced scientists and technologists (Moser et al. 2014). Nor can they induce major technological diversification in the host country, as found by Bahar et al. (2020) when considering the migration of inventors with previous patenting experience and for countries with more distant technological specializations than Switzerland and its neighbors.

Still, the patents co-signed by Swiss resident inventors with cross-border inventors include more-than-expected citations to patented inventions from the latter's home countries. This resonates with Ariu (2022)'s findings on the AFMP's impact on trade, showing that Swiss firms that hired cross-border workers were able to source better intermediate inputs from the workers' home country.

Our study has three main limitations, which we hope to overcome in future research. First, we do not investigate the mechanisms that have prevented the regions of origin of cross-border workers from experiencing a decrease in their patenting output. Evidence could be obtained by studying the careers of STEM workers who did not leave those labor markets, the evolution of

R&D jobs postings in those areas pre- and post-AFMP, and the recruitment of scientists and engineers from regions farther away from the Swiss border.

Second, our analysis of inventors' characteristics is limited to the data we can obtain from patent documents. In particular, we have no information on the specific tasks performed by cross-border and incumbent inventors collaborating on the same R&D projects. Additional information on these tasks could be obtained through inventor surveys, such as those conducted by Giuri et al. (2007) for Europe and Walsh et al. (2016) for the United States and Japan. This would allow to further investigate the degree of substitutability and complementarity of native and immigrant scientists and engineers.

Last, we do not observe the long-term consequences of the inventor immigration wave we studied. It is possible that the significant knowledge transfer effects that were not detected in the first decade following the AFMP's introduction may become more visible later on. This could happen as some of the relatively young cross-border inventors who entered Switzerland post-AFMP advance to more senior positions.

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Tables

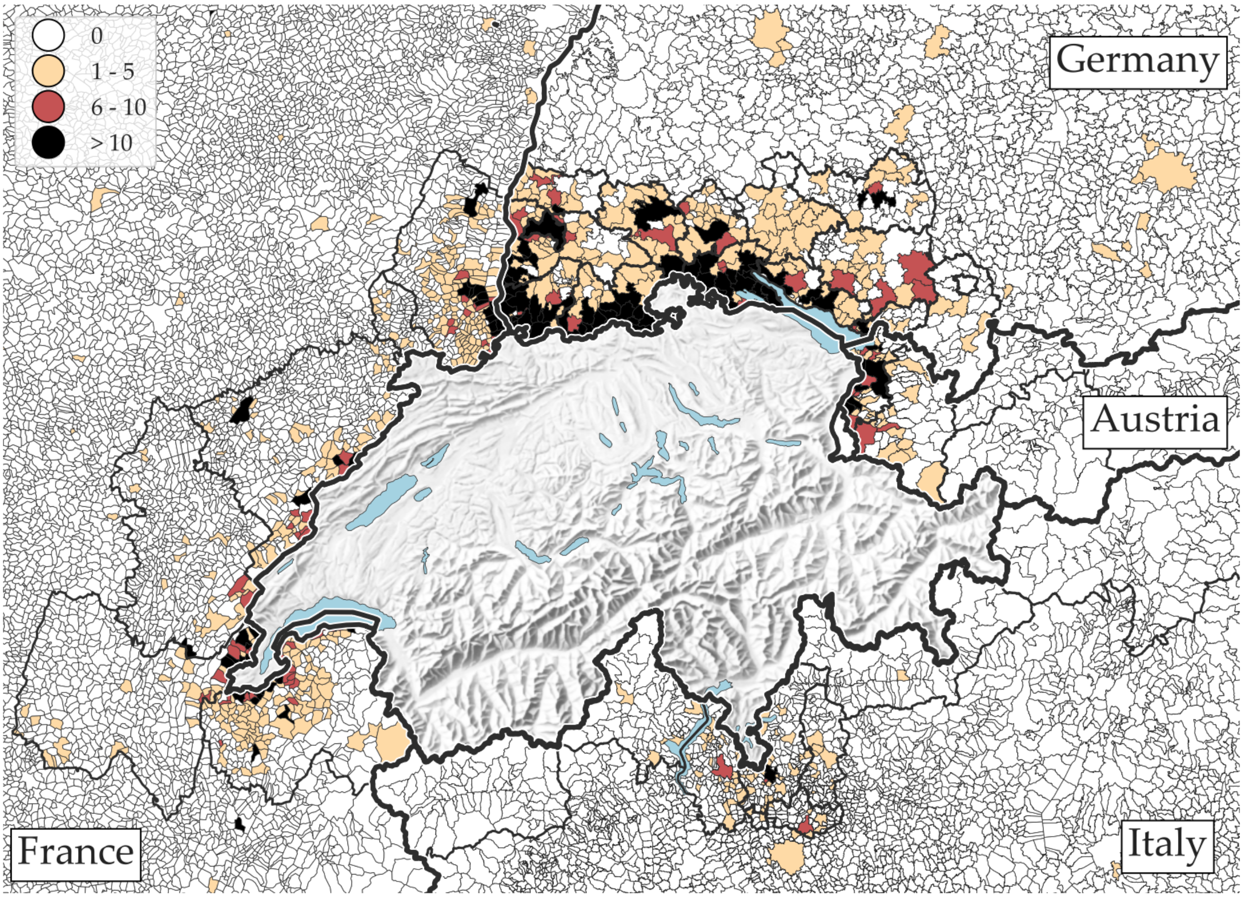
Table 1: Regional outcomes: mean and standard deviation by area and period

	Pre-AFMP (1990-1999)			**Post-AFMP (2000-2012)**		
	Treated	Control	Non-border regions	Treated	Control	Non-border regions
Patents	27.3	25.4	10.1	50.8	42.0	16.7
	(39.5)	(34.9)	(16.1)	(67.0)	(62.0)	(26.9)
Patents (incumbent applicants)	27.3	25.4	10.1	33.0	27.6	9.7
	(39.5)	(34.9)	(16.1)	(54.0)	(44.5)	(18.2)
Patents (excluding top applicants)	18.5	19.4	8.9	38.8	31.6	14.1
	(21.0)	(24.9)	(14.2)	(42.6)	(43.8)	(21.3)
Patents (cross-border inventor in team)	8.0	1.2	0.2	19.9	3.8	0.5
	(17.4)	(4.1)	(0.8)	(36.4)	(8.4)	(1.5)
Patents (resident only)	19.3	24.2	9.9	30.9	38.2	16.2
	(23.9)	(32.2)	(15.7)	(33.6)	(55.2)	(26.0)
Inventors (Swiss res.)	31.7	33.0	12.8	59.9	61.9	22.6
	(50.5)	(45.9)	(20.9)	(85.9)	(98.7)	(34.8)
Inventors (Swiss nat.)	4.8	1.9	1.0	10.3	7.6	3.3
	(13.6)	(4.3)	(2.3)	(19.8)	(14.5)	(6.1)

Notes: The table reports mean values for spatial mobility regions' yearly innovation outcomes. Standard deviation values are reported in parentheses.

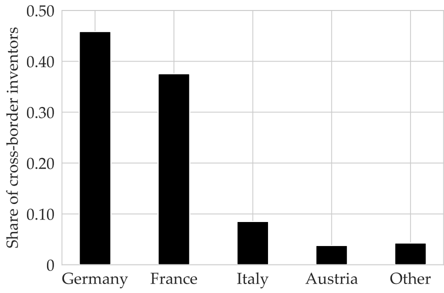
Figures

Figure 1: Number of cross-border inventors by municipality of residence, 1990-2012

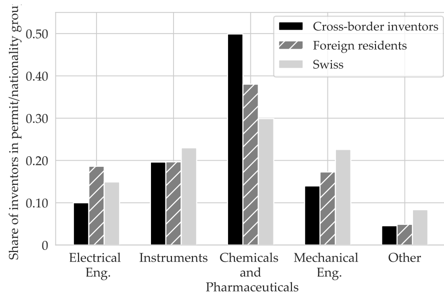


Notes: The map shows the municipalities in Austria, France, Germany, and Italy where cross-border inventors reside, according to the address found on their patents. In the same countries, the map shows the boundaries of the administrative units corresponding to the G-Permit designated areas.

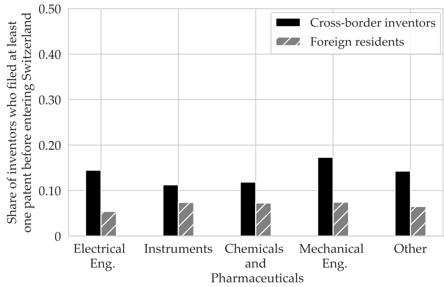
Figure 2: Cross-border inventors' characteristics (ZEMIS-based definition)



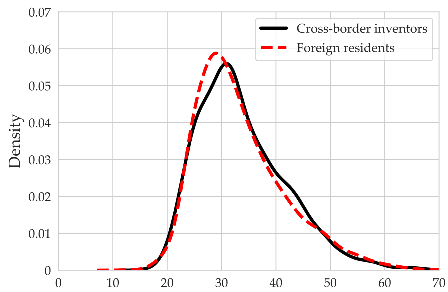
(a) Nationalities



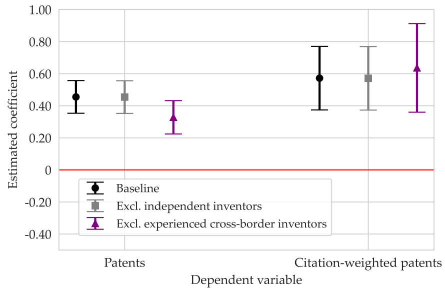
(b) Technologies



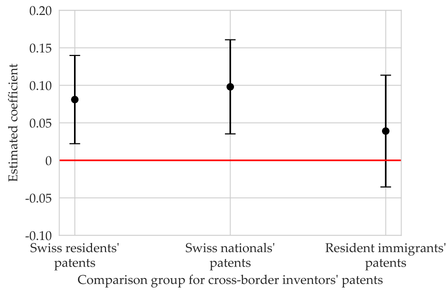
(c) Pre-arrival patenting



(d) Age at arrival in Switzerland



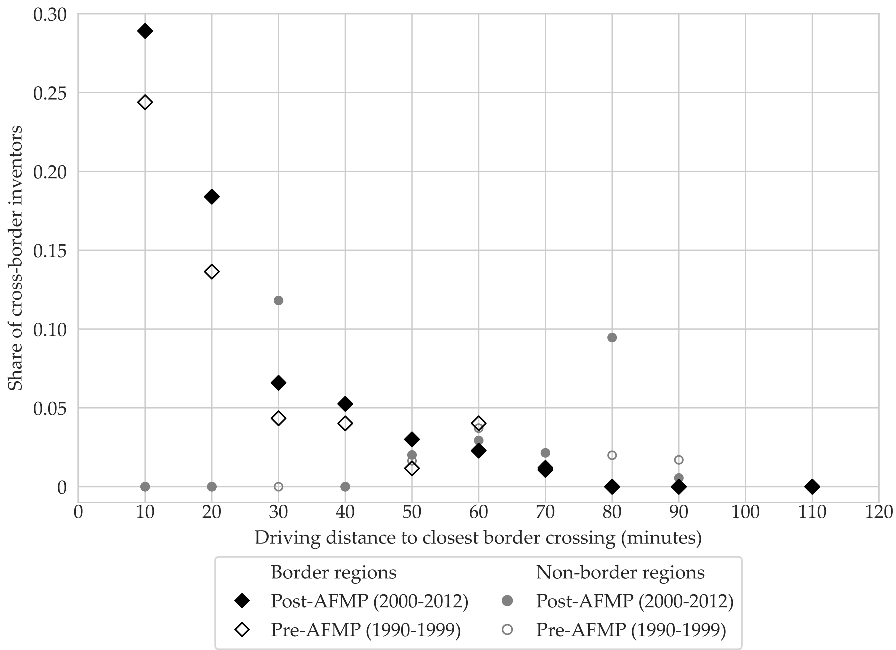
(e) Full career productivity vs. Swiss inventors



(f) Citations to neighboring countries' patents

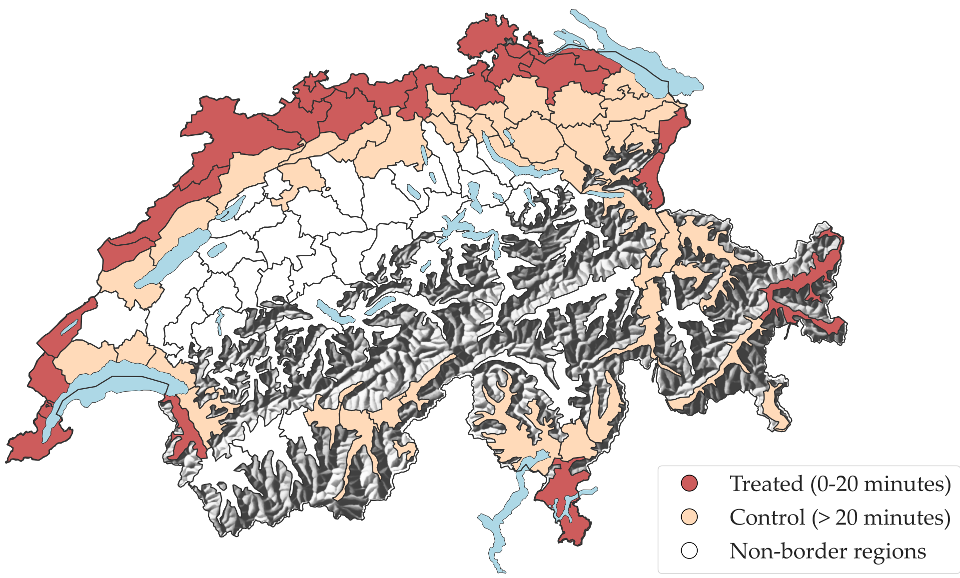
Notes: Panel (a) shows cross-border inventors' main nationalities. Panel (b) plots the distribution of active cross-border inventors, foreign resident inventors (B, C, and L permit holders), and Swiss inventors by technology field (Schmoch 2008). Panel (c) shows the share of cross-border inventors and foreign resident inventors who filed at least one patent before entering Switzerland, by technology field. Panel (d) shows the distribution of age at arrival in Switzerland for cross-border inventors and foreign resident inventors (kernel density). Panel (e) reports β estimates and 95% confidence intervals from $E[y_i|X_i] = exp[\alpha + \beta PermitG_i + \delta X_i]$, where y_i is the number of total patents or citation-weighted filed by inventor i during their full observable career, $PermitG_i$ is an indicator equal to 1 for cross-border inventors and equal to 0 for inventors with Swiss nationality, and X_i is a vector of controls, including the inventors' average number of co-inventors, average applicant size, the number of applicants they have patented during their career, as well as technology field and first patent cohort fixed effects. Panel (f) reports β estimates and 95% confidence intervals from an equivalent specification, where i indexes a patent, y_i is the number of citations made by patent i to the patent literature from Switzerland's neighboring countries, while $PermitG_i$ is an indicator equal to 1 for patents listing at least one cross-border inventor, and 0 for patents listing only Swiss resident inventors, only Swiss nationals, or only resident immigrants. We control for patents' filing year, spatial mobility region, applicant, and technology field fixed effects. Both panel (e) and (f) plot Poisson pseudo-maximum-likelihood estimates, which are reported with more details in Appendix Table D1 and Table D2, respectively. All figures refer to the post-AFMP period, except for panel (e).

Figure 3: Cross-border inventors' share of total inventors by driving distance to border crossing



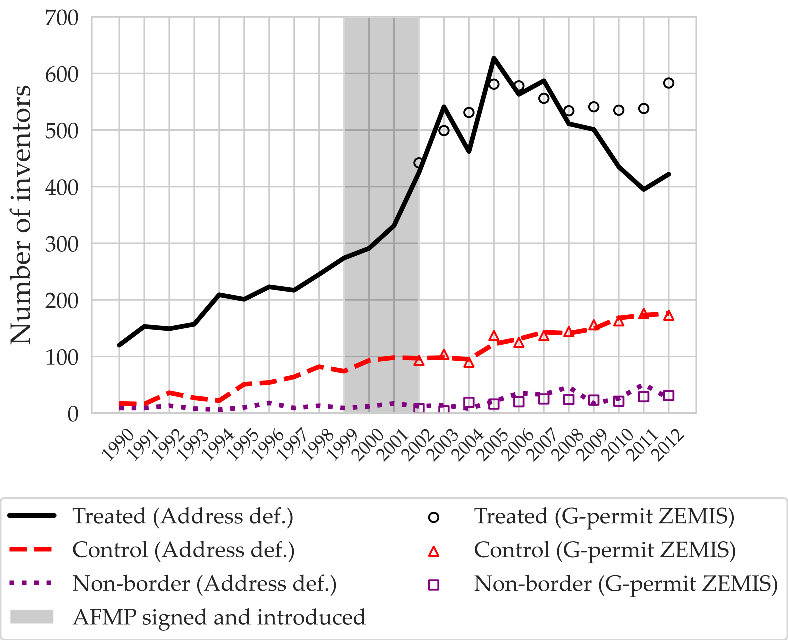
Notes: Each marker in the figure shows the share of cross-border inventors relative to the total of active inventors in spatial mobility regions' groups sorted according to their distance from the closest international border crossing, comparing the periods before and after the AFMP signing and introduction. Diamond markers indicate border regions while circle markers indicate non-border regions. The high share of cross-border inventors in non-border regions and post-AFMP period are outliers referring to regions with few total inventors.

Figure 4: Spatial mobility regions in Switzerland by driving distance area



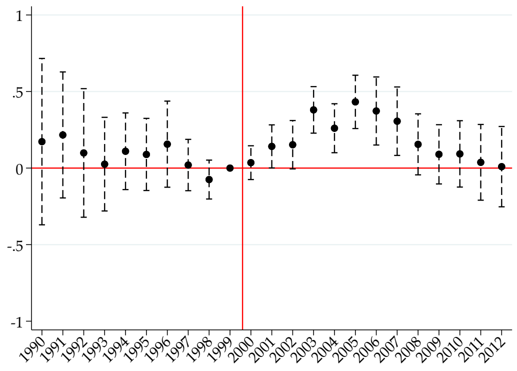
Notes: The definition of treated and control border regions is based on their distance from the closest international border crossing. Spatial mobility regions are plotted in terms of their productive areas, as defined by the Swiss Federal Statistical Office, rather than their purely political boundaries.

Figure 5: Active cross-border inventors by driving distance area

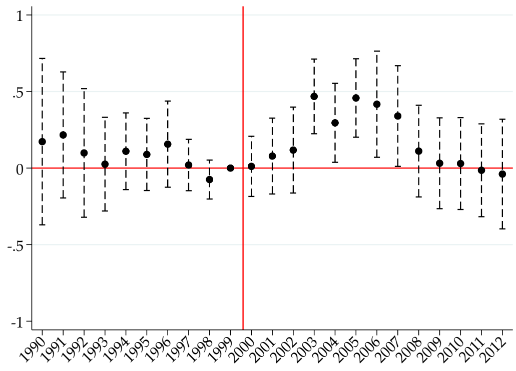


Notes: The figure shows the yearly number of active cross-border inventors by driving distance area. Lines indicate cross-border inventors identified with addresses found on their patents. Markers show cross-border inventors defined according to their residence permit (*i.e.,* permit G; EPO patents-ZEMIS match).

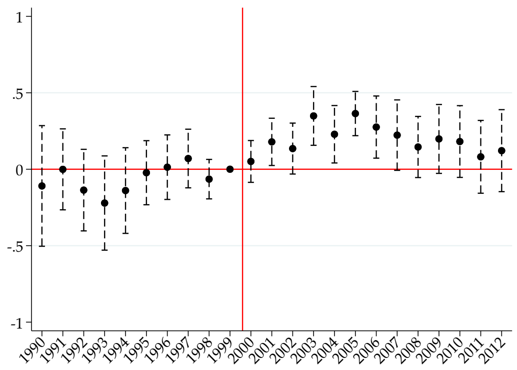
Figure 6: Regional patent count: event study results



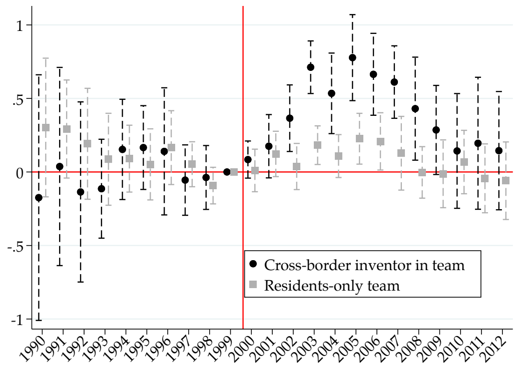
(a) Full sample



(b) Incumbent applicants only



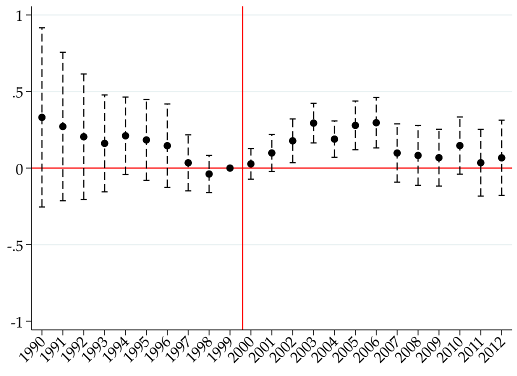
(c) No top applicants



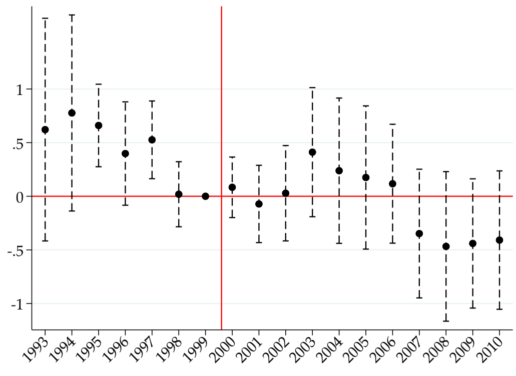
(d) Cross-border inventor-in-team VS. Resident-only

Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. In panel (a) we count all patents. In panel (b) we count only patents associated with "incumbent applicants". In panel (c) we exclude patents associated with "top applicants". In panel (d) we decompose each treated region's yearly patent output, distinguishing between patents including at least one cross-border inventor and patents including only resident inventors and running two separate regressions. The estimated coefficients for cross-border inventor-in-team patents are shown as black circles. Those for resident-only team patents are shown as gray squares. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. Panel (a): N = 1,449; Pseudo R^2 = 0.88. Panel (b): N = 1,403; Pseudo R^2 = 0.86. Panel (c): N = 1,449; Pseudo R^2 = 0.84. Panel (d): Cross-border inventor in team: N = 1,426; Pseudo R^2 = 0.89; Resident-only team: N = 1,449; Pseudo R^2 = 0.86.

Figure 7: Active Swiss inventors: event study results



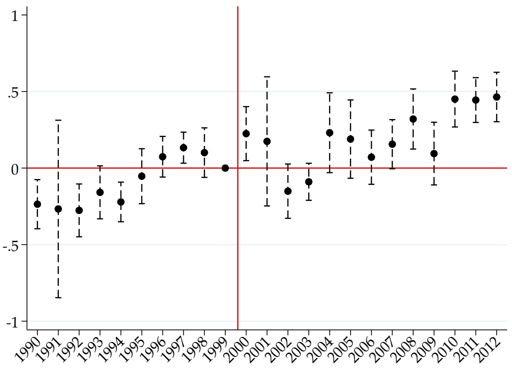
(a) Swiss residents



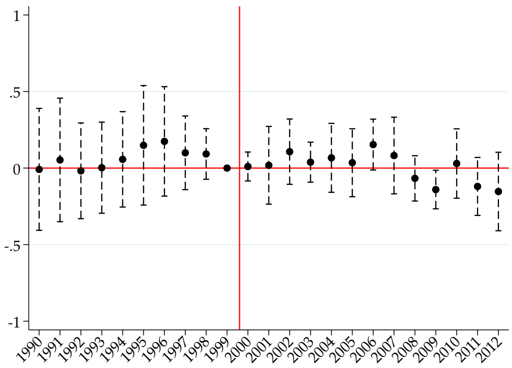
(b) Swiss nationals (subsample)

Notes: In panel (a) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panel (b) reports equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. Panel (a): N = 1,449; Pseudo R^2 = 0.91. Panel (b): N = 1,044; Pseudo R^2 = 0.78.

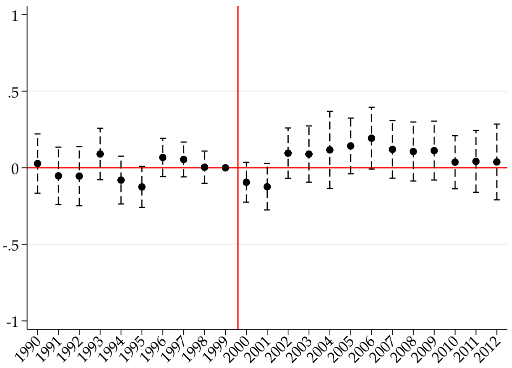
Figure 8: Regional patent count in neighbouring regions: event study results



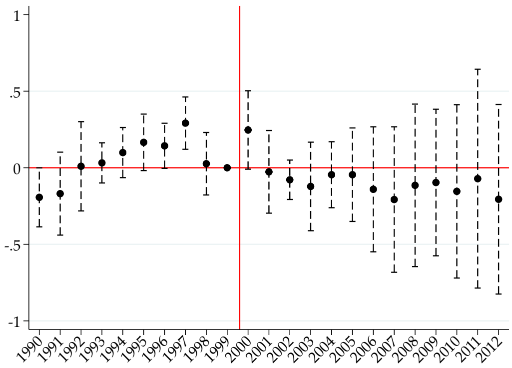
(a) Austria



(b) France



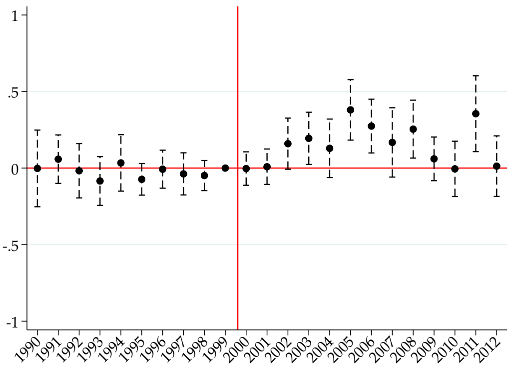
(c) Germany



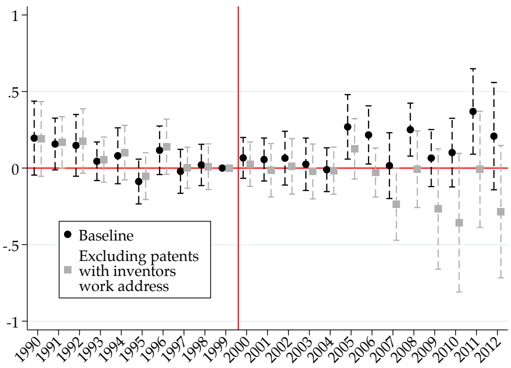
(d) Italy

Notes: The dependent variable is the number of patents filed in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. All regressions include NUTS-3 region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood. Panel (a): N = 759; Pseudo $R^2 = 0.87$. Panel (b): N = 2,189; Pseudo $R^2 = 0.95$. Panel (c): N = 8,944; Pseudo $R^2 = 0.91$. Panel (d): N = 2,224; Pseudo $R^2 = 0.91$.

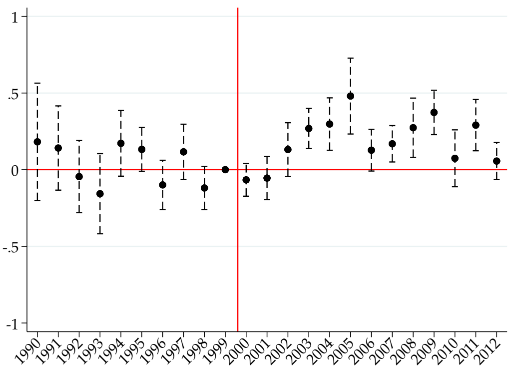
Figure 9: Incumbent inventors' patenting: event study results



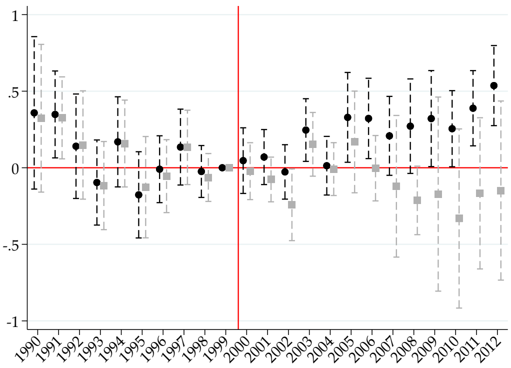
(a) Patents



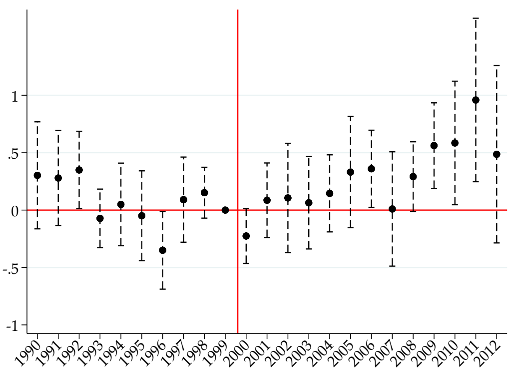
(b) Patents (excl. cross-border inventors)



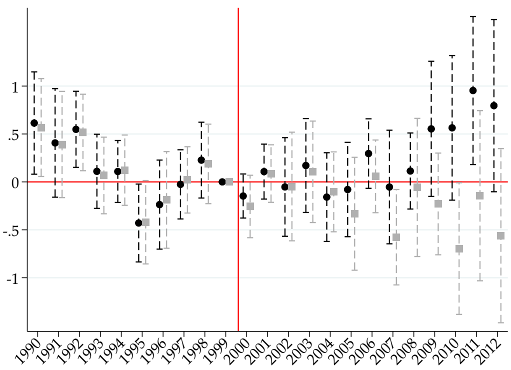
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



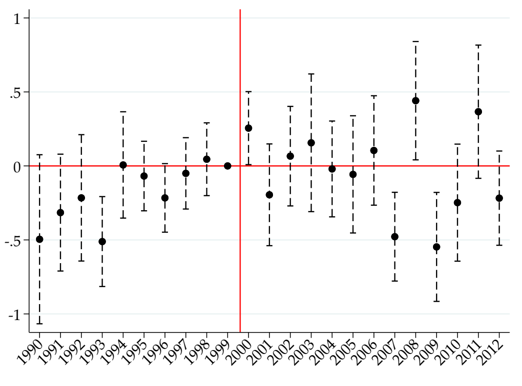
(e) Cites to cross-border inventors' countries



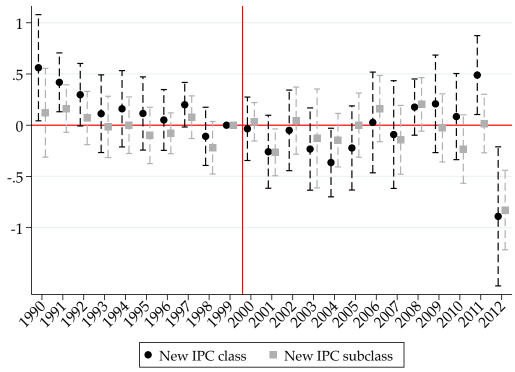
(f) Cites to cross-border inventors' countries (excl. cross-border inventors)

Notes: The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. In panels (b), (d), and (f), black dots represent the coefficients from regressions where we exclude patents filed by one or more cross-border inventors; gray squares represent the coefficients from regressions where we exclude both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses, rather than their residential one. Panel (a): N = 17,490; Pseudo R^2 = 0.10. Panel (b): Baseline: N = 16,999; Pseudo R^2 = 0.11; Excl. work address patents: N = 16,879; Pseudo R^2 = 0.12. Panel (c): N = 15,533; Pseudo R^2 = 0.28. Panel (d): Baseline: N = 14,591; Pseudo R^2 = 0.22; Excl. work address patents: N = 14,465; Pseudo R^2 = 0.22. Panel (e): N = 13,881; Pseudo R^2 = 0.33. Panel (f): Baseline: N = 12,746; Pseudo R^2 = 0.30; Excl. work address patents: N = 12,829; Pseudo R^2 = 0.34.

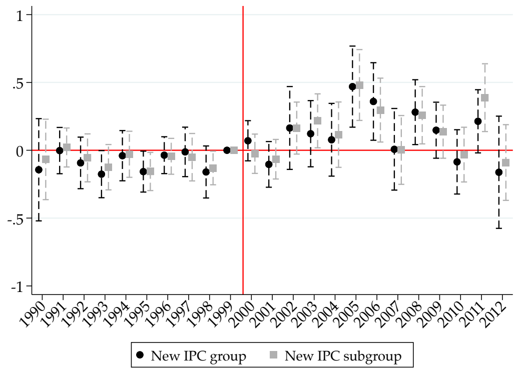
Figure 10: Incumbent inventors' patent characteristics: event study results



(a) Patents with novel terms



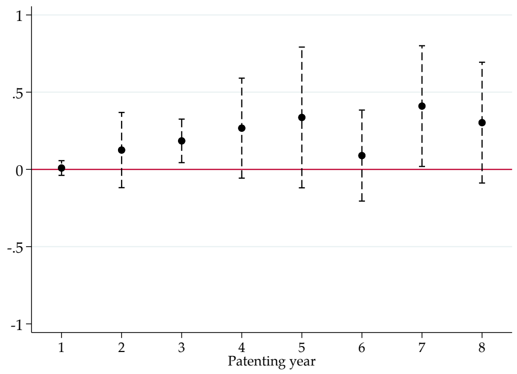
(b) Patents with new IPC class or subclass



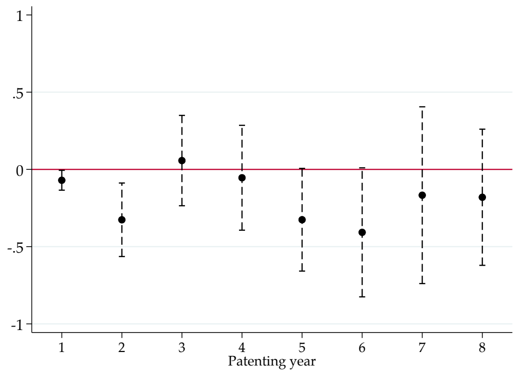
(c) Patents with new IPC group or subgroup

Notes: In panel (a), the dependent variable is the number of patents filed by inventor i in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t-1$. In panels (b) and (c), the dependent variable is the number of patents filed by inventor i in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t-1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. Panel (a): N = 12,098; Pseudo R^2 = 0.11. Panel (b): New IPC class: N = 17,457; Pseudo R^2 = 0.16; New IPC subclass: N = 17,467; Pseudo R^2 = 0.12. Panel (c): New IPC group: N = 17,477; Pseudo R^2 = 0.09; New IPC subgroup: N = 17,490; Pseudo R^2 = 0.09.

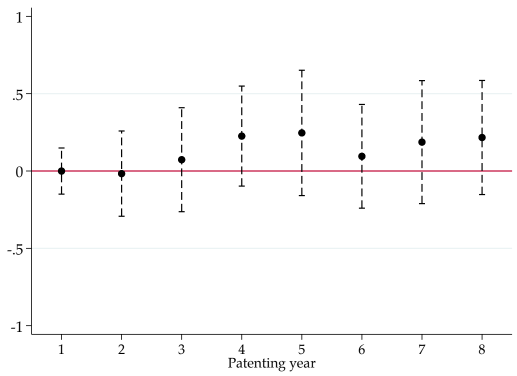
Figure 11: Junior inventors' patenting: difference-in-differences results by patenting year



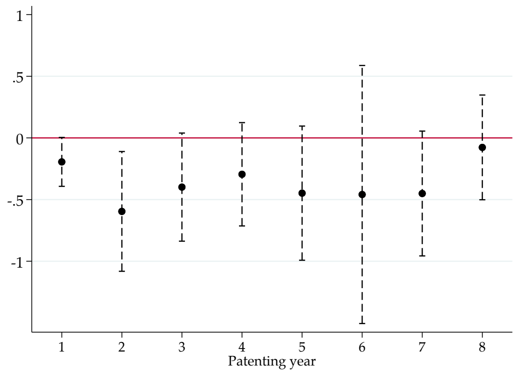
(a) Patents



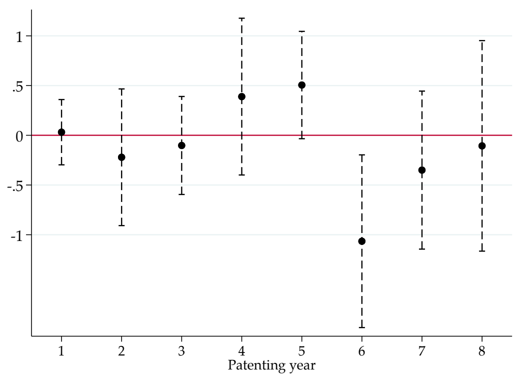
(b) Patents (excl. cross-border inventors)



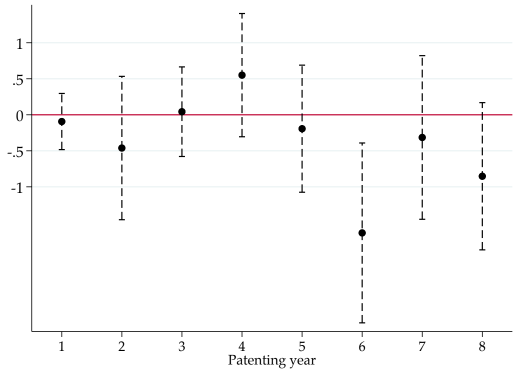
(c) Distinct co-inventors



(d) Distinct co-inventors
(excl. cross-border inventors)



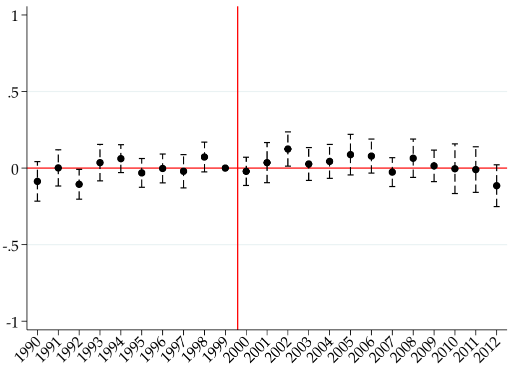
(e) Cites to cross-border inventors' countries



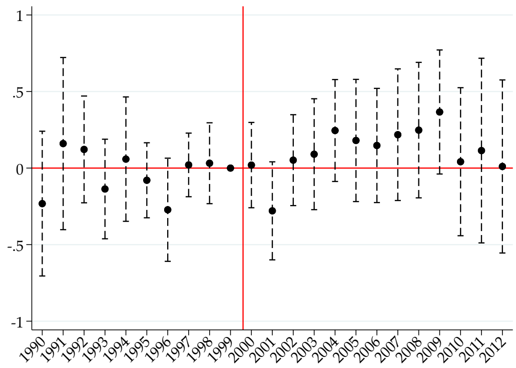
(f) Cites to cross-border inventors' countries (excl. cross-border inventors)

Notes: The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. For each panel, we report estimated coefficients, standard errors, observations, and Pseudo R^2 in Appendix Table D27.

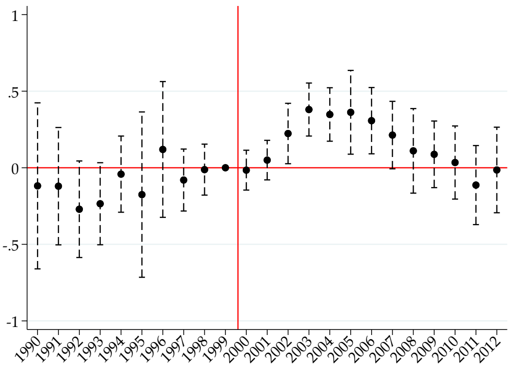
Figure 12: R&D location outcomes: event study results



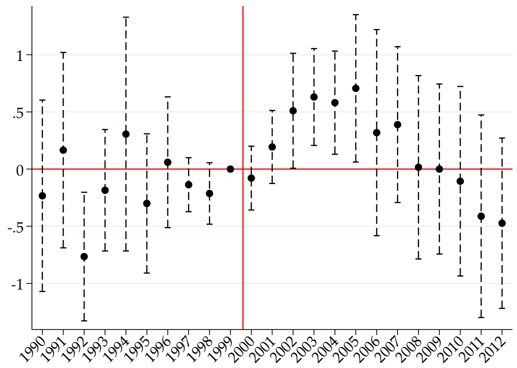
(a) Average team size



(b) Average team experience



(c) Active inventors



(d) Active cross-border inventors

Notes: The treated group includes R&D locations in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes R&D locations in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include R&D locations and year fixed effects. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. Panel (a): N = 8,653; Pseudo R^2 = 0.09. Panel (b): N = 8,092; Pseudo R^2 = 0.45. Panel (c): N = 8,653; Pseudo R^2 = 0.80. Panel (d): N = 3,625; Pseudo R^2 = 0.72.

Appendix - For Online Publication Only

"Free Movement of Inventors: Open-Border Policy and Innovation in Switzerland"

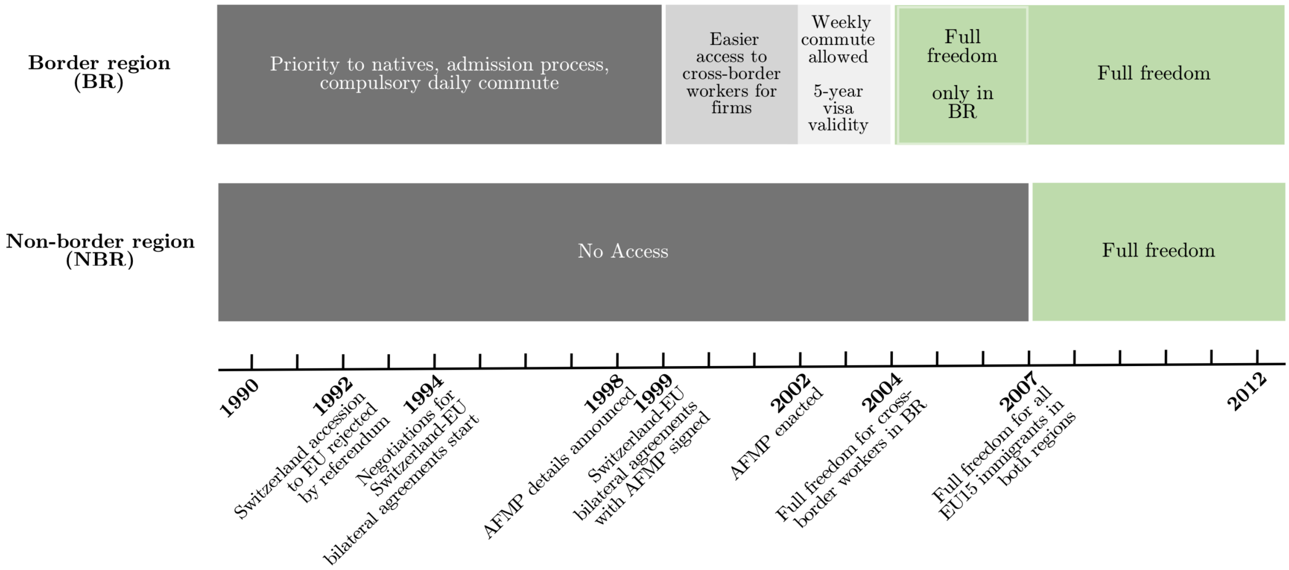
by Gabriele Cristelli and Francesco Lissoni

August 2025

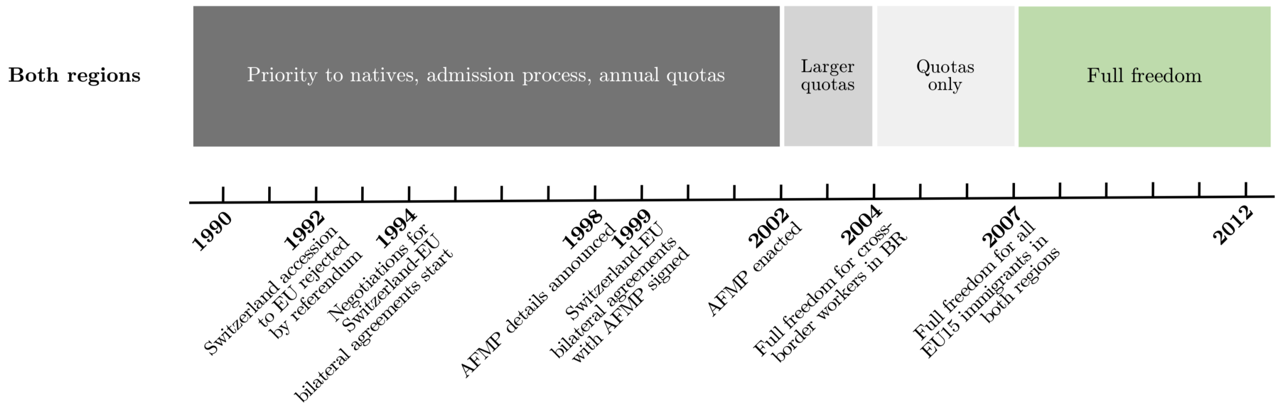
Contents

A. The Agreement on the Free Movement of Persons (AFMP)

Figure A1: Agreement on the Free Movement of Persons (AFMP) introduction timeline



(a) Cross-border workers



(b) Resident immigrants

B. Dataset Construction

B.1. Details on Patent Data

Inventors versus applicants By law, the applicants are the persons (either physical or juridical) who file the patent application at the patent office, that is, who pay the filing fees and claim the intellectual property. The inventors are instead the physical persons who have produced the ideas described and protected by the patent, which the applicant has the duty to indicate on the patent itself. Inventors and applicants can be the same in the case of independent inventors, but in the overwhelming majority of cases the applicants are firms and the inventors are their R&D employees. In other cases the inventors may be professionals who sell their ideas to a company, as part of a research contract deal (a typical case being that of a university professor hired or sponsored by a company on a project basis). For a detailed discussion and some examples, see Giuri et al. (2007) and Lissoni et al. (2008).

International extension and priority year. Swiss companies seeking patent protection in one or more European countries can file their patents either directly at the EPO or first at a national patent office such as the Swiss Federal Institute of Intellectual Property (IGE) and subsequently extend them abroad. Most extensions pass again through the EPO. All these cases are captured by our data, and we miss only the patents that Swiss companies do not extend abroad or otherwise bypass the EPO, which expert opinion at IGE and EPO suggest to be few. Notice that applicants have either 12 or 36 months since their first patent filing to complete their extensions, depending on the extension procedure they choose (for an introduction, see the online information published by the World Intellectual Property Organization: `https://www.wipo.int/pct/en/faqs/faqs.html`; last visit: August 2025). Since extensions lead to additional patent applications, each with its own filing date, the date of the first filing is indicated as the "priority" one (being essential for resolving priority disputes over initial invention claims). For all purposes, the "priority year" is the closest point in time to the invention conception. To avoid jargon, in the main text we refer to it as the year of "first filing".

Application versus granted patent data. Following common practice with EPO data, we prefer working with applications rather than granted patents for a number of reasons. First, several non-granted patents are withdrawn by their applicants during the examination time, which may range from a few months to many years, rather than rejected by the patent office for lack of novelty or obviousness. Reasons behind a withdrawal may have to do with the excessive length of the ongoing patent examination, which makes the invention obsolete in the meantime, or the intervening of new economic calculations. This means that while the patents for the most novel and non obvious inventions are usually granted, a large number of granted ones are not necessarily better than the non-granted ones. Second, being property titles, patents can be bought and sold, also as part of M&As and asset exchanges, and this applies especially to granted patents (Serrano 2010). But the new assignees, not being the original applicants, bear no association to the inventors and the original R&D activity they undertook. By focusing on patent applications, which are the earliest documents filed at the patent office, we minimise the risk of making a false inventor-company association.

B.2. Inventor and Applicant Disambiguation

Patstat data come with unique identifiers for both inventors and patent applicants. However, it occurs too often that the same inventor (or applicant) on distinct patents is not identified as the same person (or firm) and receives different identifiers, due to spelling mistakes or address changes that the Patstat disambiguation algorithms do not treat. (Instead, it never occurs that distinct inventors or applicants are treated as one).

Further disambiguation is therefore necessary to track both individuals and firms over time and across locations. Absent this treatment, we would overestimate the number of inventors and applicants in our database and underestimate, for many of them, the count of patents filed. For inventors with multiple patents, this also means that we would fail to identify many of their collaborators (co-inventors), to whom we are very much interested when it comes to study personal interactions. For companies, we would also lose useful information needed to locate their R&D labs in space, for reasons that will become clear below.

We disambiguated inventors using the inventor ids generated by Pezzoni et al. (2014) algorithm and already employed by Breschi et al. (2017), Kogler et al. (2017), Akcigit et al. (2018), and Ferrucci and Lissoni (2019). The algorithm first cleans/parses each inventor's name, surname, and address strings. Then, it selects inventor pairs (found across different patents) which could potentially be associated with the same individual, based on perfectly matching name-surname combinations or name-surname string similarity. It then filters out false positive cases using score-weighted information on common co-inventors, geographical location, and patenting technology classes, with the scores obtained from two training sets for calibration. By adjusting the scores, the algorithm can be calibrated in order to balance precision and recall.

Incidentally, one of the training sets consists of inventors affiliated to the École Polytechnique Fédérale de Lausanne (EPFL), one of the two Swiss Federal Institutes of Technology, and it is highly representative of the mix of names in French, German, Italian and other languages one can find in many large R&D labs across Switzerland.[28]

We disambiguated patent applicants by first employing the unique identifiers produced by Du Plessis et al. (2009). These are well known to Patstat users, but still present numerous instances where a single applicant is mistakenly categorized as two distinct entities. In particular, we know that different divisions of the same company are often treated as separate entities. For this reason, we manually checked all applicants in our data with at least 20 patents, which include the majority of suspect cases. Altogether, they amount to 401 initial entities and account for roughly 56% of all patents in our dataset (see Table B1). For each one, we consulted the

[28] On technicalities of inventor disambiguation see also Raffo and Lhuillery (2009) and Li et al. (2014).

companies' websites as well as several online resources containing business history information to verify their company or group affiliation. Table B2 provides some examples of the type of patent applicants we inspected and shows how we disambiguated them.

Table B1: Distribution of applicants and patents, by patent portfolio size

Patent Portfolio Size	Number	Percent	Percent of total patents
≥ 1000	5	0.03	10.62
(1000, 500]	5	0.03	5.45
(500, 100]	71	0.49	22.01
(100, 50]	74	0.51	6.97
(50, 20]	246	1.70	10.54
(20, 10]	410	2.84	8.18
(10, 5]	771	5.34	8.10
< 5	12,859	89.05	28.13
Total	14,441	100.00	100.00

Notes: The table shows the number of applicants and percent of patent filings for each applicant portfolio size bracket. The data covers EPO applications filed between 1990–2012 and including at least one Swiss-based inventor or an inventor residing in a G-permit-designated area and a Swiss-based applicant.

Table B2: Examples of applicants' disambiguation refinement

Disambiguated ID	Not-Disambiguated ID	Not-Disambiguated Name	Patent applications	Address
23665187	23665187	ROCHE	2,085	Grenzacherstrasse 124,4070 Basel
23665187	23665421	ROCHE GLYCART	56	Wagistrasse 18CH-8952 Schlieren
23665187	23665767	ROCHE VITAMINS	14	124 GrenzacherstrasseCH-4070 Basle
23665187	23665334	ROCHE DIAGNOSTICS	5	Sandhofer Strasse 116,68305 Mannheim
23665187	23665299	ROCHE CONSUMER HEALTH	1	WurmiswegCH-4303 Kaiseraugst
23665187	23665300	ROCHE CONSUMER HEALTH (WORLDWIDE)	1	1214 Vernier, Genève
23665187	23665628	ROCHE MTM LABORATORIES	1	Im Neuenheimer Feld 583,69120 Heidelberg
20140831	20140831	NESTEC	1,071	Avenue Nestlé 55,1800 Vevey
20140831	20142953	NESTLE	640	Case postale 353,1800 Vevey
27296576	27296576	SYNGENTA PARTICIPATIONS	776	Schwarzwaldallee 215CH-4058 Basel
27296576	27296548	SYNGENTA	13	European Regional Centre Priestley Road Surrey Research Park
27296576	27296564	SYNGENTA FOUNDATION FOR SUSTAINABLE AGRICULTURE	1	Schwarzwaldallee 215CH-4058 Basel
20975654	20975643	OMYA DEVELOPMENT	72	Baslerstrasse 42,4665 Oftringen
20975654	20975654	OMYA INTERNATIONAL	55	Baslerstrasse 42,4665 Oftringen
20975654	20975638	OMYA	6	Baslerstrasse 42,4665 Oftringen
23777044	23777044	ROLEX	90	3-5-7 rue François Dussaud,1211 Genève 26
23777044	19342948	MONTRES ROLEX	17	3, Rue François-Dussaud,CH-1211 Genève 24

Notes: Disambiguation performed only within the dataset of patent applications originating from Switzerland. Applicants with more than one R&D laboratory are assigned to multiple locations at a later stage.

B.3. Assignment of Patents to R&D Locations

Patent data do not explicitly report the address of the R&D laboratories (or other facilities) that sourced the inventions they protect. They only include the address of applicants and inventors. Hence, we must deduce the presumed location of the invention source (to which we most often refer as "R&D location") from either one or both sets of addresses.

With regard to the applicant's address, the larger the company, the more likely the address coincides with that of the company's headquarters or intellectual property division. These may be located in different cities than those hosting the R&D laboratories. In the case of multinationals, even the countries may not coincide. As for the inventors' address, the most common practice followed by patent attorneys is to report their home ones, which we expect to be relatively close to the inventors' workplaces. In this case, the inventor and applicant addresses differ. When they coincide, it is because the attorney preferred using the applicant address also for the inventors.

Based on these considerations, we infer each applicant's R&D location(s) from the distribution of its inventor addresses, with the applicant addresses playing an auxiliary role.[29] We first use the Google Maps Geolocation API to geocode each Swiss address and assign it to a spatial mobility region (or "region" from the French "Mobilité Spatiale").[30] For each applicant, we calculate the frequency distribution of all its inventor-patent instances across regions, thus obtaining one or more candidate R&D locations. When applicants have just one candidate, we retain this as the one and only relevant R&D location. Together, these cases account for 22% of all patents in the dataset.

When applicants have multiple candidate locations and at least 20 patents in their portfolios, we extensively search the companies' websites and other online resources. In this way, we manually identify as many of their R&D laboratories as possible (some of which are currently inactive but were active during our observation period), and we retain only the candidate R&D locations that match them. These cases account for about 58% of all patents in the dataset. For the remaining applicants with multiple candidates, but fewer than 20 patents (20% of total patents), we retain only one R&D location that corresponds to the region with the highest number of inventor-patent instances. In this case, we perform no systematic manual checking except for ambiguous cases (e.g., when the number of patents in two or more candidate locations are close).

[29] Only for this purpose, we extend the time frame of our data before 1990, using EPO patents filed in Switzerland from 1978 onwards.

[30] Spatial mobility regions are defined by the Swiss Federal Statistical Office as travel-to-work areas for micro-regional analyses (Schuler et al. 2005). They consist of agglomerations of municipalities and are large enough to track our inventors' commutes to work. They are also ideal units of analysis for our econometric exercises due to their heterogeneity in terms of G-permit holders' presence.

We conclude by looking for any false R&D location to filter out. These correspond to applicants whose patents never report a Swiss address nor have any known Swiss-based facility and yet hold a few patents with one or more Swiss-based inventors. Such patents are typically due to collaboration between a Swiss academic and a foreign research institution or a Swiss-based inventor consulting internationally.[31]

These procedures result in a final sample of 67,869 patents, 13,831 applicants, and 86,876 inventors. Around 91% of all patents in our dataset are filed by firms. Patents filed by universities and nonprofit research organizations are just about 2%, while the remaining 7% is filed by independent inventors (Table B4). Most patents originate either from applicants with just one R&D location or, for applicants with multiple R&D locations, from just one of them (47,108 patents, approximately 70% of all patents). In these cases, we treat all the inventors listed on the patent as employed in that location, even if their addresses are outside the corresponding region. As for the patents with multiple R&D locations, they may originate from multiple labs of the same company or joint applications by different companies, each one with its own lab. In both cases, we assign each inventor to one or another location (and the corresponding region) by simply picking the closest to the inventor's address, and assign patents fractionally to each location.

We believe our method of identifying R&D locations to be accurate and necessary, due to the need to remove the noise contained in the applicants' and inventors' addresses and to locate correctly within Switzerland the patents signed by local inventors and foreign-resident ones. However, we also experiment with simpler methods, which do not require the use of personal judgment and external information. In one case we simply assign each patent and inventor to the applicant's region, alternatively we use the inventor's residential region.

Table B3: Applicant categories based on inventor-patent instances distribution

	Applicants		Patents	
	Number	Percent	Number	Percent
Single R&D location candidate	11,720	69.67	18,456	21.84
Multi R&D location candidate (hand-checked)	350	2.08	48,641	57.57
Multi R&D location candidate (partly hand-checked)	4,753	28.25	17,392	20.58
Total	16,823	100.00	84,489	100.00

Notes: The table shows the number of applicants and their associated patent filings for each applicant portfolio size bracket. The sample includes EPO patents filed in Switzerland between 1978 and 2012. The time window is extended from our baseline 1990-2012 in order to gather more information about R&D laboratories potential location.

[31] We search and eliminate the former by looking at keywords such as "university" or "foundation" in the applicants' names (237 patents). As for the latter, we search online for corporate information and eliminate all those for which no Swiss-based R&D facility is ever mentioned (3,466 patents).

Table B4: Patents by applicant type

	Number	Percent
Firms	61,834	91.11
Universities and research labs	1,331	1.96
Independent inventors	4,704	6.93
Total	67,869	100.00

Notes: Patents filed by universities and research laboratories are identified based on the name of the applicant, *i.e.,* if the string contains either: "`universit`", "`EPFL`", "`ETHZ`", "`federal institute of technology`", "`polytechnique`", "`technische hochschule`", "`CERN`", "`paul scherrer`". Independent inventors' patents are those associated with inventors always patenting without collaborators and filing patents as both inventor and applicant. The remaining patents are labeled as filed by firms.

Table B5: Top five applicants by type

	Firms		
	Number	% (category)	% (total)
ABB	2,512	3.78	3.70
Novartis	2,184	3.28	3.22
Roche	2,160	3.25	3.18
Nestlé	1,711	2.57	2.52
Alstom Technology	1,539	2.31	2.27
	Universities and research labs		
	Number	% (category)	% (total)
ETHZ	353	26.15	0.52
EPFL	326	24.15	0.48
University of Zurich	186	13.78	0.27
Paul Scherrer Institut	111	8.22	0.16
University of Geneva	100	7.41	0.15

B.4. Cross-Border Workers Residence and Work Locations

Table B6: G-permit-designated areas in Austria, France, Germany, and Italy

Country	First Administrative Unit		Second Administrative Unit
Austria	Bezirk (District)	NUTS-3 code	Bundesland (State)
	Bludenz	AT341	Vorarlberg
	Bregenz	AT341/AT342	Vorarlberg
	Dornbirn	AT342	Vorarlberg
	Feldkirch	AT342	Vorarlberg
	Landeck	AT334	Tirol
France	Département (Department)	NUTS-3 code	Région (Region)
	Ain	FR711	Auvergne-Rhône-Alpes
	Haute-Savoie	FR718	Auvergne-Rhône-Alpes
	Doubs	FR431	Bourgogne-Franche-Comté
	Jura	FR432	Bourgogne-Franche-Comté
	Territoire de Belfort	FR434	Bourgogne-Franche-Comté
	Haut-Rhin	FR422	Grand Est
Germany	Landkreis (District) or Stadt (City)	NUTS-3 code	Land (State)
	Biberach	DE146	Baden-Württenberg
	Bodenseekreis	DE147	Baden-Württenberg
	Breisgau-Hochschwarzwald	DE132	Baden-Württenberg
	Freiburg im Breisgau	DE131	Baden-Württenberg
	Konstanz	DE138	Baden-Württenberg
	Lörrach	DE139	Baden-Württenberg
	Ravensburg	DE148	Baden-Württenberg
	Sigmaringen	DE149	Baden-Württenberg
	Schwarzwald-Baar-Kreis	DE136	Baden-Württenberg
	Tuttlingen	DE137	Baden-Württenberg
	Waldshut-Tiengen	DE13A	Baden-Württenberg
	Emmendingen	DE133	Baden-Württenberg
	Kempten (Allgäu)	DE273	Bavaria
	Lindau	DE27A	Bavaria
	Oberallgäu	DE27E	Bavaria
Italy	Provincia (Province)	NUTS-3 code	Regione (Region)
	Aosta	ITC20	Valle d'Aosta
	Bolzano	ITH10	Trentino-Südtirol
	Como	ITC42	Lombardia
	Lecco	ITC43	Lombardia
	Monza e Brianza	ITC4D	Lombardia
	Varese	ITC41	Lombardia
	Sondrio	ITC44	Lombardia
	Verbania-Cusio-Ossola	ITC14	Piemonte

Notes: The table shows the administrative units in Austria, France, Germany, and Italy we used to: (i) select patent applications filed by Swiss-based applicants and potential cross-border inventors employed in Switzerland and not collaborating with any Swiss-based inventor on those specific projects; (ii) identify cross-border inventors; (iii) select treated regions in Switzerland's neighbouring countries to test brain drain effects following the AFMP introduction. These are the areas where prospective cross-border workers were required to reside for at least six months before being eligible to apply for a Permit G to work in Switzerland, before the AFMP introduction (G-permit designated areas). They remained cross-border border workers' main residential areas also in the post-AFMP period (Figure C4).

Table B7: Cross-border inventors potential residential districts for spatial mobility region groups

spatial mobility regions	**cross-border inventors potential districts of residence**
(1) Zurich, (2) Glattal-Furttal, (3) Limmattal, (4) Knonaueramt, (5) Zimmerberg, (6) Pfannenstiel, (7) Zurcher Oberland, (8) Winterthur, (9) Weinland, (10) Zurcher Unterland, (26) Luzern, (27) Sursee-Seetal, (28) Willisau, (29) Entlebuch, (30) Uri, (34) Sarneraatal, (35) Nidwalden, (38) Zug, (50) Schaffhausen, (76) Thurtal, (77) Untersee, (78) Oberthurgau	Germany: Biberach, Bodenseekreis, Breisgau-Hochschwarzwald, Freiburg, Konstanz, Lörrach, Ravensburg, Sigmaringen, Schwarzwald-Baar-Kreis, Tuttlingen, Waldshut-Tiengen, Emmendingen, Kempten (Allgäu), Lindau, Oberallgäu
(11) Bern, (12) Erlach-Seeland, (13) Biel/Bienne, (14) Jura bernois, (15) Oberaargau, (16) Burgdorf, (17) Oberes Emmental, (18) Aaretal, (19) Schwarzwasser, (20) Thun, (21) Saanen-Obersimmental (22) Kandertal, (23) Oberland-Ost, (24) Grenchen, (25) Laufental, (44) Olten, (45) Thal, (46) Solothurn, (47) Basel-Stadt, (48) Unteres Baselbiet, (49) Oberes Baselbiet	France: Doubs, Haut-Rhin, Territoire de Belfort Germany: Biberach, Bodenseekreis, Breisgau-Hochschwarzwald, Freiburg, Konstanz, Lörrach, Ravensburg, Sigmaringen, Schwarzwald-Baar-Kreis, Tuttlingen, Waldshut-Tiengen, Emmendingen, Kempten (Allgäu), Lindau, Oberallgäu
(31) Innerschwyz, (32) Einsiedeln, (33) March, (36) Glarner Unterland, (37) Glarner Hinterland, (51) Appenzell A. Rh., (52) Appenzell I. Rh., (53) St.Gallen, (54) Rheintal, (55) Werdenberg, (56) Sarganserland, (57) Linthgebiet, (58) Toggenburg, (59) Wil	Austria: Bludenz, Bregenz, Dornbirn, Feldkirch, Landeck Germany: Biberach, Bodenseekreis, Breisgau-Hochschwarzwald, Freiburg, Konstanz, Lörrach, Ravensburg, Sigmaringen, Schwarzwald-Baar-Kreis, Tuttlingen, Waldshut-Tiengen, Emmendingen, Kempten (Allgäu), Lindau, Oberallgäu
(39) La Sarine, (40) La Gruyere, (41) Sense, (42) Murten/Morat, (43) Glane-Veveyse	France: Doubs, Haut-Rhin, Haute-Savoie, Territoire de Belfort
(60) Chur, (61) Prattigau, (62) Davos, (63) Schanfigg	Austria: Bludenz, Bregenz, Dornbirn, Feldkirch, Landeck
(64) Mittelbunden, (65) Viamala, (66) Surselva, (68) Oberengadin, (69) Mesolcina	Italy: Como, Sondrio
(67) Engiadina Bassa	Austria: Bludenz, Bregenz, Dornbirn, Feldkirch, Landeck Italy: Bolzano, Como, Sondrio
(70) Aarau, (71) Brugg-Zurzach, (72) Baden, (73) Mutschellen, (74) Freiamt, (75) Fricktal	France: Haut-Rhin Germany: Biberach, Bodenseekreis, Breisgau-Hochschwarzwald, Freiburg, Konstanz, Lörrach, Ravensburg, Sigmaringen, Schwarzwald-Baar-Kreis, Tuttlingen, Waldshut-Tiengen, Emmendingen, Kempten (Allgäu), Lindau, Oberallgäu
(79) TreValli, (80) Locarno, (81) Bellinzona, (82) Lugano, (83) Mendrisio	Italy: Como, Lecco, Monza e Brianza, Varese, Verbania-Cusio-Ossola
(84) Lausanne, (85) Morges, (86) Nyon, (87) Vevey, (88) Aigle, (89) Pays-d'Enhaut (90) Gros-de-Vaud, (91) Yverdon, (92) La Vallee, (93) La Broye, (105) Geneve	France: Ain, Doubs, Haute-Savoie, Jura
(94) Goms, (95) Brig, (96) Visp, (97) Luek	Italy: Verbania-Cusio-Ossola
(98) Sierre, (99) Sion, (100) Martigny, (101) Monthey	France: Haute-Savoie Italy: Aosta
(102) Neuchatel, (103) La Chaux-de-Fonds, (104) Val-de-Travers	France: Doubs, Jura, Territoire de Belfort
(106) Jura	France: Doubs, Haut-Rhin, Territoire de Belfort Germany: Biberach, Bodenseekreis, Breisgau-Hochschwarzwald, Freiburg, Konstanz, Lörrach, Ravensburg, Sigmaringen, Schwarzwald-Baar-Kreis, Tuttlingen, Waldshut-Tiengen, Emmendingen, Kempten (Allgäu), Lindau, Oberallgäu

Notes: The table shows cross-border inventors' potential residential areas for groups of spatial mobility regions in Switzerland. Since G-permit holders were allowed to obtain a job in Swiss non-border regions after 2007, we also included regions in those areas to find potential cross-border inventors. We identified very few of them working in non-border regions.

B.5. Matching EPO Inventors with ZEMIS Immigrant Records

We match foreign inventors working in Switzerland to their immigrant records by linking patent applications filed at the European Patent Office (EPO) with the Swiss Central Migration Information System database (ZEMIS).

Patent applications provide extensive information on scientists and engineers requesting intellectual property protection for their inventions, including their residential location, co-inventors, patent applicants (in many cases their employer), and the inventions' technological features. We select EPO applications because of the quality of their address information and due to the large amount of filings from Swiss-based organizations. The main sample used for the match includes all inventors reporting a Swiss address. In order to capture cross-border commuters working as inventors, we also add all inventors residing in foreign regions bordering Switzerland and appearing on Swiss-based applicants' patents. This sample includes 118,750 inventors, tracked from 1978 onwards.

ZEMIS is the complete census of foreign individuals with a Swiss resident or work permit. It is a mirror of Switzerland's Central Migration Information System, which monitors the country's foreign population, gathering immigrants' information produced by the administrative entities tasked to issue and renew residence and work permits. ZEMIS contains information about immigrants' nationality, residence permit type, entry year, birth year and location, and parents' nationality. The earliest ZEMIS version was issued in 2002. We use a version of the database containing information on about three million individuals, holding immigrant status in Switzerland between 2002-2015.

To prepare ZEMIS and inventor raw records for the match, we parse the individuals' full names in both datasets and harmonize the information about their residence and work location. For name parsing, we split full name strings into first, last, and middle names (if any), and remove all accents. ZEMIS residence and work locations are classified by main administrative units (such as municipalities or cantons). We update all municipalities according to the latest Swiss administrative division, accounting for communities' mergers and incorporations, and assign each municipality to its corresponding spatial mobility region (as defined above and in Schuler et al. (2005)). EPO patents provide geographic information about an inventor only in the form of address strings. In order to make them comparable to those in ZEMIS, we first submit the address strings to the Google Maps Geolocation API and obtain their administrative units, and then we repeat the municipalities' update and addition of regions performed for ZEMIS' records.[32]

[32]For more information on Google Maps Geolocation API: `https://developers.google.com/maps/documentation/geolocation/intro` (last visit: August 2025).

The last data preparation step deals with individuals' disambiguation. For ZEMIS records, we exploit its unique identifier, which is assigned to each person entering the database and never changed thereafter, even if its assignee temporarily exits and subsequently re-enters Switzerland. Inventors found on EPO patents, however, are only mildly disambiguated, based on the perfect similarity of their names and address strings. We rely on the algorithm developed by Pezzoni et al. (2014) and assign a unique identifier to the same individual appearing on different patents with different addresses or different spellings of name and/or surname.

In order to link inventors to their immigrant records in ZEMIS, we adopt a fuzzy match approach, based on the computation of string similarity measures between individuals' names and corresponding geographic and age-based information.[33] We treat the immigrant-inventor matching as a binary classification problem and follow the supervised machine learning strategy originally developed by Feigenbaum (2016). This strategy is particularly suited to situations where a *ground-truth* training set is not readily available and has to be constructed by researchers.

We start by creating a sample of all candidate matches. To do so, we compare first and last names of individuals in ZEMIS and inventors on EPO patents. To exclude false matches and limit the number of comparisons to be performed, we introduce the following blocking conditions:[34]

- The first two initials of first name and last name must coincide;
- The canton of residence/work must coincide;
- The potential match must be between 18 and 75 years old at the time of the patent filing;
- The potential matches must have filed at least one patent during their period of residence/work in Switzerland.

We then produce a Jaro-Winkler string similarity score (Jaro (1989); Winkler (1990)) for the first names and for the last names of each pair of potential matches. We retain only potential matches displaying similarity scores greater or equal to 0.8 for both the first names and last names comparisons, obtaining 889,532 candidate matches.[35]

In order to tune the matching algorithm, we construct a training set by randomly extracting 6,000 candidate matches, stratifying the sampling on individuals' nationality, canton of residence (country in the case of cross-border workers), and year of birth. We then manually check each record, creating a binary indicator "`match`" equal to 1 for those we believe refer to the same

[33]Recent works involving fuzzy matches of inventors to non-patent data sources include Depalo and Di Addario (2014); Jung and Ejermo (2014); Toivanen and Väänänen (2016); Dorner et al. (2016) and Bell et al. (2019).

[34]A comparison based on the full cartesian product of ZEMIS and EPO patents individual records would require enormous computational power, almost exclusively inflated by false matches.

[35]Feigenbaum (2016) uses a similar score threshold. Extensive checks revealed that below that score true matches were unlikely.

individual and equal to 0 in all other cases.[36]

Following Feigenbaum (2016), we train the matching algorithm using a Probit classifier.[37] We essentially run a Probit model, relating the binary indicator "`match`" to a series of predictors, all reported in Table B8.

Based on the coefficients of the Probit regression, we estimate the predicted probability score for each candidate match in the training set. In order to tune the algorithm, we aim at finding a lower bound for the score to declare a match which would simultaneously maximize *precision* (*i.e.*, true positives / true positives + false positives) and *recall* (*i.e.*, true positives / true positives + false negatives). Figure B1 relates these two measures to the predicted probability scores we calculated, evaluating the in-sample performance of the algorithm.

Table B8: List of predictors to train the algorithm

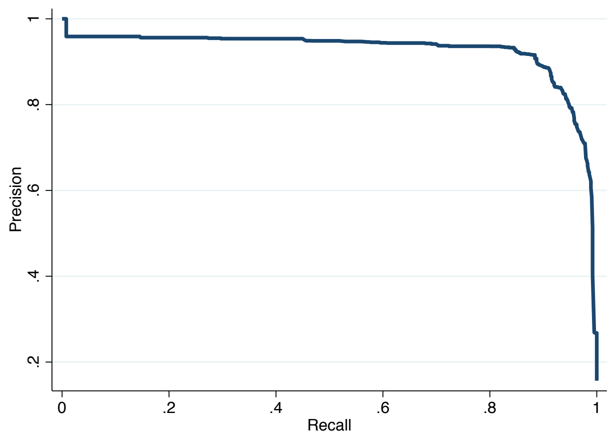
Variable	**Description**
jw_first_name	Jaro-Winkler string similarity between $\texttt{first\_name}_{ZEMIS}$ and $\texttt{first\_name}_{EPO}$
jw_last_name	Jaro-Winkler string similarity between $\texttt{last\_name}_{ZEMIS}$ and $\texttt{last\_name}_{EPO}$
jw_full_name	Jaro-Winkler string similarity between $\texttt{full\_name}_{ZEMIS}$ and $\texttt{full\_name}_{EPO}$
same_first_name	Dummy indicator equal to 1 if $\texttt{first\_name}_{ZEMIS}$ perfectly matches $\texttt{first\_name}_{EPO}$
same_last_name	Dummy indicator equal to 1 if $\texttt{last\_name}_{ZEMIS}$ perfectly matches $\texttt{last\_name}_{EPO}$
same_full_name	Dummy indicator equal to 1 if $\texttt{full\_name}_{ZEMIS}$ perfectly matches $\texttt{full\_name}_{EPO}$
same_lastone_first_name	Dummy indicator equal to 1 if $\texttt{first\_name}_{ZEMIS}$'s last letter perfectly matches $\texttt{first\_name}_{EPO}$'s one
same_lasttwo_first_name	Dummy indicator equal to 1 if $\texttt{first\_name}_{ZEMIS}$'s last two letters perfectly matches $\texttt{first\_name}_{EPO}$'s ones
same_lastthree_first_name	Dummy indicator equal to 1 if $\texttt{first\_name}_{ZEMIS}$'s last three letters perfectly matches $\texttt{first\_name}_{EPO}$'s ones
same_lastone_last_name	Dummy indicator equal to 1 if $\texttt{last\_name}_{ZEMIS}$'s last letter perfectly matches $\texttt{last\_name}_{EPO}$'s one
same_lasttwo_last_name	Dummy indicator equal to 1 if $\texttt{last\_name}_{ZEMIS}$'s last letter perfectly matches $\texttt{last\_name}_{EPO}$'s one
same_lastthree_last_name	Dummy indicator equal to 1 if $\texttt{last\_name}_{ZEMIS}$'s last letter perfectly matches $\texttt{last\_name}_{EPO}$'s one
age_at_appln	Age at the time of invention
age_at_first_inv	Age at first invention
age_20_70	Dummy indicator equal to 1 if age at the time of invention if comprised between 20 and 70 years old
age_25_65	Dummy indicator equal to 1 if age at the time of invention if comprised between 25 and 65 years old
age_30_60	Dummy indicator equal to 1 if age at the time of invention if comprised between 30 and 60 years old
age_35_55	Dummy indicator equal to 1 if age at the time of invention if comprised between 35 and 55 years old
first_age_20_70	Dummy indicator equal to 1 if age at first invention if comprised between 20 and 70 years old
first_age_25_65	Dummy indicator equal to 1 if age at first invention if comprised between 25 and 65 years old
first_age_30_60	Dummy indicator equal to 1 if age at first invention if comprised between 30 and 60 years old
first_age_35_55	Dummy indicator equal to 1 if age at first invention if comprised between 35 and 55 years old
d_loc_city	Dummy indicator equal to 1 if ZEMIS residence or work municipality matches EPO's municipality
d_loc_region	Dummy indicator equal to 1 if ZEMIS residence or work region matches EPO's region*

Notes: *For Swiss locations we use spatial mobility regions, while for Austrian, French, German, and Italian locations we use "Politischer Bezirk", "Départements", "Landkreis", and "Province" respectively.

[36] While the majority of non-matches stem from individuals with similar but clearly different names (*e.g.*, James Page with Jamie Page or Christopher Cornell with Christian Corney), a portion of them involved homonyms. In that case, we defined a match only if the geographic information corresponded.

[37] Feigenbaum (2016) demonstrates how in his case using alternatives such as logistic or non-paramentric classifiers like random forests and support-vector-machines does not improve the matching algorithm performance.

Figure B1: Precision and recall curve, training set



We identify the optimal score lower bound by maximising a function including the sum of *precision* and *recall*. Table B9 reports the results of the optimal score search under different weighting schemes for precision and recall. We opt for a weight of 1.75 on recall defining as matches all those records with a score greater than 0.28. We privilege recall to obtain the highest-number of matches possible with reasonable precision rates, keeping the freedom to raise the lower bound to declare a match in subsequent stages of the analysis for robustness checks.

Table B9: Grid search results according to different weighting schemes

Weight on Precision	**Weight on Recall**	**Score**	**Precision**	**Recall**
3	1	0.580	0.884	0.878
1.75	1	0.560	0.880	0.884
1	1	0.560	0.880	0.884
1	1.75	0.280	0.813	0.936
1	3	0.236	0.785	0.948

Having selected the optimal score to declare a match, we return to the full dataset of candidate matches, run the algorithm we tuned on the training set, estimate each record's predicted probability, and identify as matches all those with a score higher than 0.28. We obtain 23,123 combinations of individuals in ZEMIS matched to EPO inventors.

As a final step, we consider all those ambiguous cases where only one individual in ZEMIS is matched to multiple EPO inventors (*1:m*), multiple individuals in ZEMIS are matched to only one EPO inventor (*m:1*), and multiple individuals in ZEMIS are matched to multiple EPO inventors (*m:m*). Table B10 shows that altogether these cases account for 43% of the matches (that is, 57% are 1:1 matches).

Table B10: Match type breakdown

Zemis : EPO inventors	**N. Records**	**Percent**
1 : 1	13,280	57.43
1 : m	4,297	18.58
m : 1	2,677	11.58
m : m	2,869	12.41
Total	23,123	100.00

We restore the remaining records to a *1:1* set up as follows:

- *1:m* : most of these records stem from inventor disambiguation issues not solved by the Pezzoni et al. (2014)'s algorithm. We manually check each record and assign a common identifier to inventors who are clearly the same person (*i.e.*, same applicant, same address declared), reducing the initial 4,297 records to 2,108. For persisting 1:m links we keep the match with highest predicted score, obtaining the final 1,949 1:1 matches.
- *m:1* : we reduce the initial 2,677 matches to 1,003 1:1 links keeping the ZEMIS : EPO inventor combination with the highest predicted score.
- *m:m* : we first get rid of multiple matches on the inventor side assigning a common identifier to inventors with the same identity, reducing the records from 2,869 to 1,984. We subsequently take care of the duplicate matches on the ZEMIS side by selecting the links with the highest predicted score, obtaining 618 1:1 matches.

The final dataset of matched records includes 16,844 unique inventors connected to their ZEMIS immigrant records.

To further assess the matching algorithm performance, we test its precision and recall on an external validation set. Such out-of-sample test should provide a more reliable indication of the algorithm's quality than that inferred at the training stage (in-sample performance). We generate a validation set by selecting all "academic inventors" (namely, the inventors listed on patent applications filed or co-filed by universities and other academic institutions) active in Switzerland and listed on patents filed through the Patent Cooperation Treaty (PCT), which until 2011, if extended to the Unites States, reported the inventors' self-declared nationalities (Miguelez and Fink (2017)).[38] We focus on academic inventors to increase the likelihood of finding online information about their careers and background, as academic researchers are more likely to have public profiles on university or personal websites than scientists involved in industrial R&D. We manually validate each inventor's nationality and (potential) immigrant status browsing their profiles. We define as "immigrants" (*i.e.,* records to be matched) all those whose validated nationality is not Swiss.

[38] The Patent Cooperation Treaty enables inventors to seek patent protection in all of its contracting states through a single patent filing, in one language, and paying a unique set of fees. PCT applications can be filed at a contracting state's national patent office or at the World Intellectual Property Organization (WIPO).

Implementing the same procedure we used to create the final dataset of 16,844 linked inventors, we compare the match prediction of the algorithm with the validation set by immigrant status. Table B11 shows a matrix enabling the calculation of precision and recall scores for this exercise. The ratio of the true positives matches (613) and the sum of true and false positives matches (663) gives us the precision rate, in this case around 93%. The ratio of true positives matches (613) and the sum of true positives and false negatives (863) matches allows to calculate the recall rate, in this case around 71%.

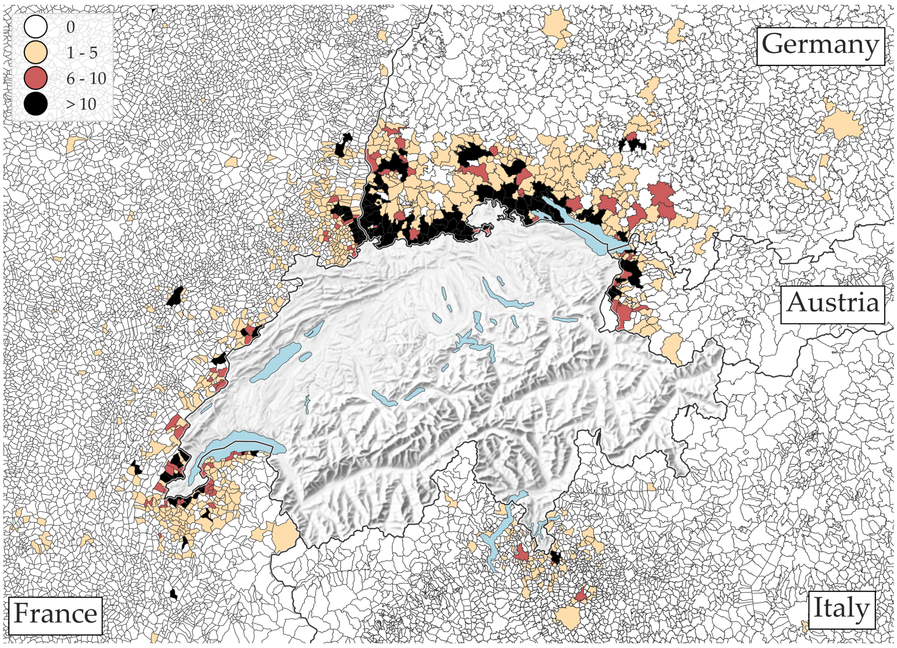
Table B11: Testing the algorithm on the validation set

	Validation set Status		
Algorithm prediction	*Not matched (Swiss)*	*Matched (Foreign national)*	
Not matched	654	250	904
Matched	50	613	663
	704	863	1,567

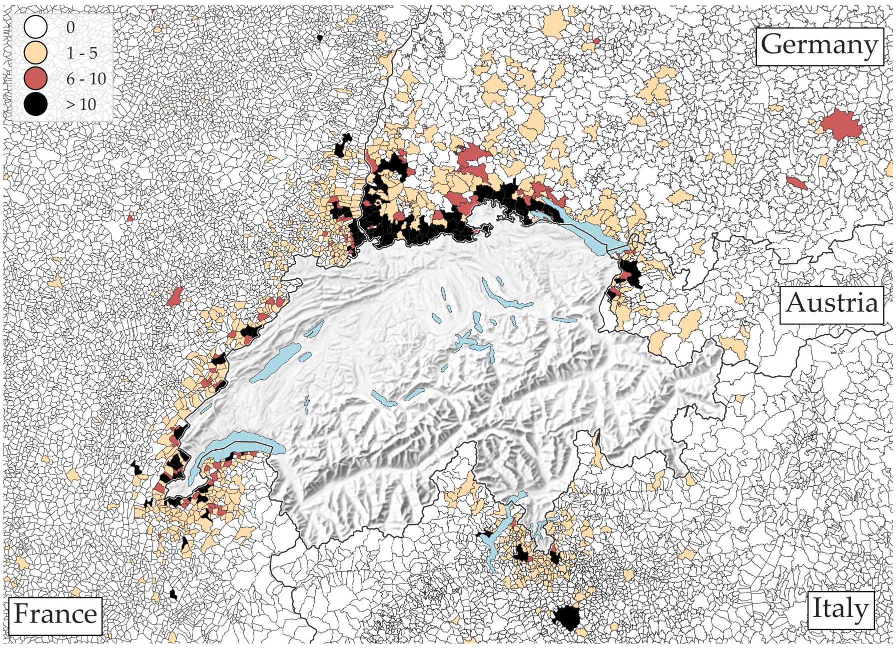
C. Additional Descriptive Evidence

C.1. Cross-Border Inventors

Figure C1: Number of cross-border inventors by municipality of residence



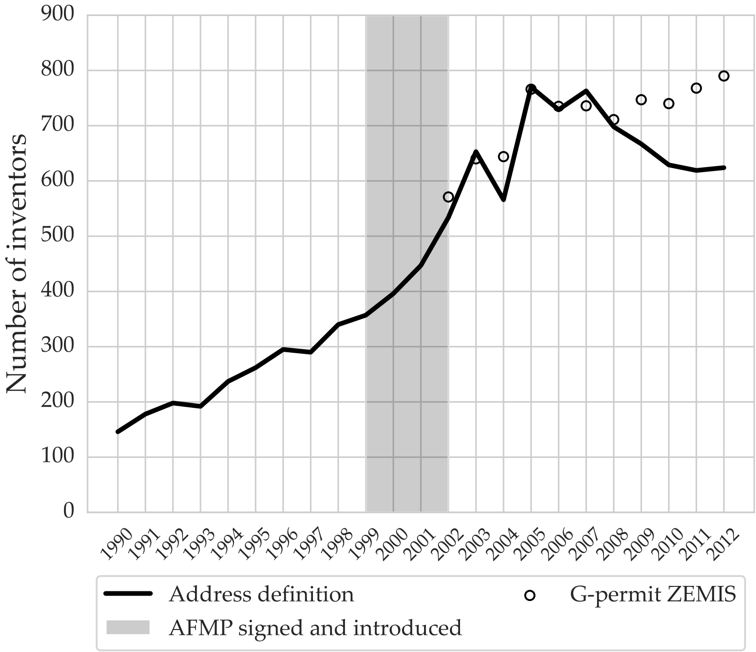
(a) Address definition



(b) G-permit ZEMIS definition

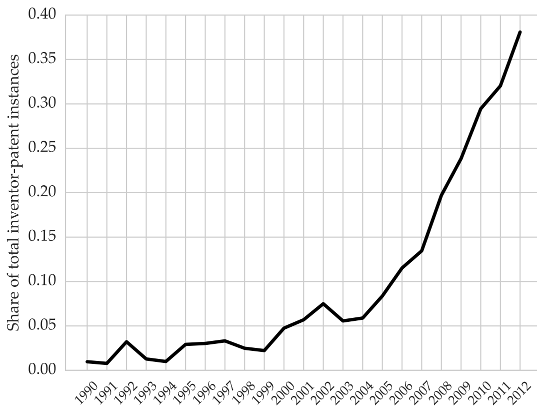
Notes: The two maps show the municipalities in Austria, France, Germany, and Italy where cross-border inventors reside, comparing the cross-border inventors' geographic distribution according to their the patent address definition (panel a) and G-permit ZEMIS definition (panel b).

Figure C2: Active cross-border inventors, full Switzerland

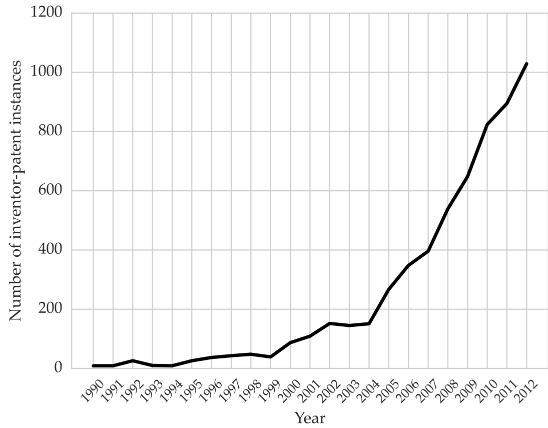


Notes: The solid line indicates cross-border inventors identified with addresses found on their patents. The dashed line indicates cross-border inventors identified according to their residence permit (*i.e.,* permit G; EPO patents-ZEMIS match).

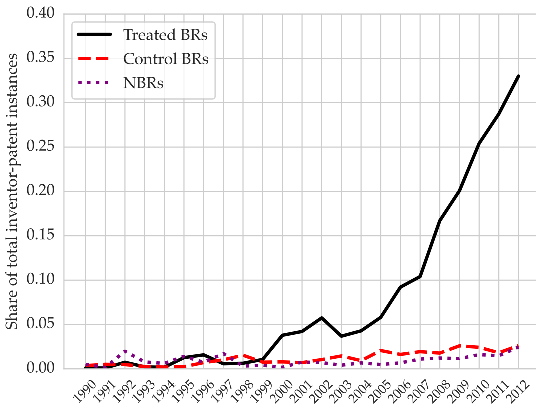
Figure C3: Inventor-patent instances with the inventors' work address



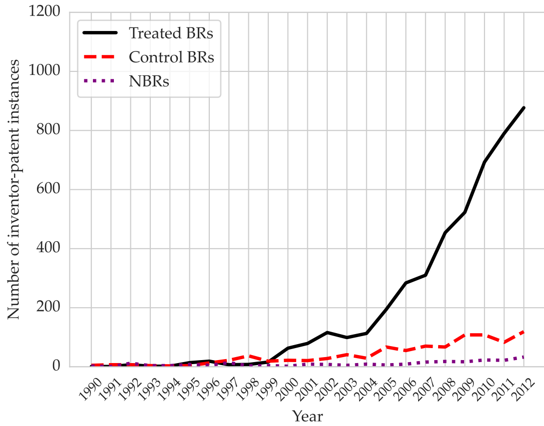
(a) Share



(b) Number



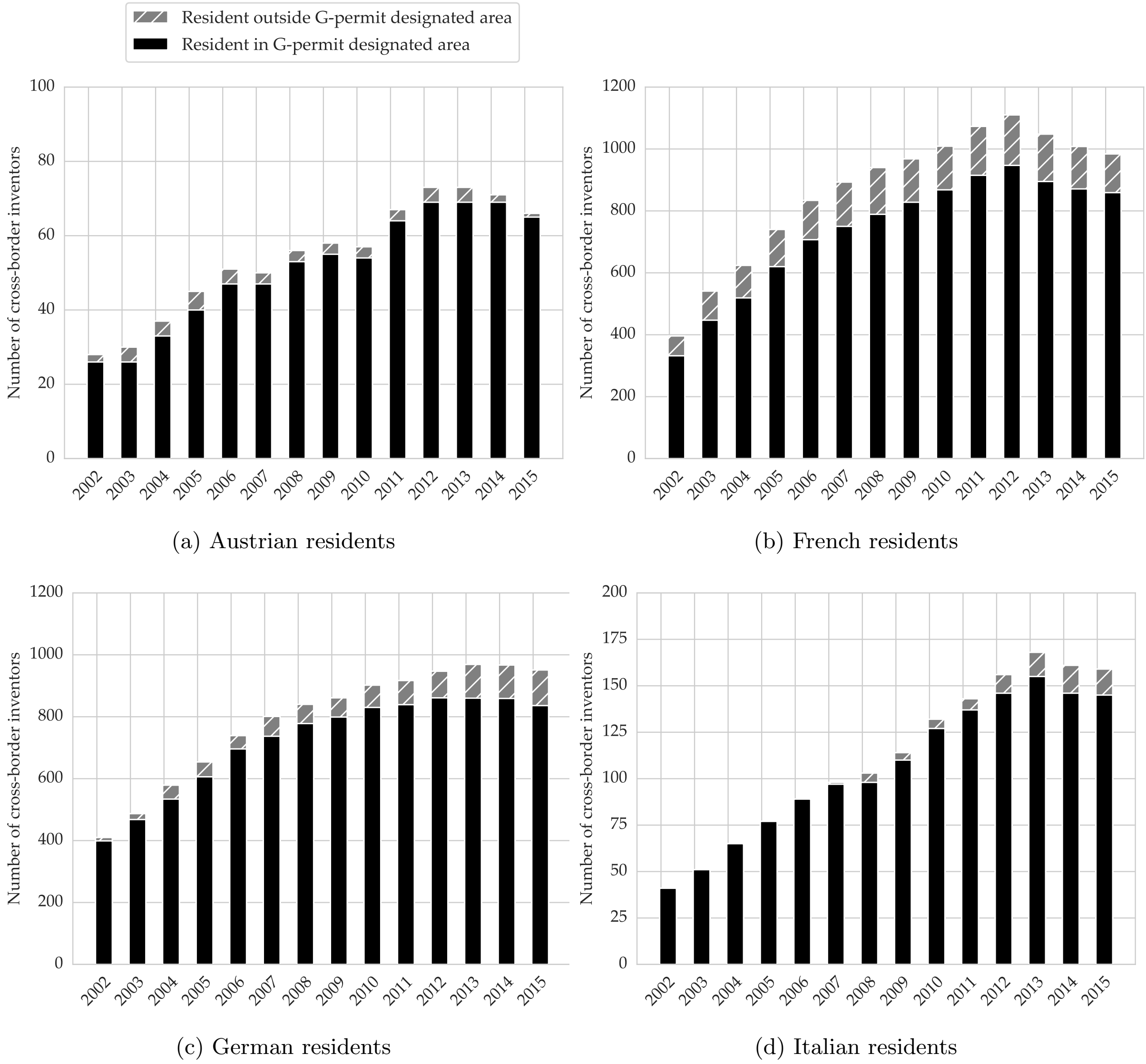
(c) Share, by region



(d) Number, by region

Notes: The table reports the number and share of patents reporting the inventors' work address instead of the residence one. Inventor-patent instances with the inventors' work address are identified as those containing `"c/o"` or the name of the applicant in the string of the inventor address. We observe a sharp increase after 2005. Notice that, in accordance with rule 19 of the Implementing Regulations of the Europe Patent Conventions, applicants must indicate the names and residence of the inventors, but the EPO does not verify the accuracy of the information (`https://www.epo.org/en/legal/epc/2020/r19.html`, last visit: August 2025). Informal conversations with EPO officers suggest that some applicants, especially large ones, increasingly try to save time by not looking for their inventors' addresses and using instead their own.

Figure C4: Cross-border inventors by region of residence (post-AFMP, ZEMIS definition)



(a) Austrian residents

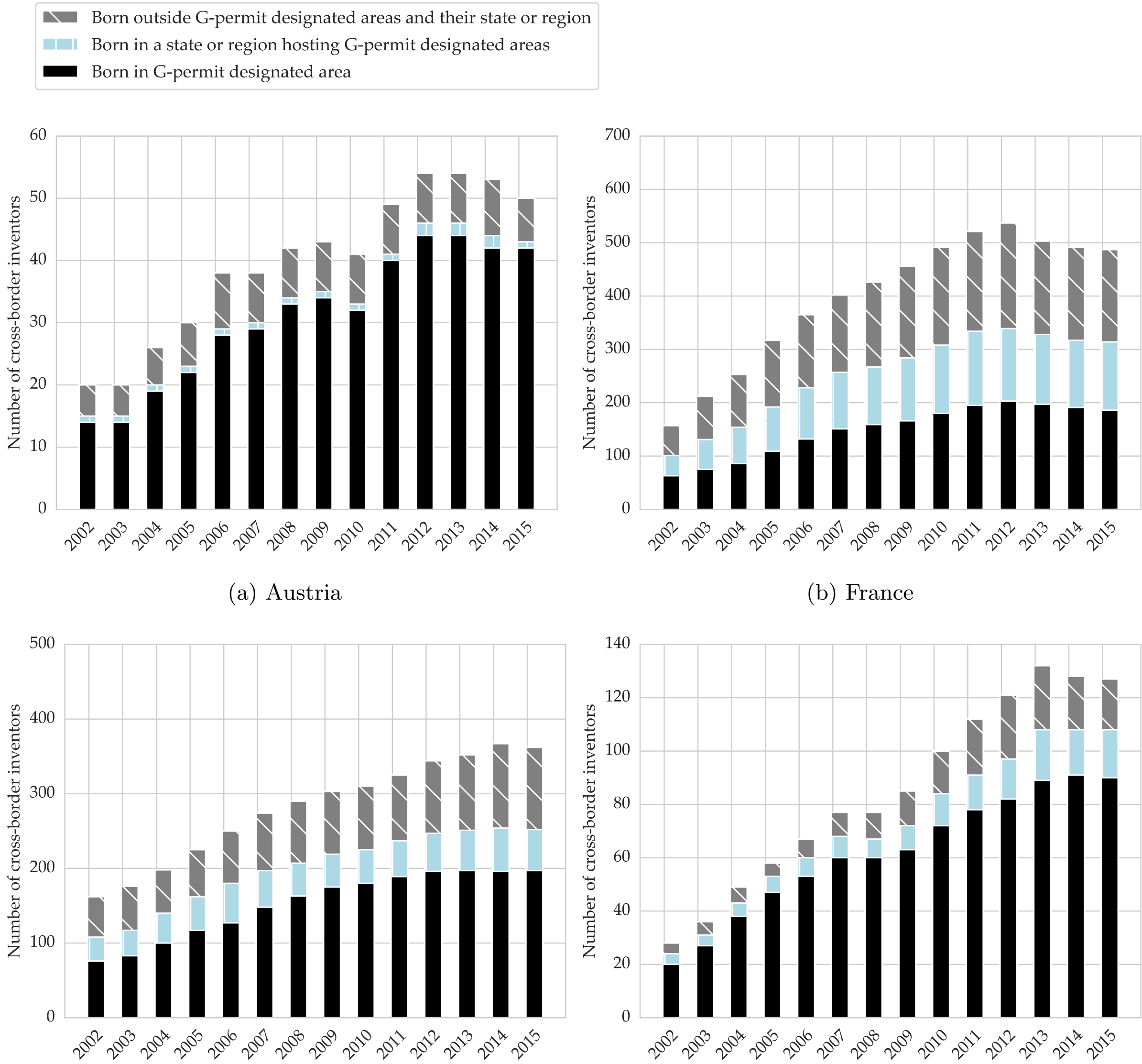
(b) French residents

(c) German residents

(d) Italian residents

Notes: The graphs show the evolution of Permit G holders employed in Switzerland and residing in Austria (a), France (b), Germany (c), and Italy (d), distinguishing between those resident in G-permit designated areas and those resident in regions farther away. The sample includes only Permit G holders hired in Switzerland for the first time in the post-AFMP period. Data from inventor-ZEMIS matched records.

Figure C5: Cross-border inventors by region of birth (post-AFMP, ZEMIS definition)



(a) Austria

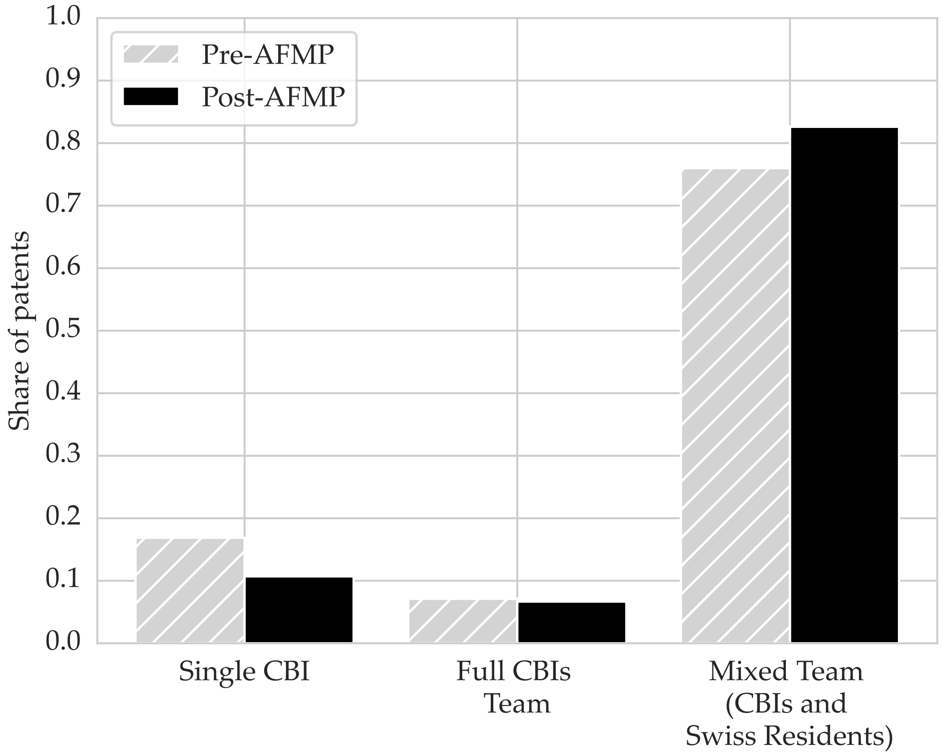
(b) France

(c) Germany

(d) Italy

Notes: The graphs show the evolution of Permit G holders employed in Switzerland and residing in Austria (a), France (b), Germany (c), and Italy (d), distinguishing between those born in G-permit designated areas, those born in the same state or region of G-permit designated areas, and those born in regions farther away. The sample includes only Permit G holders hired in Switzerland for the first time in the post-AFMP period and residing in a G-permit designated area. Data from inventor-ZEMIS matched records.

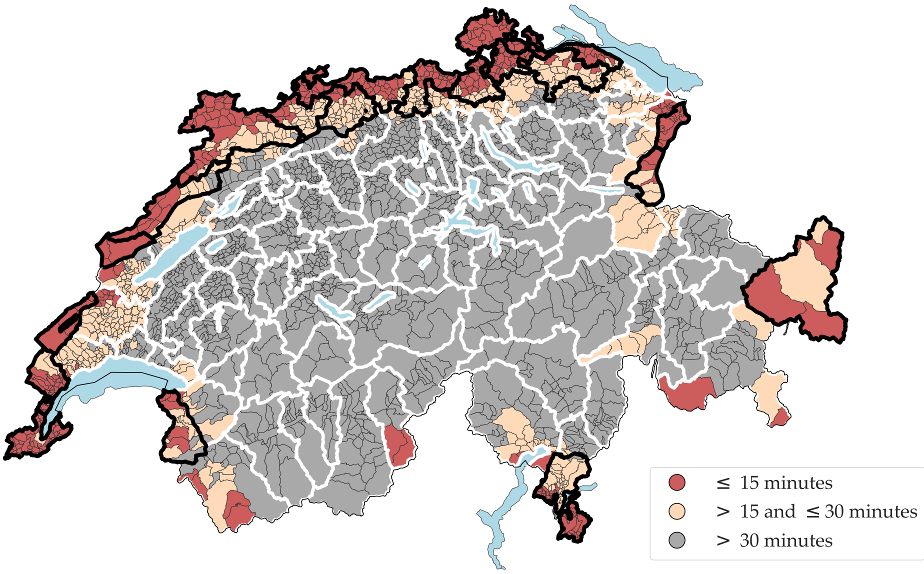
Figure C6: Cross-border inventors' patents by collaboration type



Notes: The graph show the share of cross-border inventors' patents according to the inventor team composition.

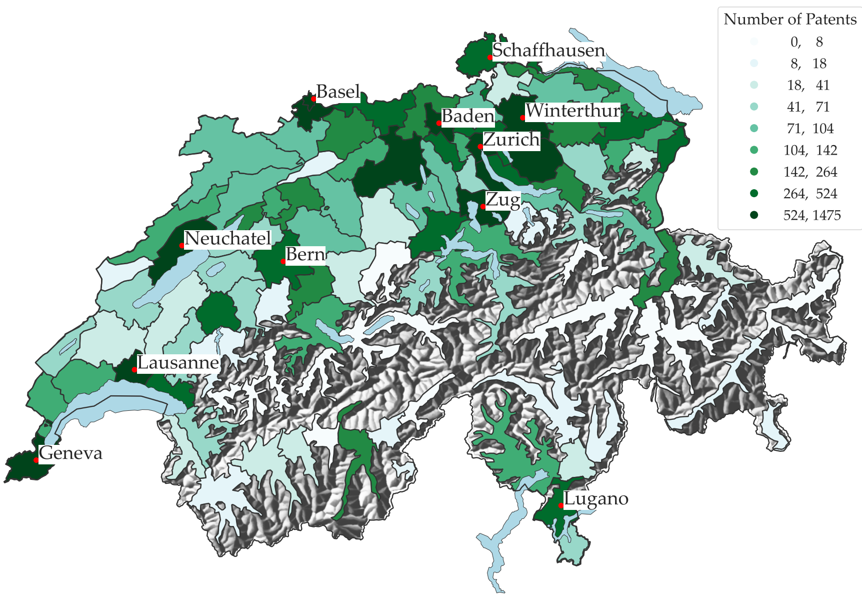
C.2. Spatial Mobility Regions and Technological fields

Figure C7: Treated spatial mobility regions (border regions) vs. municipalities by driving distance area



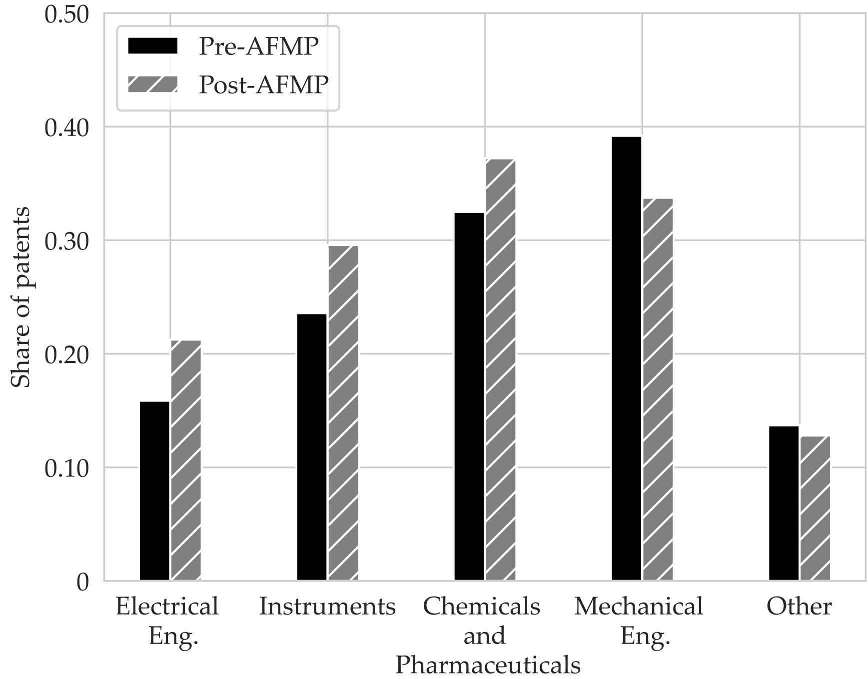
Notes: The map shows Swiss municipalities within 15 minutes and between 15-30 minutes of driving distance to the nearest border crossing. "Treated" spatial mobility regions within 20 minutes to the nearest border crossing, as measured by the average distance of their municipalities, are shown with black borders.

Figure C8: spatial mobility regions in Switzerland: Patent filings between 1990-1999



Notes: The map plots spatial mobility regions according to the number of patents filed between 1990-1999, before the AFMP was signed and introduced. regions are plotted in terms of their productive areas, as defined by the Swiss Federal Statistical Office.

Figure C9: Distribution of patents by main technology field, before and after the AFMP introduction



Notes: The plot shows the distribution of patents in our sample by Schmoch's (2008) five main technology fields, before and after the signing and introduction of the AFMP. Notice that a patent can be assigned to more than one technology field.

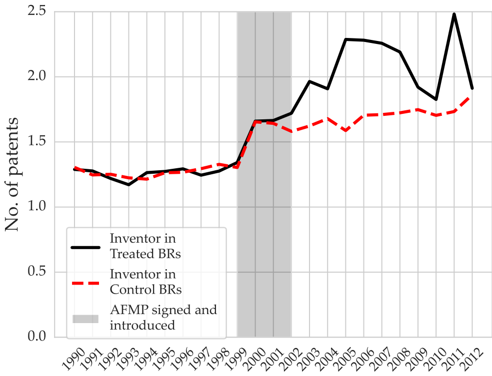
C.3. Inventor-level Analysis

Table C1: Incumbent inventors' outcomes: mean and standard deviation by area and period

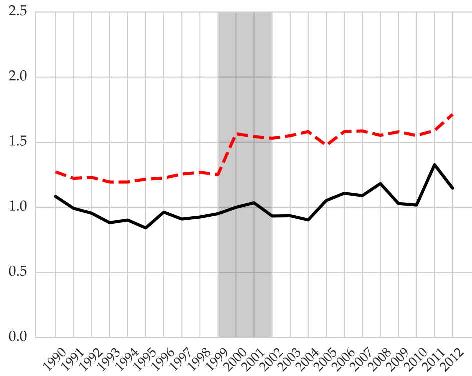
	Pre-AFMP (1990-1999)			**Post-AFMP (2000-2012)**		
	Treated	Control	Non-border regions	Treated	Control	Non-border regions
Patents	1.3	1.3	1.3	1.9	1.6	1.7
	(0.7)	(0.8)	(0.8)	(1.8)	(1.3)	(1.7)
Patents (excl. cross-border inventors)	0.9	1.2	1.2	1.0	1.5	1.7
	(0.7)	(0.8)	(0.8)	(1.2)	(1.2)	(1.7)
Co-inventors	1.7	1.5	1.2	3.4	2.2	2.0
	(2.0)	(1.7)	(1.4)	(3.8)	(2.3)	(2.3)
Co-inventors (excl. cross-border inventors)	0.8	1.4	1.2	1.1	1.9	1.8
	(1.3)	(1.6)	(1.4)	(1.9)	(2.1)	(2.2)
Citations to cross-border inventor-country	0.9	0.7	0.8	2.5	1.6	2.0
	(1.8)	(1.4)	(1.7)	(6.3)	(3.2)	(4.0)
Cit. to cross-border inventor-country (excl. cross-border inventors)	0.6	0.7	0.8	1.2	1.4	1.9
	(1.4)	(1.4)	(1.7)	(3.8)	(3.1)	(3.8)
Patents with novel terms	0.4	0.3	0.3	0.4	0.3	0.3
	(0.6)	(0.5)	(0.6)	(0.7)	(0.6)	(0.6)
Patents with IPC class	0.9	1.0	1.0	0.3	0.5	0.5
	(0.7)	(0.7)	(0.7)	(0.6)	(0.7)	(0.7)
Patents with IPC subclass	1.0	1.0	1.1	0.5	0.6	0.7
	(0.7)	(0.7)	(0.7)	(0.8)	(0.8)	(0.9)
Patents with IPC group	1.1	1.1	1.1	1.2	0.9	1.0
	(0.7)	(0.7)	(0.7)	(1.2)	(1.0)	(1.1)
Patents with IPC subgroup	1.2	1.2	1.2	1.6	1.3	1.3
	(0.7)	(0.7)	(0.7)	(1.6)	(1.1)	(1.3)

Notes: The table reports mean values for incumbent inventors' yearly innovation outcomes. Standard deviation values are reported in parentheses.

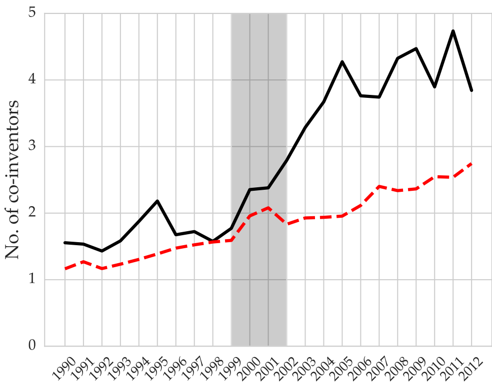
Figure C10: Incumbent inventors' average inventive outcomes



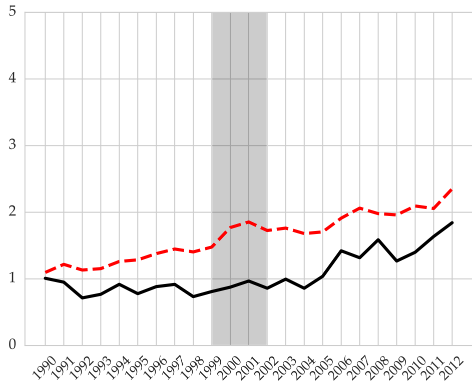
(a) Patents



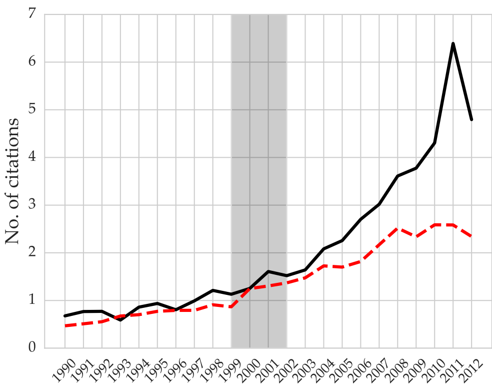
(b) Patents (excl. cross-border inventors)



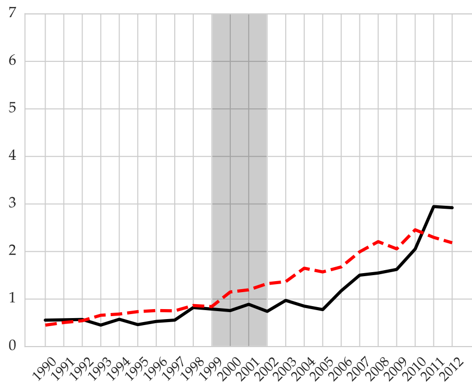
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



(e) Cites to cross-border inventor-country



(f) Cites to cross-border inventor-country (excl. cross-border inventors)

Notes: The figure shows incumbent inventors' average inventive outcomes between 1990-2012. Those located in treated regions (solid black line) and those located in control regions (dashed red line).

Table C2: Junior inventors' outcomes: mean and standard deviation by area and cohort

Cohort	**Treated (1999-2000)**			**Control (1990-1993)**		
Region	Treated	Control	Non-border regions	Treated	Control	Non-border regions
Patents	1.6	1.4	1.3	1.3	1.3	1.2
	(1.3)	(0.9)	(0.8)	(1.0)	(0.8)	(0.7)
Patents (excl. cross-border inventors)	0.9	1.3	1.2	0.9	1.2	1.2
	(0.9)	(0.9)	(0.7)	(0.8)	(0.7)	(0.6)
Co-inventors	2.4	1.9	1.5	1.8	1.4	1.1
	(3.1)	(2.0)	(1.5)	(2.3)	(1.6)	(1.4)
Co-inventors (excl. cross-border inventors)	0.8	1.7	1.4	0.8	1.3	1.1
	(1.3)	(1.9)	(1.5)	(1.3)	(1.5)	(1.4)
Citations to cross-border inventor-country	1.3	1.0	0.9	1.1	0.6	0.7
	(3.4)	(2.4)	(1.9)	(2.9)	(1.4)	(1.7)
Cit. to cross-border inventor-country (excl. cross-border inventors)	0.8	0.9	0.8	0.6	0.6	0.7
	(2.5)	(2.3)	(1.9)	(2.0)	(1.3)	(1.7)

Notes: The table reports mean values for junior inventors' yearly innovation outcomes. Standard deviation values are reported in parentheses.

C.4. R&D Location Analysis

Table C3: R&D location outcomes mean and standard deviation by area and period

	Pre-AFMP (1990-1999)			**Post-AFMP (2000-2012)**		
	Treated	Control	Non-border regions	Treated	Control	Non-border regions
Average team size	1.49	1.47	1.45	1.92	1.84	1.79
	(0.88)	(0.78)	(0.77)	(1.08)	(1.00)	(0.95)
Average team experience	1.73	1.64	1.62	3.57	2.74	3.29
	(4.24)	(4.07)	(6.05)	(5.72)	(4.53)	(6.07)
Active inventors	3.52	3.39	2.20	10.35	9.75	4.96
	(14.53)	(10.03)	(3.50)	(30.95)	(25.89)	(9.05)
Active cross-border inventors	0.73	0.13	0.03	2.98	0.50	0.06
	(3.93)	(1.12)	(0.23)	(10.63)	(2.24)	(0.36)

Notes: The table reports mean values for R&D labs' yearly outcomes. Standard deviation values are reported in parentheses.

D. Additional Estimations and Robustness Checks

D.1. Immigrant Patenting and Citations

Table D1: Inventors' full career productivity: Swiss vs. cross-border inventors

	Patents			Citation-weighted patents		
	(1)	(2)	(3)	(4)	(5)	(6)
$PermitG_i$	0.455***	0.454***	0.328***	0.572***	0.571***	0.636***
	(0.052)	(0.052)	(0.053)	(0.101)	(0.101)	(0.141)
Observations	39446	37739	37504	39446	37739	37504
Pseudo R^2	0.438	0.435	0.434	0.543	0.546	0.543
Controls	✓	✓	✓	✓	✓	✓
Excl. independent inventors		✓	✓		✓	✓
Excl. experienced cross-border inventors			✓			✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. Regression results from the specification: $E[y_i|X_i] = exp[\alpha + \beta PermitG_i + \delta X_i]$, where y_i is the number of total patents or citation-weighted filed by inventor i during their career. $PermitG_i$ is an indicator equal to 1 for cross-border inventors, that is, inventors who ever held a permit G to work in Switzerland, and equal to 0 for inventors with Swiss nationality. X_i is a vector of controls, including the inventors' average number of co-inventors, average applicant size, the number of applicants they have patented during their career, as well as technology field and first patent cohort fixed effects. Estimations by Poisson pseudo-maximum-likelihood.

Table D2: Citations to prior art from neighbouring countries

	Address-definition		**ZEMIS-definition**		
	Pre-AFMP	Post-AFMP	Post-AFMP	Post-AFMP	Post-AFMP
	(1)	(2)	(3)	(4)	(5)
Cross-border inventor	0.134**	0.110***	0.081***	0.098***	0.039
	(0.057)	(0.033)	(0.030)	(0.032)	(0.038)
Resident-Immigrant				0.033	
				(0.025)	
Observations	14031	34488	34395	34395	15141
Pseudo R^2	0.152	0.188	0.182	0.182	0.186
Year, Region, Applicant, Tech. field FE	✓	✓	✓	✓	✓
Baseline patents	Swiss residents	Swiss residents	Swiss residents	Swiss nationals	Resident immigrants

Notes: *** p<0.01, ** p<0.05, * p<0.1. Regressions based on a cross section of EPO patents filed in Switzerland. The dependent variable is patent *i*'s number of citations to prior art from Switzerland's neighbouring countries. Prior art consists of all the patent and non-patent literature concerning inventions produced worldwide before the focal patent's filing date. We focus on so-called front-page citations to prior patents as reported on the focal patent's legal documentation and do not consider in-text ones (for the difference between the two, see Bryan et al. 2020). Cross-border inventor is an indicator taking value 1 if patent *i* lists one or more cross-border inventors. Resident-immigrant is an indicator taking value 1 if patent *i* lists one or more immigrants but no cross-border inventors. Robust standard errors are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

Table D3: Citations to prior art from the U.S.

	Address-definition		**ZEMIS-definition**		
	Pre-AFMP	Post-AFMP	Post-AFMP	Post-AFMP	Post-AFMP
	(1)	(2)	(3)	(4)	(5)
Cross-border inventor	0.070	0.007	0.006	0.033	-0.071*
	(0.068)	(0.035)	(0.035)	(0.039)	(0.041)
Resident-Immigrant				0.056*	
				(0.033)	
Observations	14330	36118	34683	34683	15413
Pseudo R^2	0.270	0.342	0.304	0.304	0.273
Year, Region, Applicant, Tech. field FE	✓	✓	✓	✓	✓
Baseline patents	Swiss residents	Swiss residents	Swiss residents	Swiss nationals	Resident immigrants

Notes: *** p<0.01, ** p<0.05, * p<0.1. Regressions based on a cross section of EPO patents filed in Switzerland. The dependent variable is patent i's number of citations to prior art from the United States. Prior art consists of all the patent and non-patent literature concerning inventions produced worldwide before the focal patent's filing date. We focus on so-called front-page citations to prior patents as reported on the focal patent's legal documentation and do not consider in-text ones (for the difference between the two, see Bryan et al. 2020). Cross-border inventor is an indicator taking value 1 if patent i lists one or more cross-border inventors. Resident-immigrant is an indicator taking value 1 if patent i lists one or more immigrants but no cross-border inventors. Robust standard errors are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

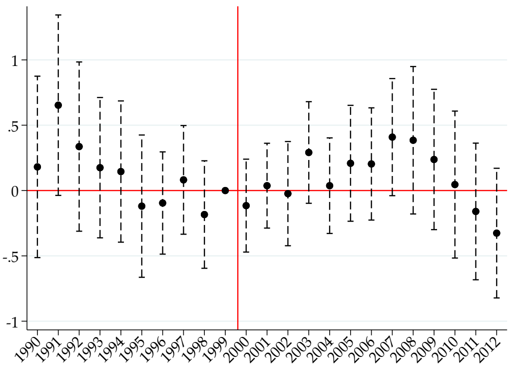
D.2. Regional Analysis: Patenting in Switzerland

Table D4: Regional patent count: difference-in-differences results

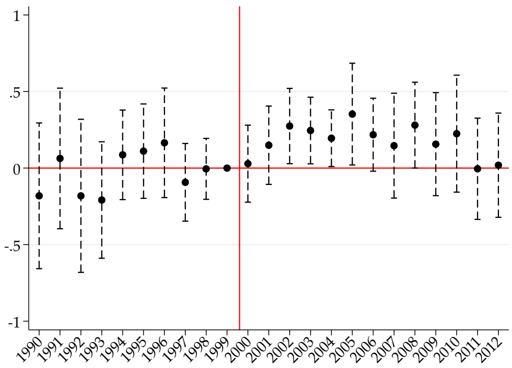
	Full sample		**Incumbents only**		**No top applicants**		**Cross-border inventor in team**		**Residents-only team**	
	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AFMP × Treated	0.118	0.200**	0.107	0.207	0.249**	0.286***	0.406***	0.520***	-0.031	0.028
	(0.100)	(0.090)	(0.134)	(0.130)	(0.113)	(0.106)	(0.119)	(0.093)	(0.109)	(0.099)
Observations	1449	1134	1403	1098	1449	1134	1426	1116	1449	1134
Pseudo R^2	0.878	0.876	0.855	0.855	0.842	0.837	0.882	0.881	0.863	0.855
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

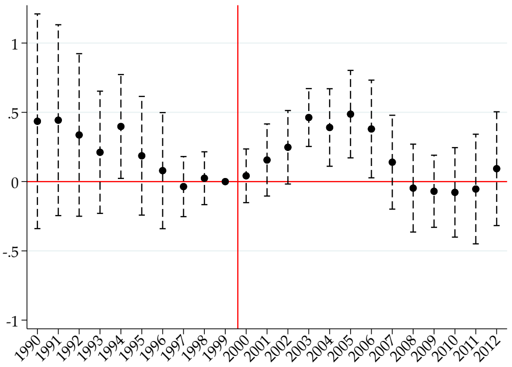
Figure D1: Regional patent count: event study results (by technology field)



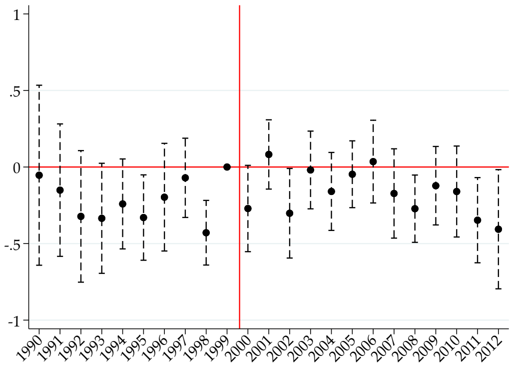
(a) Electrical engineering



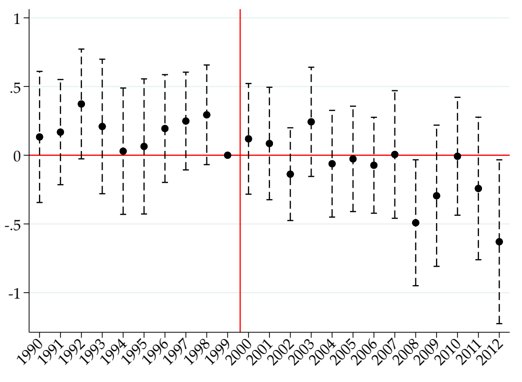
(b) Instruments



(c) Chemicals and pharmaceuticals



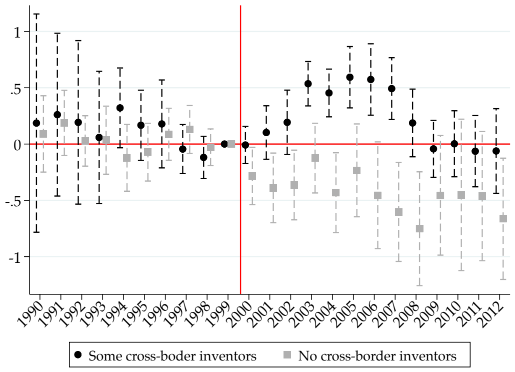
(d) Mechanical engineering



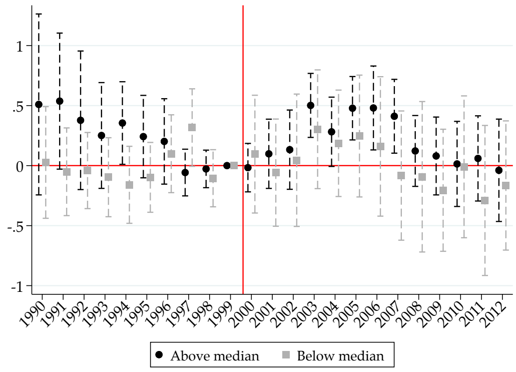
(e) Other

Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

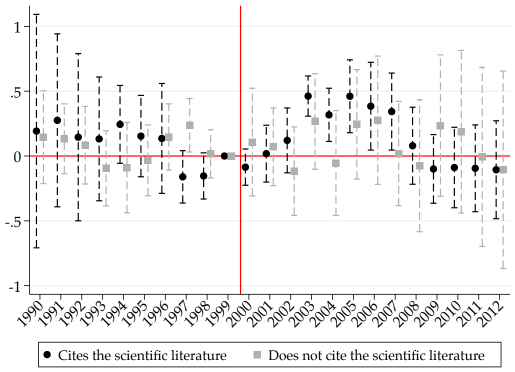
Figure D2: Regional patent count: event study results (by applicants' pre-AFMP characteristics)



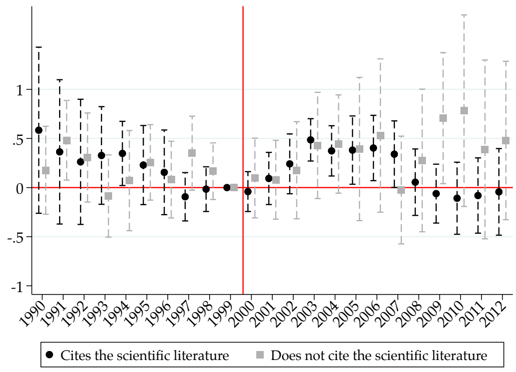
(a) Employing cross-border inventors



(b) Share of citations to foreign prior art



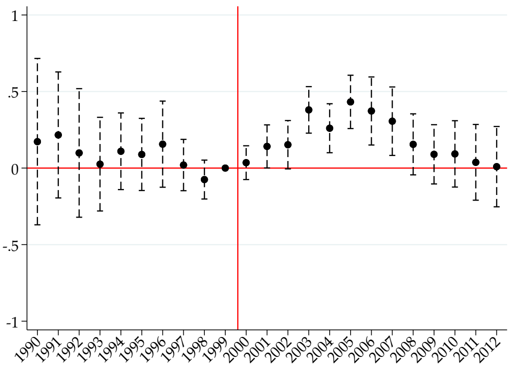
(c) Reliance on scientific literature



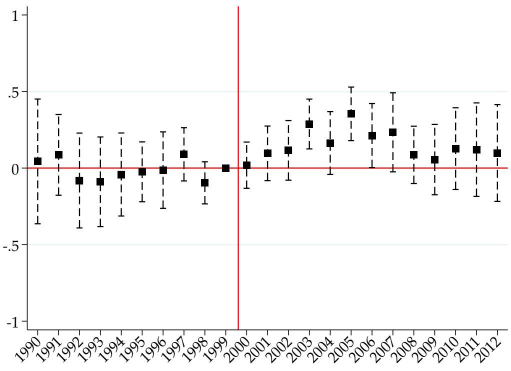
(d) Reliance on scientific literature
(only chemicals and pharmaceuticals)

Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. We count only patents from incumbent applicants, comparing the patenting output of different groups based on their pre-AFMP characteristics. In panel (a) we report regressions based on the patenting output of applicants which employed at least one cross-border inventor and compare it with that of applicants which did not employ any. In panel (b) we count only patents from applicants whose share of citations to foreign prior art was either above or below the median in the pre-AFMP (for the definition of prior art see Table D2 and Table D3). In panel (c) we count only patents from applicants which cited at least one scientific article in the text of their patents, versus those which did not cite any. In panel (d) we repeat the previous exercise, although focusing only on applicants active in the "instruments" or "chemicals and pharmaceuticals" technology fields. Information on patents' in-text citations to the scientific literature is from Verluise and de Rassenfosse (2020). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

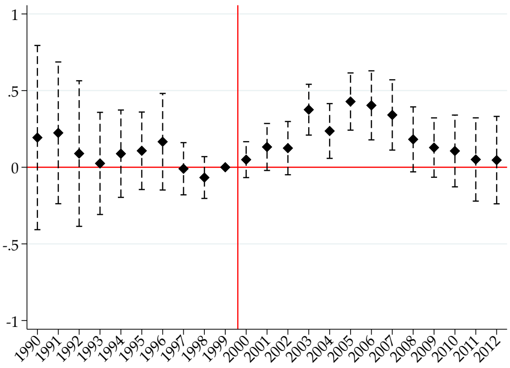
Figure D3: Regional patent count: event study results (excluding Basel and Geneva)



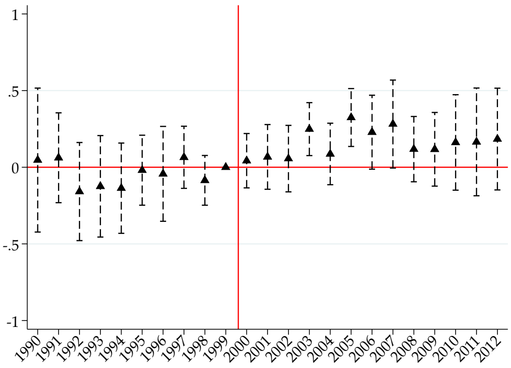
(a) Baseline



(b) Excluding Basel



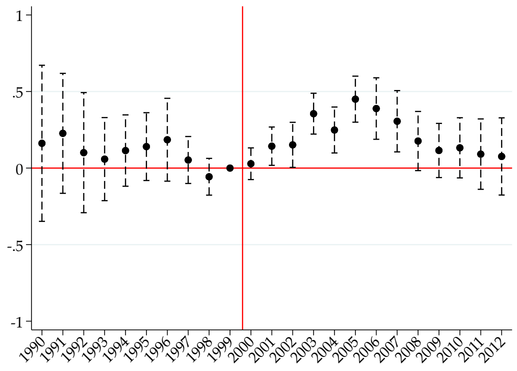
(c) Excluding Geneva



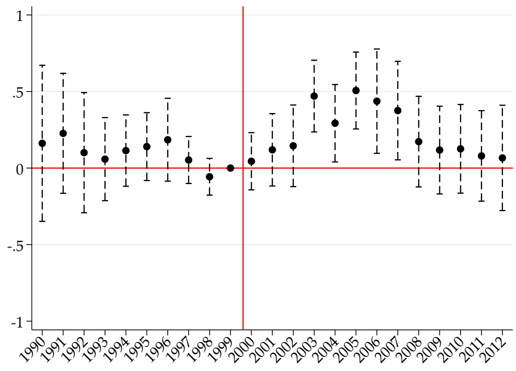
(d) Excluding Basel and Geneva

Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

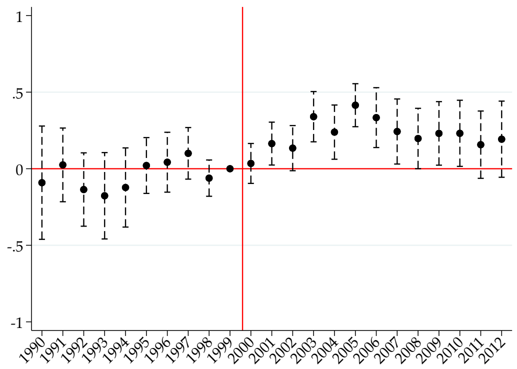
Figure D4: Regional patent count: event study results (including non-border region in the control group)



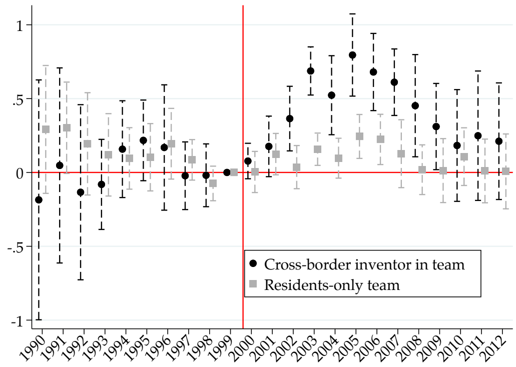
(a) Full sample



(b) Incumbent applicants only



(c) No top applicants



(d) Cross-border inventor in team
VS. Resident-only

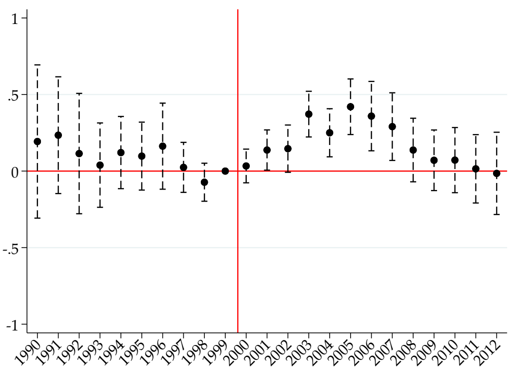
Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes and all the non-border regions. For the estimations in panel (a) we count all patents. For those in panel (b) we count only patents associated with "incumbent applicants;" for those in panel (c) we exclude patents associated with "top applicants". For the estimations in panel (d) we decompose each treated region's yearly patent output, distinguishing between patents including at least one cross-border inventor (*Cross-border inventor in team*) and patents including only resident inventors (*Resident-only team*) and running two separate event study regressions. The estimated parameters related to cross-border inventor-in-team patents are shown as black circles. Those related to Resident-only team patents are shown as gray squares. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D5: Regional patent count: difference-in-differences results (including non-border region in the control group)

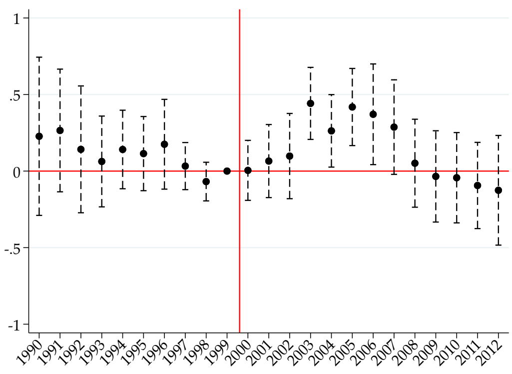
	Full sample		Incumbents only		No top applicants		Cross-border inventor in team		Residents-only team	
	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AFMP × Treated	0.119	0.182***	0.142	0.216*	0.261***	0.281***	0.407***	0.503***	-0.031	0.011
	(0.079)	(0.070)	(0.119)	(0.118)	(0.095)	(0.090)	(0.102)	(0.073)	(0.089)	(0.080)
Observations	2438	1908	2392	1872	2438	1908	2415	1890	2438	1908
Pseudo R^2	0.876	0.873	0.856	0.856	0.840	0.835	0.871	0.869	0.860	0.854
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes and all non-border regions. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

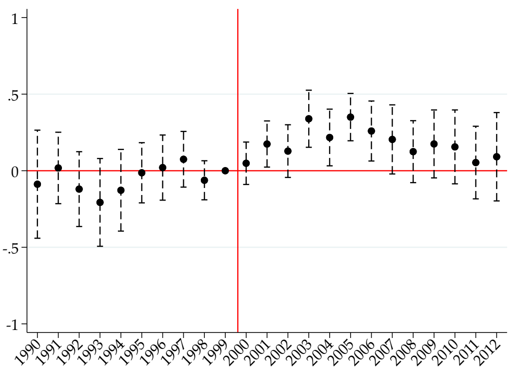
Figure D5: Regional patent count: event study results (including NUTS-2-specific time trends)



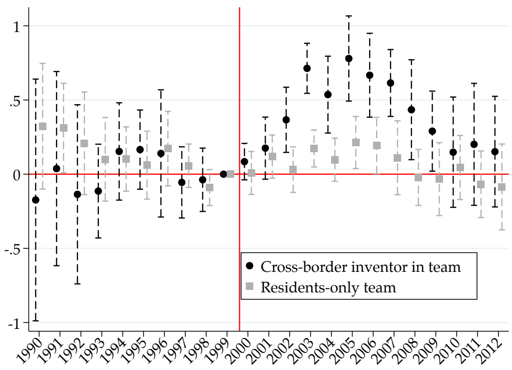
(a) Full sample



(b) Incumbent applicants only



(c) No top applicants



(d) Cross-border inventor in team
VS. Resident-only

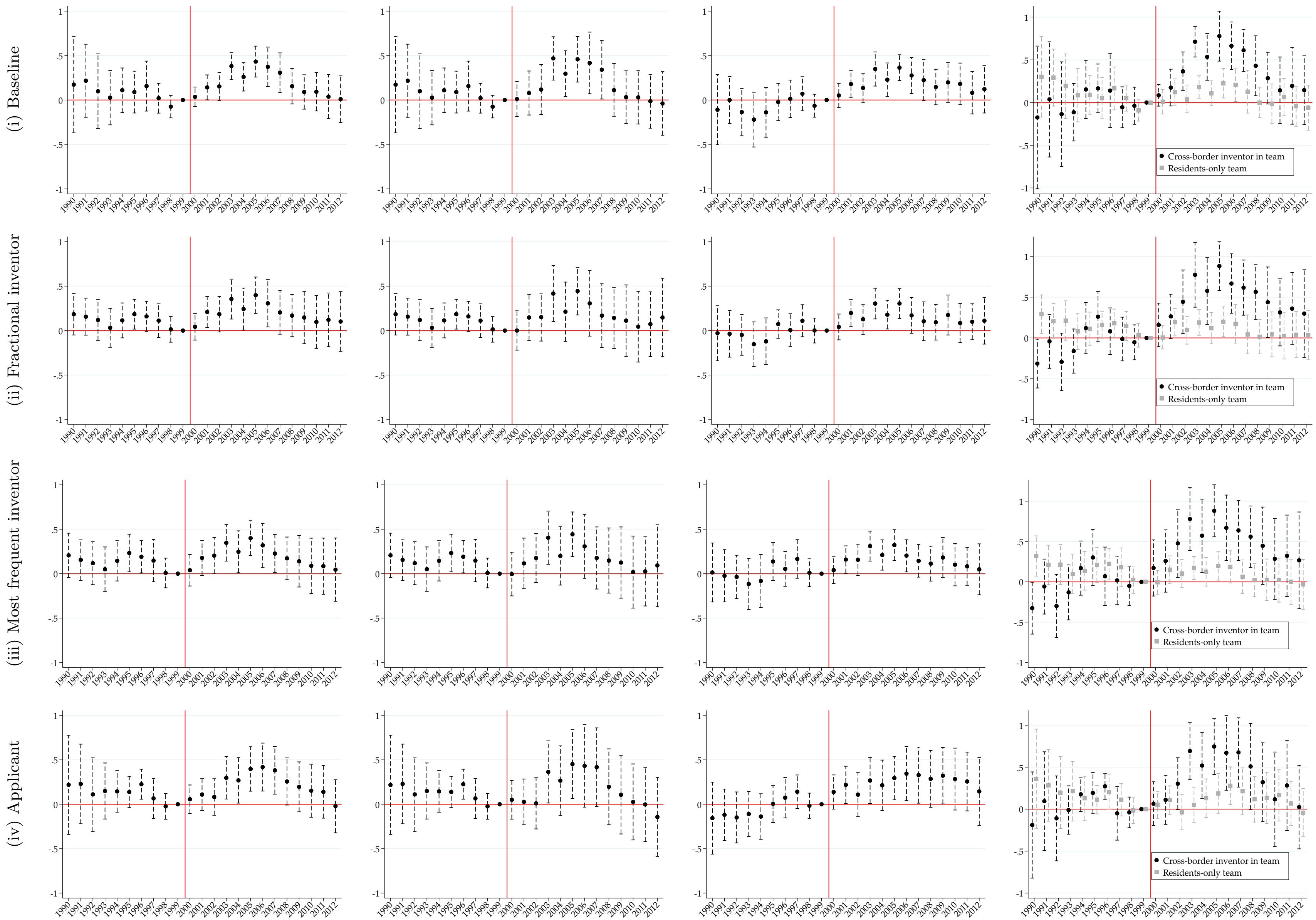
Notes: The dependent variable is the number of patents filed in spatial mobility region m in year t. The treated group includes all the spatial mobility border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes all the spatial mobility border regions whose driving distance from the closest border crossing is above 20 minutes. For the estimations in panel (a) we count all patents. For those in panel (b) we count only patents associated with "incumbent applicants;" for those in panel (c) we exclude patents associated with "top applicants". For the estimations in panel (d) we decompose each treated region's yearly patent output, distinguishing between patents including at least one cross-border inventor (*Cross-border inventor in team*) and patents including only resident inventors (*Resident-only team*) and running two separate event study regressions. The estimated parameters related to cross-border inventor-in-team patents are shown as black circles. Those related to Resident-only team patents are shown as gray squares. All regressions include region fixed effects, year fixed effects, and NUTS-2-specific time trends. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D6: Regional patent count: difference-in-differences results (including NUTS-2-specific time trends)

	Full sample		Incumbents only		No top applicants		Cross-border inventor in team		Residents-only team	
	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AFMP × Treated	0.111*	0.205***	0.057	0.177*	0.226**	0.270***	0.418***	0.539***	-0.044	0.042
	(0.066)	(0.053)	(0.120)	(0.103)	(0.092)	(0.084)	(0.073)	(0.061)	(0.080)	(0.064)
Observations	1449	1134	1403	1098	1449	1134	1426	1116	1449	1134
Pseudo R^2	0.880	0.876	0.860	0.857	0.843	0.837	0.884	0.881	0.864	0.856
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is the number of patents filed in region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region fixed effects, year fixed effects, and NUTS-2-specific time trends. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

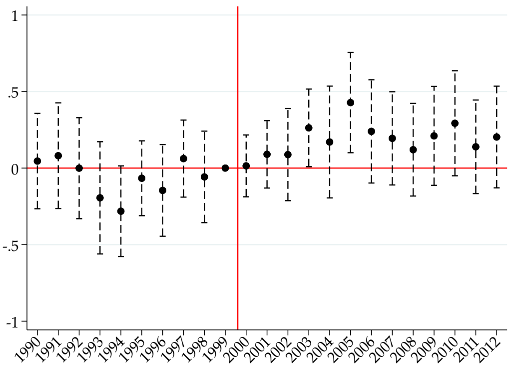
Figure D6: Regional patent count: event study results (alternative patent location assignment)



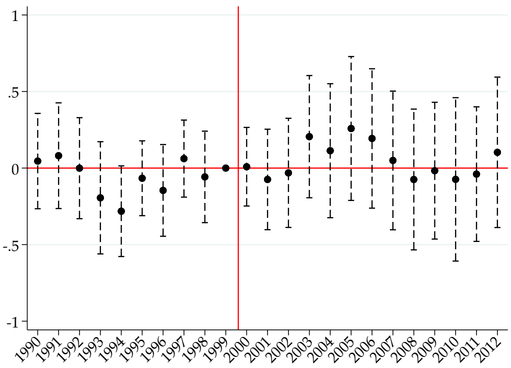
(a) Full sample | (b) Incumbent applicants only | (c) No top applicants | (d) Cross-border inventors in team vs. Resident-only

Notes: Row (i) shows our baseline estimates (Figure 6 in the paper). Estimates in row (ii) are based on a sample where we assign each patent to the inventors' spatial mobility regions via fractional counting. In row (iii), we assign each patent to the region where most of its inventors reside. In row (iv), we assign each patent to its applicant's region. All regressions include region and year fixed effects. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

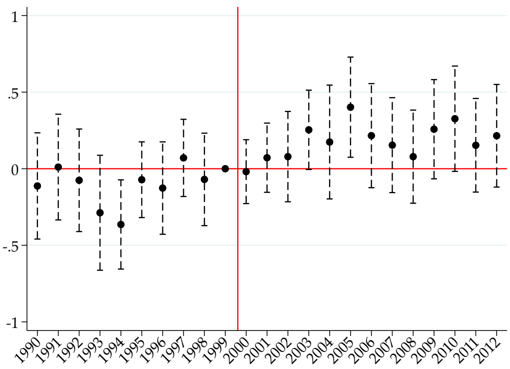
Figure D7: Regional patent count: event study results (OLS)



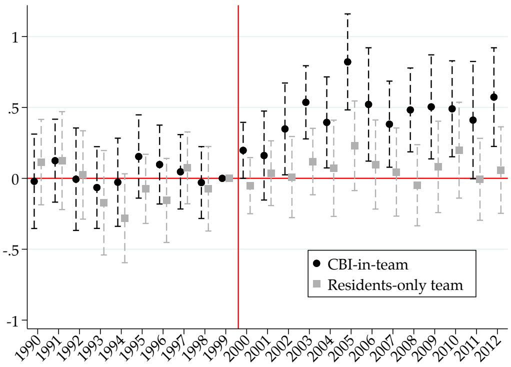
(a) Full sample



(b) Incumbent applicants only



(c) No top applicants



(d) Cross-border inventor in team
VS. Resident-only

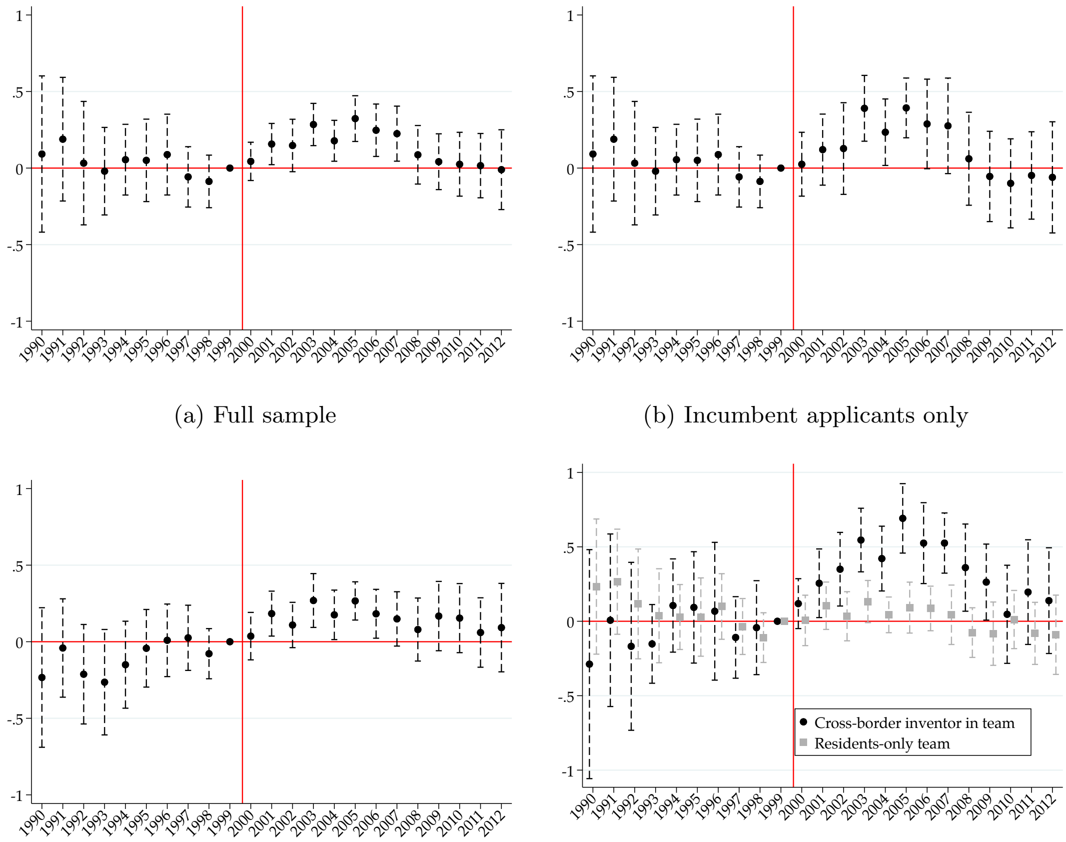
Notes: The dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. For the estimations in panel (a) we count all patents. For those in panel (b) we count only patents associated with "incumbent applicants;" for those in panel (c) we exclude patents associated with "top applicants". For the estimations in panel (d) we decompose each treated region's yearly patent output, distinguishing between patents including at least one cross-border inventor (*Cross-border inventor-in-team*) and patents including only resident inventors (*Resident-only team*) and running two separate event study regressions. The estimated parameters related to cross-border inventor-in-team patents are shown as black circles. Those related to Resident-only team patents are shown as gray squares. All regressions include region fixed effects, year fixed effects, and NUTS-2-specific time trends. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Ordinary Least Squares.

Table D7: Regional patent count: difference-in-differences results (OLS)

	Full sample		**Incumbents only**		**No top applicants**		**Cross-border inventor in team**		**Residents-only team**	
	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AFMP × Treated	0.244***	0.242***	0.104	0.146	0.284***	0.269***	0.421***	0.393***	0.106	0.111
	(0.073)	(0.073)	(0.143)	(0.136)	(0.077)	(0.079)	(0.099)	(0.091)	(0.070)	(0.073)
Observations	1449	1134	1449	1134	1449	1134	1449	1134	1449	1134
R^2	0.930	0.929	0.915	0.917	0.918	0.915	0.927	0.930	0.925	0.923
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the logarithmic transformation ($log(1+patents)$) of the number of patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Ordinary Least Squares.

Figure D8: Regional patent count: event study results (only granted patents)



(a) Full sample

(b) Incumbent applicants only

(c) No top applicants

(d) Cross-border inventor-in-team
VS. Resident-only

Notes: The dependent variable is the number of *granted* patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. For the estimations in panel (a) we count all patents. For those in panel (b) we count only patents associated with "incumbent applicants;" for those in panel (c) we exclude patents associated with "top applicants". For the estimations in panel (d) we decompose each treated region's yearly patent output, distinguishing between patents including at least one cross-border inventor (*Cross-border inventor in team*) and patents including only resident inventors (*Resident-only team*) and running two separate event study regressions. The estimated parameters related to cross-border inventor-in-team patents are shown as black circles. Those related to Resident-only team patents are shown as gray squares. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

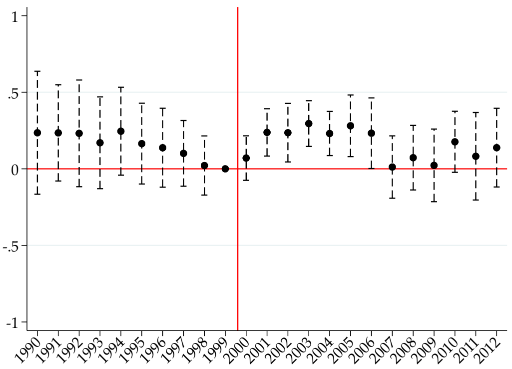
Table D8: Regional patent count: difference-in-differences results (only granted patents)

	Full sample		**Incumbents only**		**No top applicants**		**Cross-border inventor in team**		**Residents-only team**	
	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007	Baseline	Until 2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AFMP × Treated	0.106	0.176**	0.101	0.205*	0.238**	0.264**	0.392***	0.488***	-0.047	0.006
	(0.095)	(0.085)	(0.123)	(0.114)	(0.120)	(0.113)	(0.115)	(0.096)	(0.102)	(0.096)
Observations	1426	1116	1403	1098	1426	1116	1403	1098	1426	1116
Pseudo R^2	0.854	0.853	0.836	0.837	0.817	0.814	0.860	0.859	0.835	0.829
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

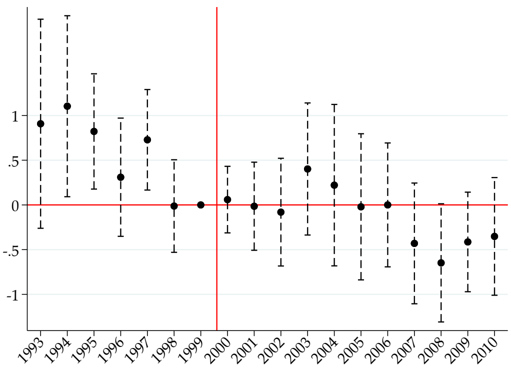
Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of *granted* patents filed in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

D.3. Regional Analysis: Displacement Effects

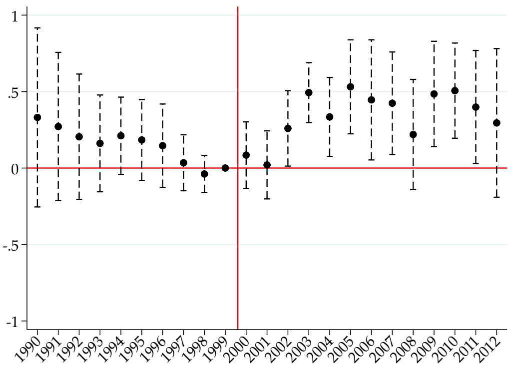
Figure D9: Active Swiss inventors: event study results (entrant and incumbent inventors)



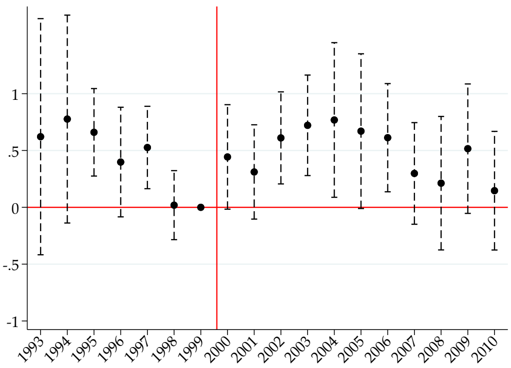
(a) Entrant Swiss residents



(b) Entrant Swiss nationals (subsample)



(c) Incumbent Swiss residents



(d) Incumbent Swiss nationals (subsample)

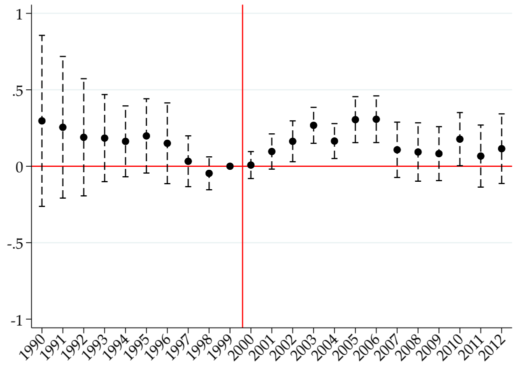
Notes: In panels (a) and (c) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b) and (d) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D9: Active Swiss inventors: difference-in-differences results

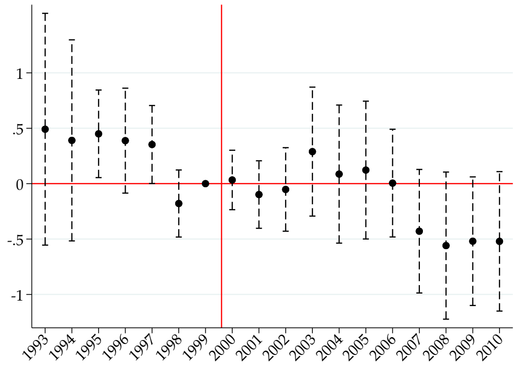
	Swiss residents (1)	Swiss nationals (2)	Entrant Swiss residents (3)	Entrant Swiss nationals (4)	Incumbent Swiss residents (5)	Incumbent Swiss nationals (6)
AFMP × Treated	0.007	-0.528**	0.017	-0.688***	0.167	0.109
	(0.112)	(0.214)	(0.103)	(0.199)	(0.115)	(0.141)
Observations	1449	1044	1449	1044	1403	954
Pseudo R^2	0.905	0.771	0.864	0.617	0.870	0.710
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of inventors resident in Switzerland or with Swiss nationality (EPO-PCT subsample) active in spatial mobility region m in year t. The treated group includes all the spatial mobility border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includesall the spatial mobility border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

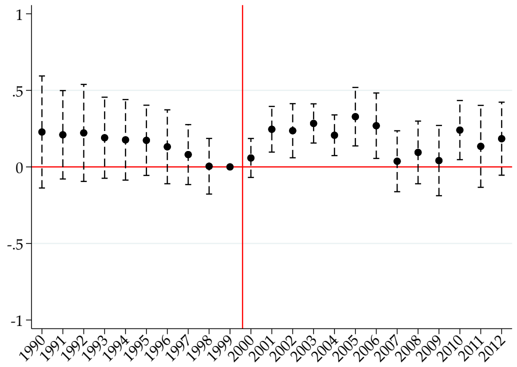
Figure D10: Active Swiss inventors: event study results (including non-border region in the control group)



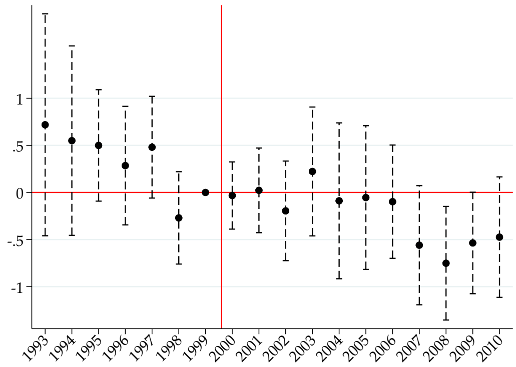
(a) Swiss residents



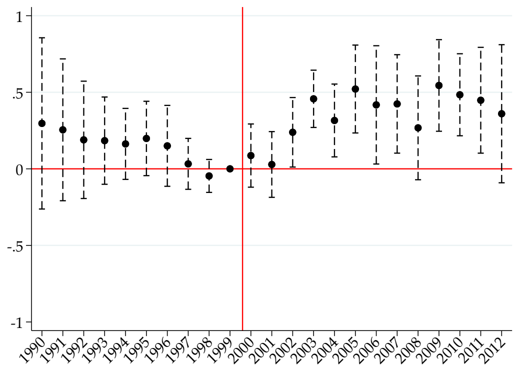
(b) Swiss nationals (subsample)



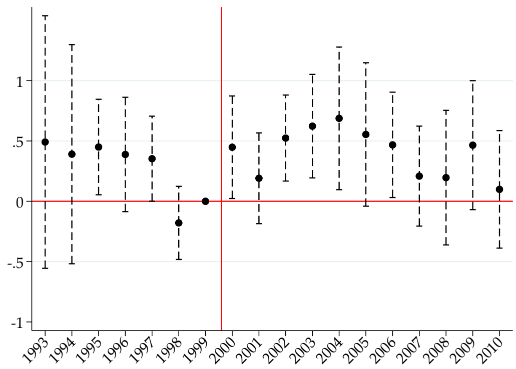
(c) Entrant Swiss residents



(d) Entrant Swiss nationals (subsample)



(e) Incumbent Swiss residents



(f) Incumbent Swiss nationals (subsample)

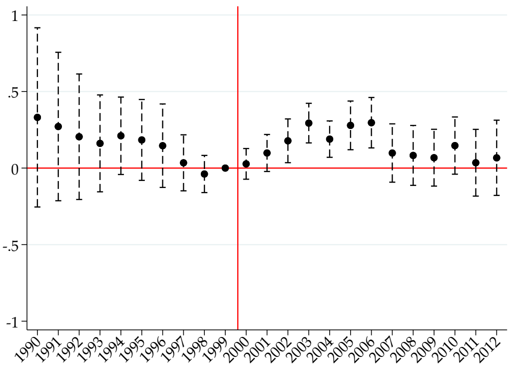
Notes: In panels (a), (c), and (e) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes all the spatial mobility border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes all the spatial mobility border regions whose driving distance from the closest border crossing is above 20 minutes and non-border regions. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimation by Poisson pseudo-maximum-likelihood.

Table D10: Active Swiss inventors: difference-in-differences results (including non-border region in the control group)

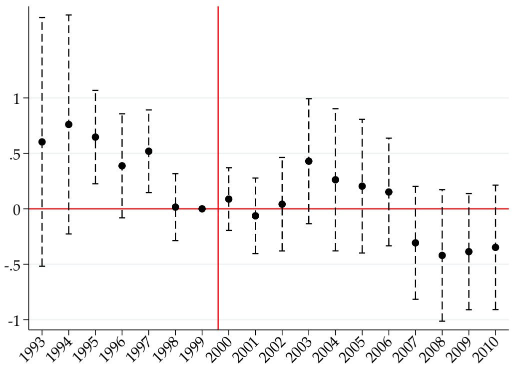
	Swiss residents (1)	Swiss nationals (2)	Entrant Swiss residents (3)	Entrant Swiss nationals (4)	Incumbent Swiss residents (5)	Incumbent Swiss nationals (6)
AFMP × Treated	0.024	-0.487**	0.053	-0.607***	0.174	0.162
	(0.092)	(0.200)	(0.087)	(0.182)	(0.108)	(0.127)
Observations	2438	1746	2438	1746	2392	1512
Pseudo R^2	0.900	0.754	0.854	0.601	0.866	0.681
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of inventors resident in Switzerland or with Swiss nationality (EPO-PCT subsample) active in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes and all non-border regions. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

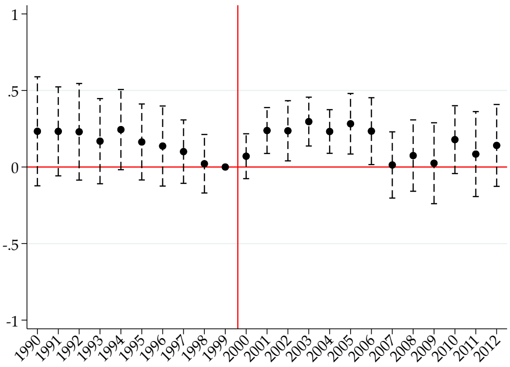
Figure D11: Active Swiss inventors: event study results (including NUTS-2-specific time trends)



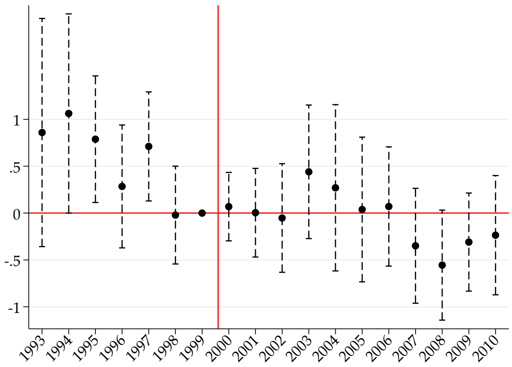
(a) Swiss residents



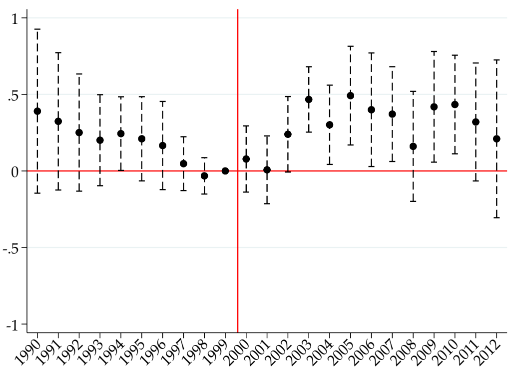
(b) Swiss nationals (subsample)



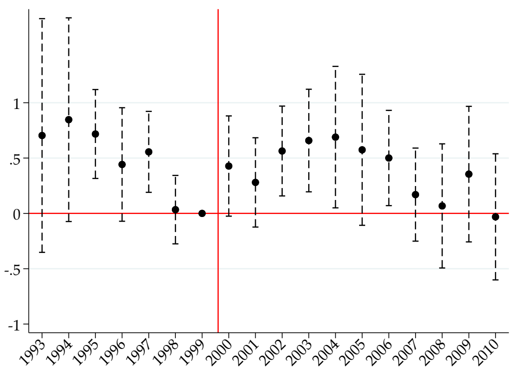
(c) Entrant Swiss residents



(d) Entrant Swiss nationals (subsample)



(e) Incumbent Swiss residents



(f) Incumbent Swiss nationals (subsample)

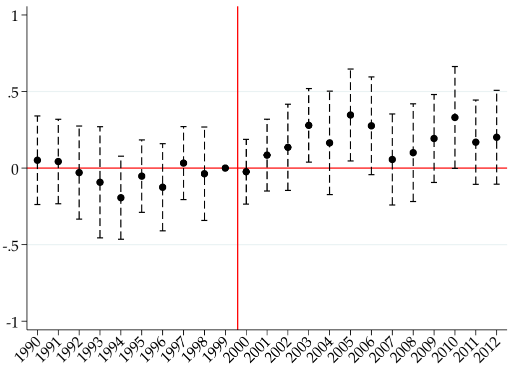
Notes: In panels (a), (c), and (e) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region fixed effects, year fixed effects, and NUTS-2-specific time trends. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D11: Active Swiss inventors: difference-in-differences results (including NUTS-2-specific time trends)

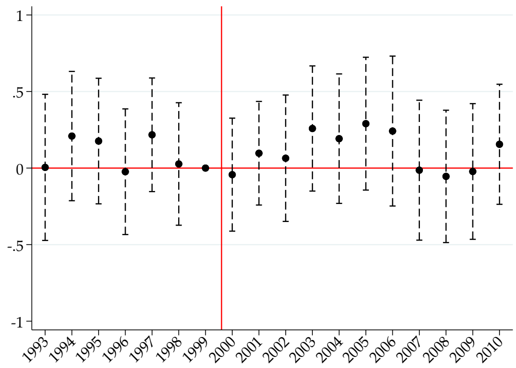
	Swiss residents (1)	Swiss nationals (2)	Entrant Swiss residents (3)	Entrant Swiss nationals (4)	Incumbent Swiss residents (5)	Incumbent Swiss nationals (6)
AFMP × Treated	0.172**	0.179	0.186***	0.035	0.280*	0.544**
	(0.067)	(0.149)	(0.066)	(0.186)	(0.169)	(0.231)
Observations	1449	1044	1449	1044	1403	954
Pseudo R^2	0.920	0.798	0.877	0.647	0.880	0.730
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of inventors resident in Switzerland or with Swiss nationality (EPO-PCT subsample) active in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region fixed effects, year fixed effects, and NUTS-2-specific time trends. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

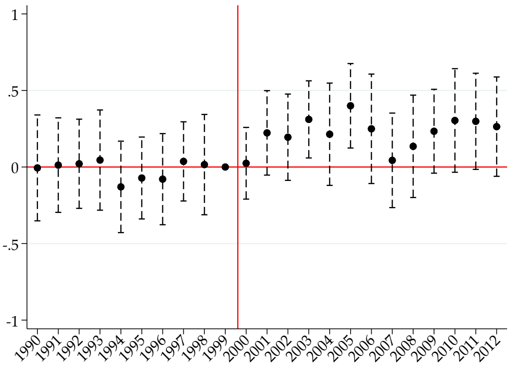
Figure D12: Active Swiss inventors: event study results (OLS)



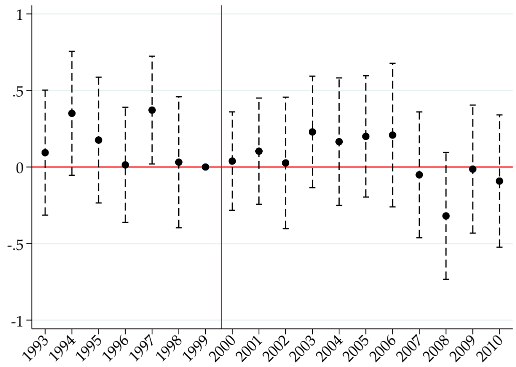
(a) Swiss residents



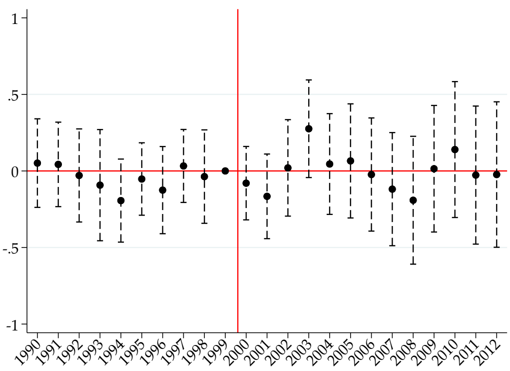
(b) Swiss nationals (subsample)



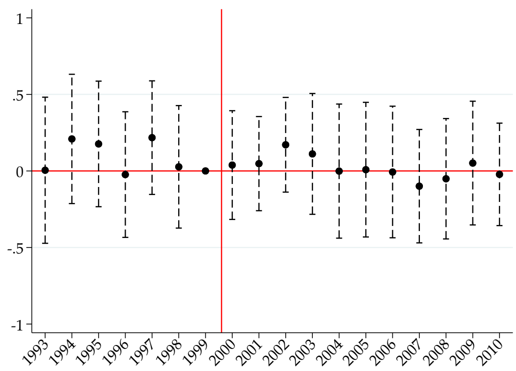
(c) Entrant Swiss residents



(d) Entrant Swiss nationals (subsample)



(e) Incumbent Swiss residents



(f) Incumbent Swiss nationals (subsample)

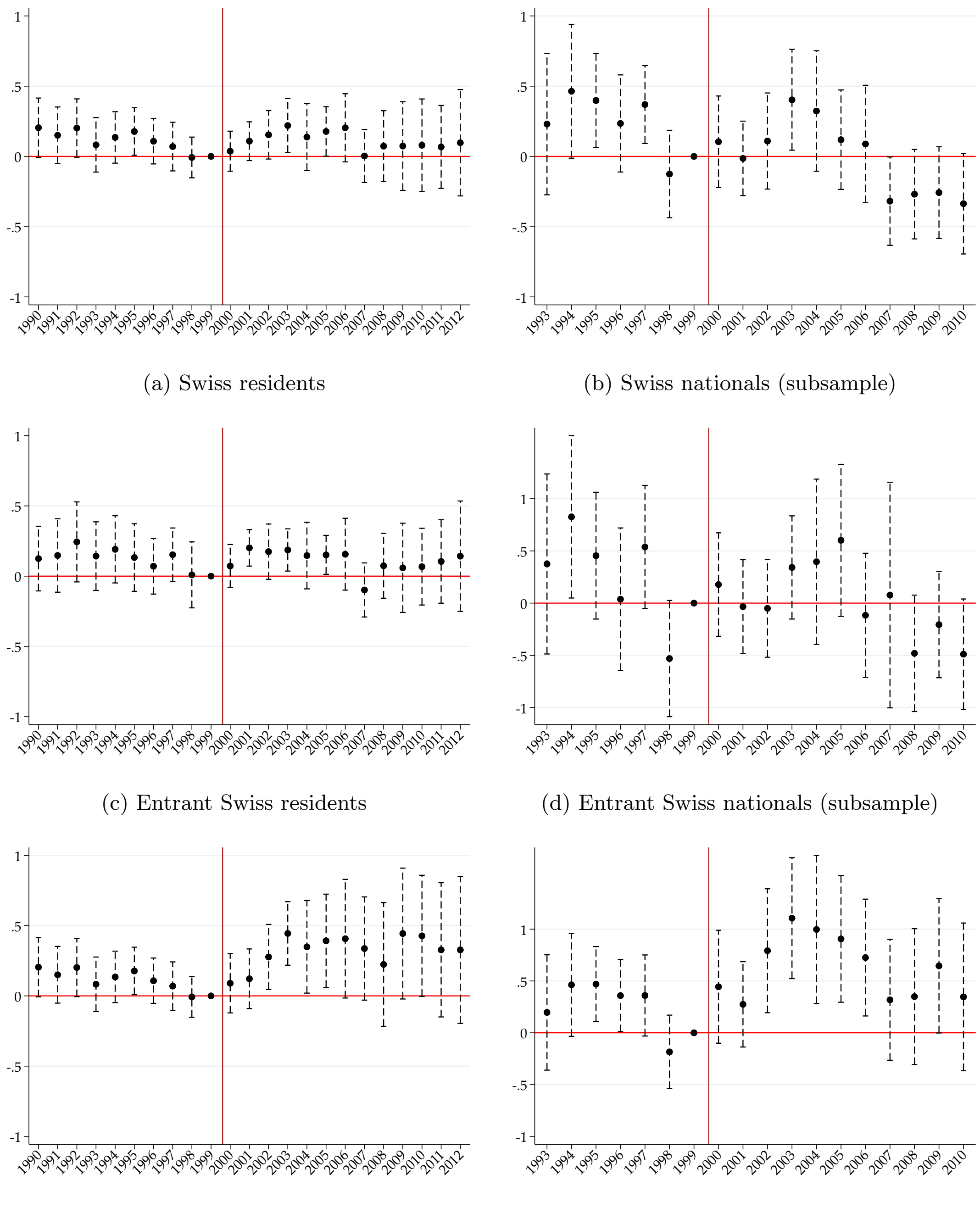
Notes: In panels (a), (c), and (e) the dependent variable is the logarithmic transformation ($log(1 + inventors)$) of the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D12: Active Swiss inventors: difference-in-differences results (OLS)

	Swiss residents (1)	Swiss nationals (2)	Entrant Swiss residents (3)	Entrant Swiss nationals (4)	Incumbent Swiss residents (5)	Incumbent Swiss nationals (6)
AFMP × Treated	0.218***	0.019	0.238***	-0.103	0.035	-0.065
	(0.080)	(0.114)	(0.086)	(0.098)	(0.116)	(0.094)
Observations	1449	1134	1449	1134	1449	1134
R^2	0.932	0.803	0.906	0.699	0.904	0.774
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the logarithmic transformation ($log(1 + inventors)$) of the number of inventors resident in Switzerland or with Swiss nationality (EPO-PCT subsample) active in spatial mobility region m in year t. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Ordinary Least Squares.

Figure D13: Active Swiss inventors: event study results (alternative location assignment: inventor residential address)



(a) Swiss residents

(b) Swiss nationals (subsample)

(c) Entrant Swiss residents

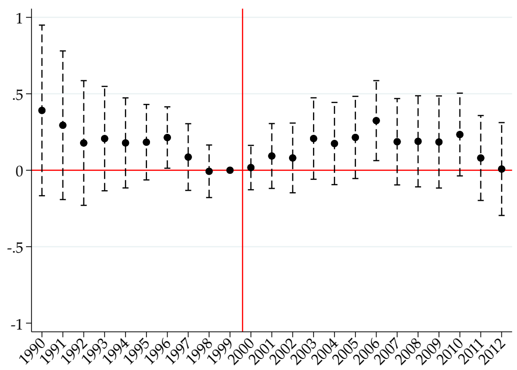
(d) Entrant Swiss nationals (subsample)

(e) Incumbent Swiss residents

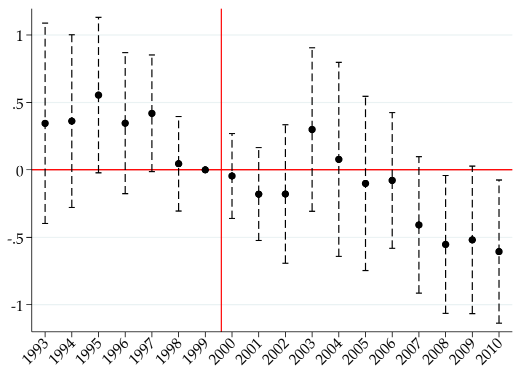
(f) Incumbent Swiss nationals (subsample)

Notes: Inventors are assigned to their spatial mobility region of residence instead of the spatial mobility region associated with their R&D location. In panels (a), (c), and (e) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region fixed effects and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimation by Poisson pseudo-maximum-likelihood.

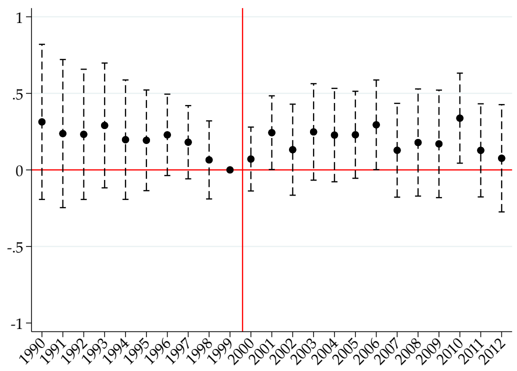
Figure D14: Active Swiss inventors: event study results (alternative location assignment: applicant location)



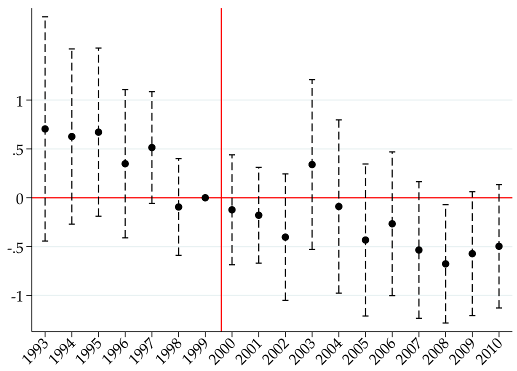
(a) Swiss residents



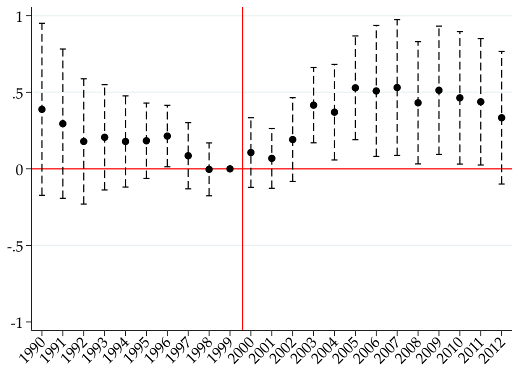
(b) Swiss nationals (subsample)



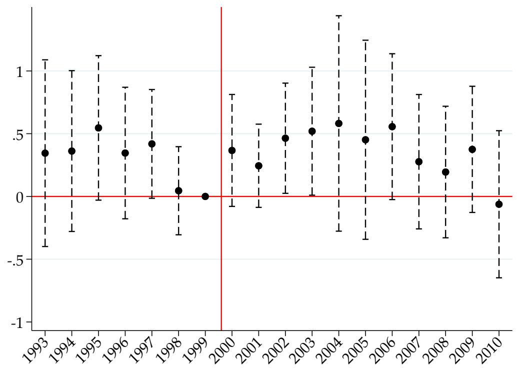
(c) Entrant Swiss residents



(d) Entrant Swiss nationals (subsample)



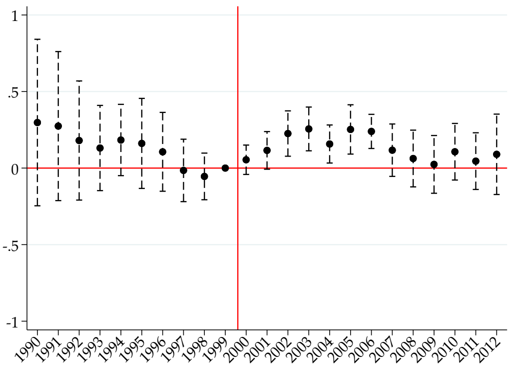
(e) Incumbent Swiss residents



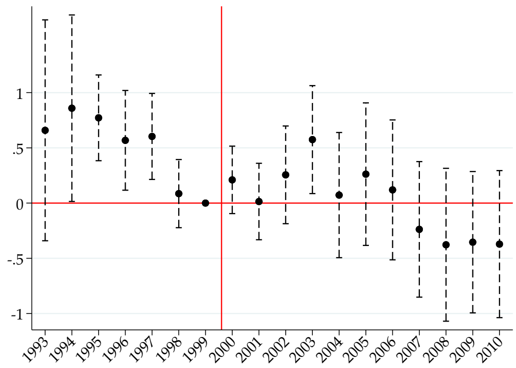
(f) Incumbent Swiss nationals (subsample)

Notes: Inventors are assigned to the spatial mobility region of their applicant instead of the spatial mobility region associated with their R&D location. In panels (a), (c), and (e) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include region fixed effects and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimation by Poisson pseudo-maximum-likelihood.

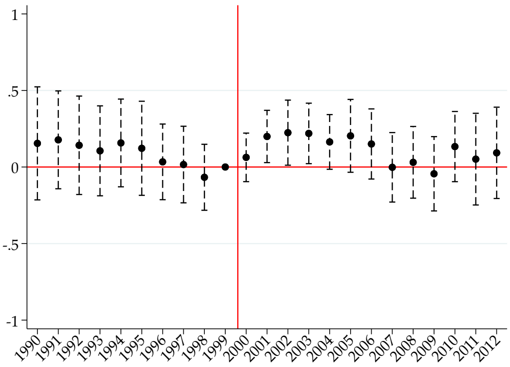
Figure D15: Active Swiss inventors: event study results (only granted patents)



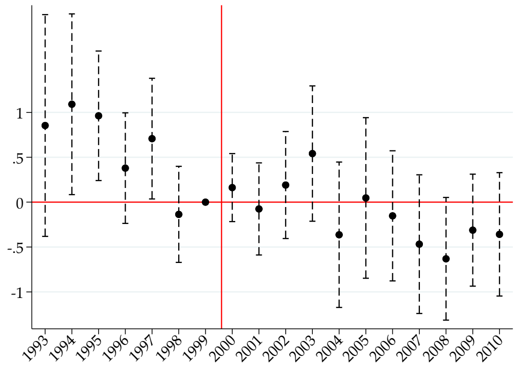
(a) Swiss residents



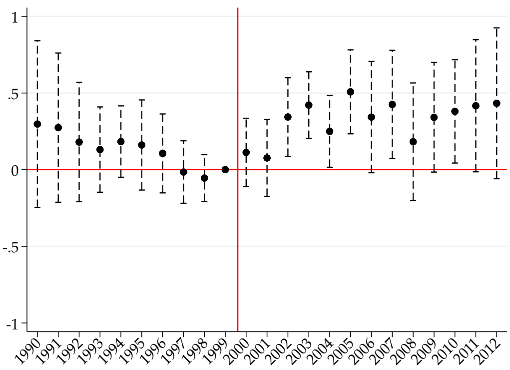
(b) Swiss nationals (subsample)



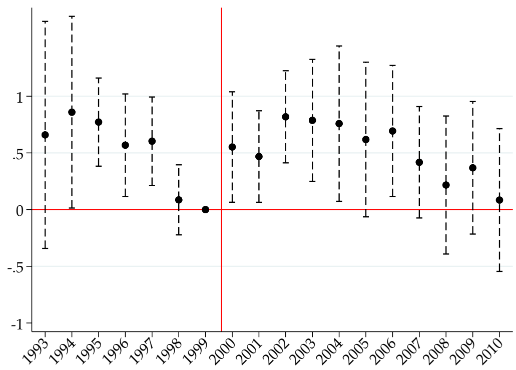
(c) Entrant Swiss residents



(d) Entrant Swiss nationals (subsample)



(e) Incumbent Swiss residents



(f) Incumbent Swiss nationals (subsample)

Notes: In panels (a), (c), and (e) the dependent variable is the number of Swiss-resident inventors active in spatial mobility region m in year t. Panels (b), (d), and (f) report equivalent estimates using the sample of Swiss national inventors (identified through PCT nationality information). We count only inventors listed on granted patents. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimation by Poisson pseudo-maximum-likelihood.

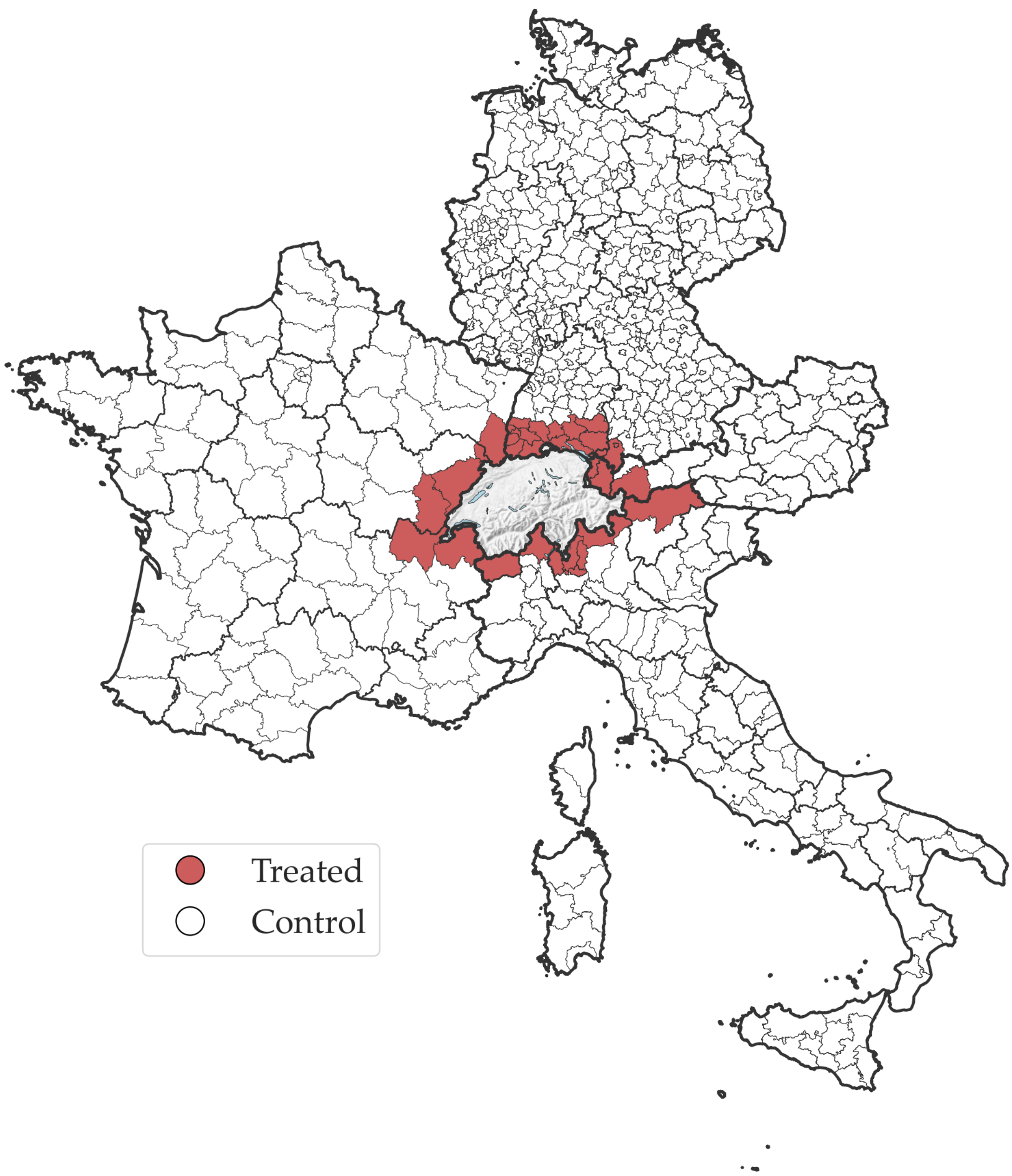
Table D13: Active Swiss inventors: difference-in-differences results (only granted patents)

	Swiss residents (1)	Swiss nationals (2)	Entrant Swiss residents (3)	Entrant Swiss nationals (4)	Incumbent Swiss residents (5)	Incumbent Swiss nationals (6)
AFMP × Treated	0.007	-0.528**	0.017	-0.688***	0.167	0.109
	(0.112)	(0.214)	(0.103)	(0.199)	(0.115)	(0.141)
Observations	1449	1044	1449	1044	1403	954
Pseudo R^2	0.905	0.771	0.864	0.617	0.870	0.710
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of inventors resident in Switzerland or with Swiss nationality (EPO-PCT subsample) active in spatial mobility region m in year t. We count only inventors listed on granted patents. The treated group includes the border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes the border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

D.4. Regional Analysis: Brain Drain Effects

Figure D16: Treated and control NUTS-3 regions in Austria, France, Germany, and Italy



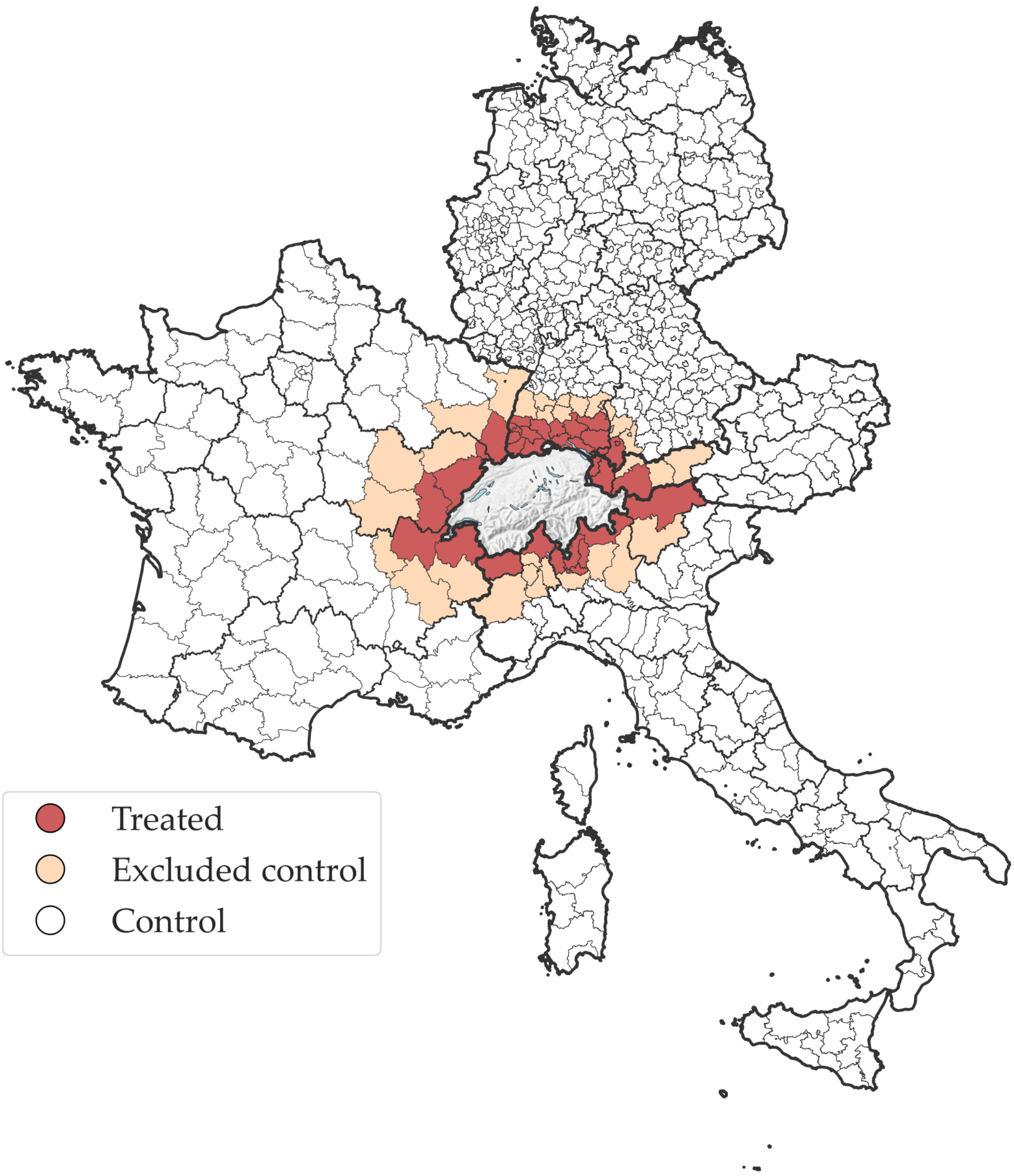
Notes: Treated NUTS-3 regions are those where the pre-AFMP legislation required G-permit holders to reside for at least six months before being eligible to apply for a Permit G to work in Switzerland.

Table D14: Regional patent count in neighbouring regions: difference-in-differences results

	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	0.287***	-0.058	0.073	-0.137
	(0.046)	(0.091)	(0.069)	(0.179)
Observations	759	2189	8944	2224
Pseudo R^2	0.871	0.949	0.914	0.913
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

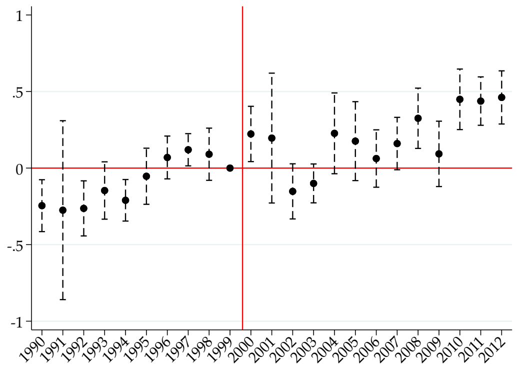
Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patents filed in NUTS-3 region m and year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. Robust standard errors clustered at the NUTS-3 level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

Figure D17: Treated and control NUTS-3 regions in Austria, France, Germany, and Italy (reduced control group)

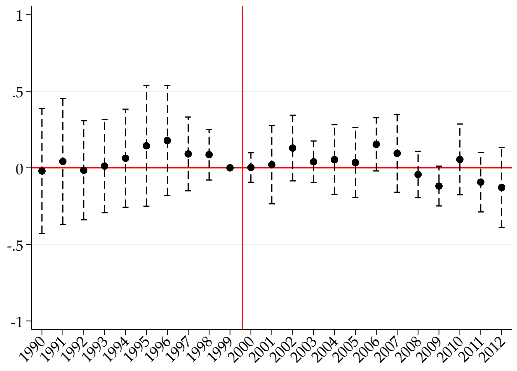


Notes: Treated NUTS-3 regions are those where the pre-AFMP legislation required G-permit holders to reside. NUTS-3 regions excluded from the control group are those bordering the treated ones.

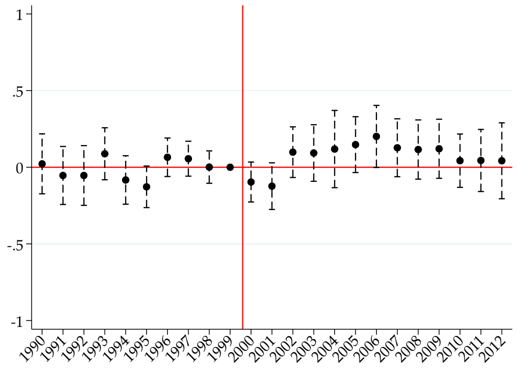
Figure D18: Regional patent count in neighbouring regions: event study results (reduced control group)



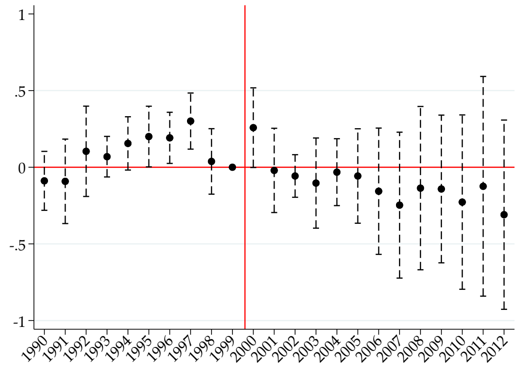
(a) Austria



(b) France



(c) Germany



(d) Italy

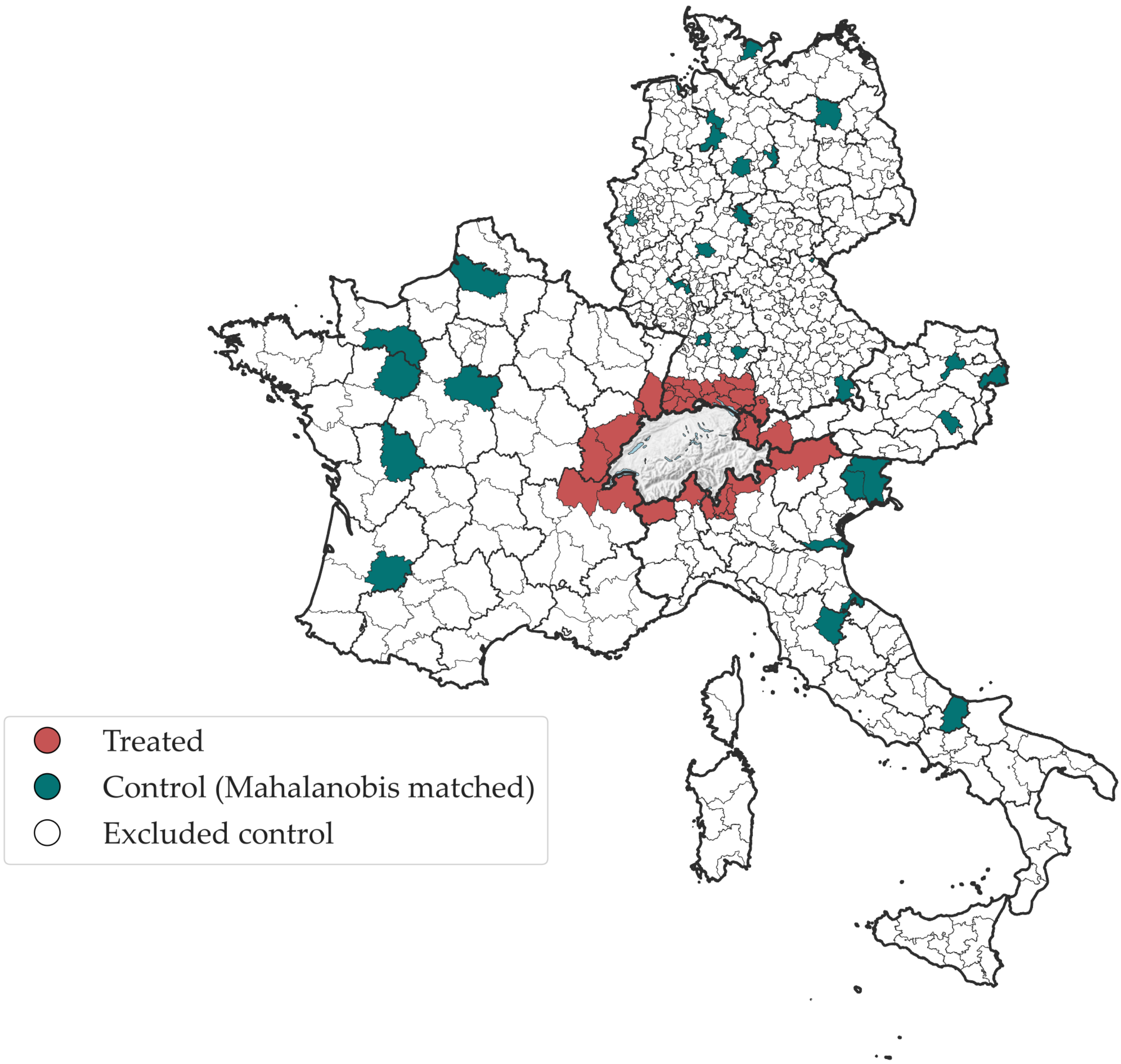
Notes: The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions, except those directly bordering the treated ones (see Figure D17). All regressions include NUTS-3 region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D15: Regional patent count in neighbouring regions: difference-in-differences results (reduced control group)

	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	0.287***	-0.045	0.079	-0.202
	(0.047)	(0.092)	(0.070)	(0.177)
Observations	690	2005	8646	2040
Pseudo R^2	0.878	0.947	0.916	0.865
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

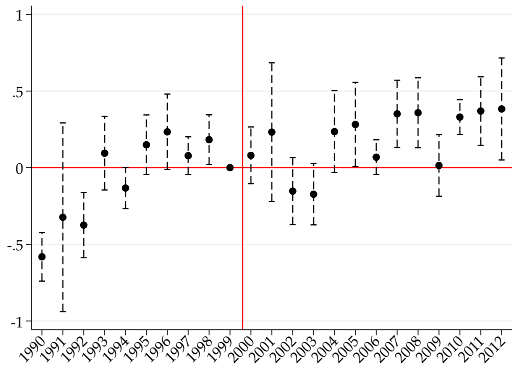
Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions, except those directly bordering the treated ones (see Figure D17). Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Figure D19: Treated and control NUTS-3 regions in Austria, France, Germany, and Italy (Mahalanobis matched control group)

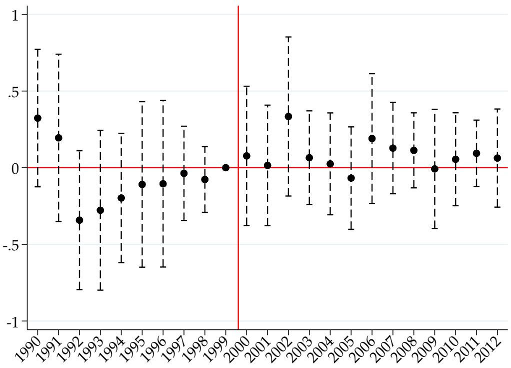


Notes: Treated NUTS-3 regions are the areas where the pre-AFMP legislation required G-permit holders to reside. Control regions are selected via Mahalanobis matching. For each treated region, we select a control that minimizes the normalized Euclidean distance between some selected pre-AFMP features of the two. As matching features, we use the average regional GDP, population, and number of active inventors as well as the share of patents across the five technology groups of Schmoch (2008) and across applicants of different size.

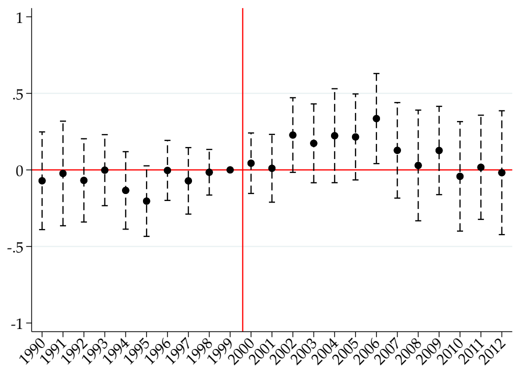
Figure D20: Regional patent count in neighbouring regions: event study results (Mahalanobis matched control group)



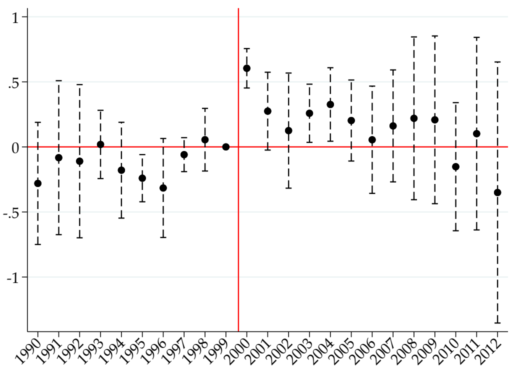
(a) Austria



(b) France



(c) Germany



(d) Italy

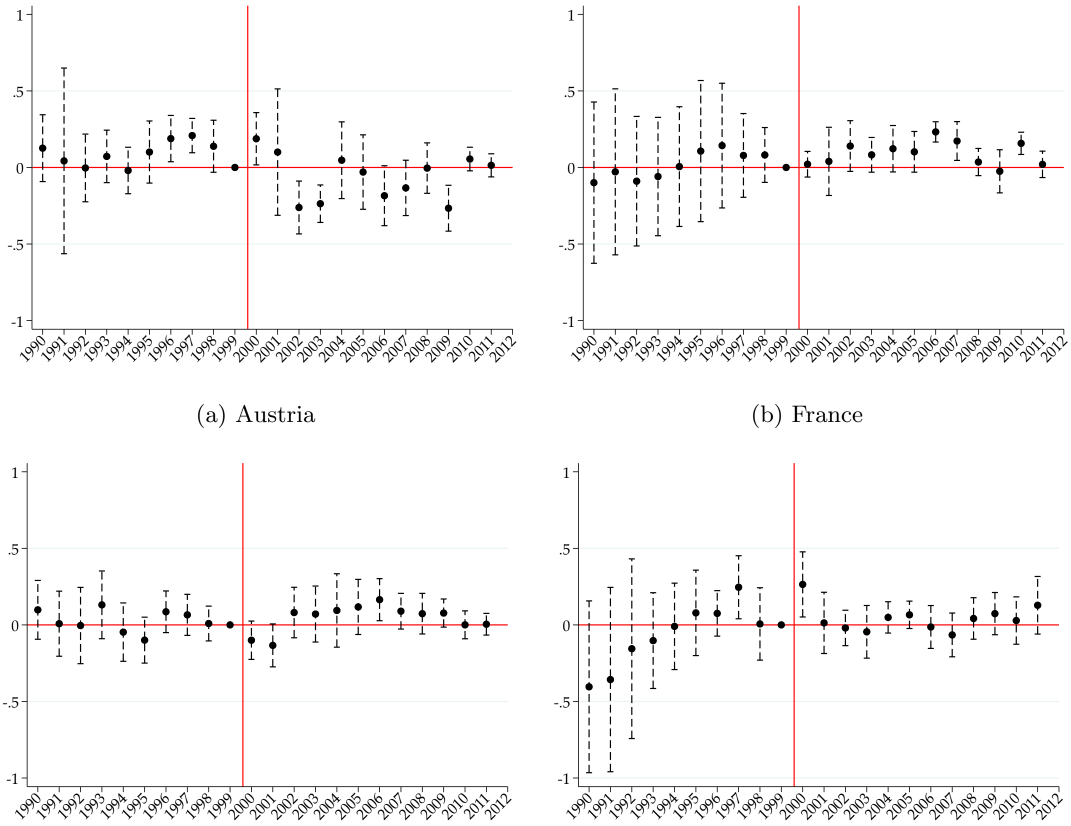
Notes: The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes NUTS-3 regions selected via Mahalanobis matching (see Figure D19). All regressions include NUTS-3 region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D16: Regional patent count in neighbouring regions: difference-in-differences results (Mahalanobis matched control group)

	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	0.256***	0.156	0.168	0.242
	(0.058)	(0.098)	(0.112)	(0.172)
Observations	136	276	679	259
Pseudo R^2	0.874	0.770	0.750	0.899
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes NUTS-3 regions selected via Mahalanobis matching (see Figure D19). Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Figure D21: Regional patent count in neighbouring regions: event study results (including NUTS-3-specific time trends)



(a) Austria

(b) France

(c) Germany

(d) Italy

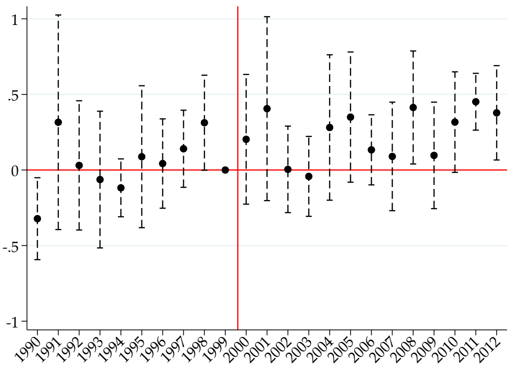
Notes: The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. All regressions include NUTS-3 region and year fixed effects, as well as NUTS-3-specific time trends. Vertical bars represent 95% confidence intervals. The coefficient for baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D17: Regional patent count in neighbouring regions: difference-in-differences results (including NUTS-3-specific time trends)

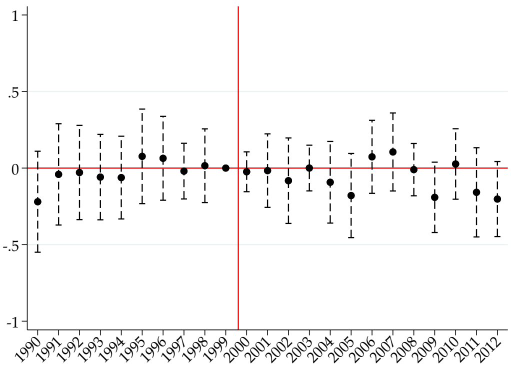
	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	-0.158	0.042	-0.005	-0.024
	(0.163)	(0.061)	(0.089)	(0.052)
Observations	759	2189	8944	2224
Pseudo R^2	0.878	0.956	0.928	0.923
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. All regressions include NUTS-3 region and year fixed effects, as well as NUTS-3-specific time trends. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

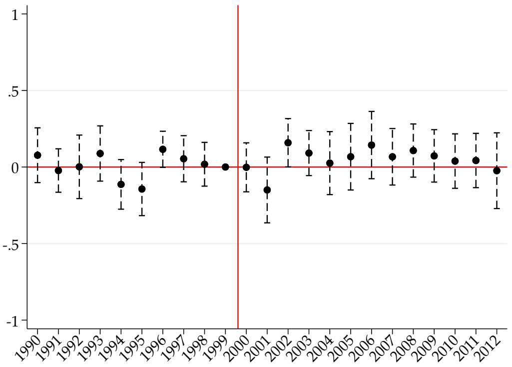
Figure D22: Regional patent count in neighbouring regions: event study results (OLS)



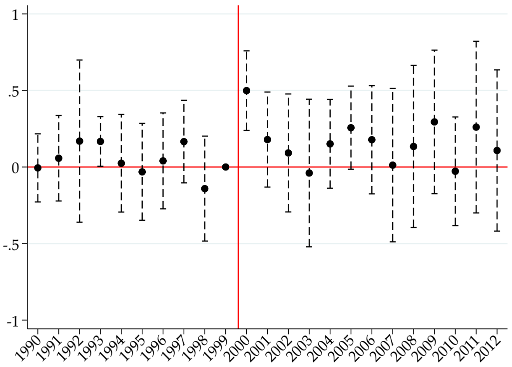
(a) Austria



(b) France



(c) Germany



(d) Italy

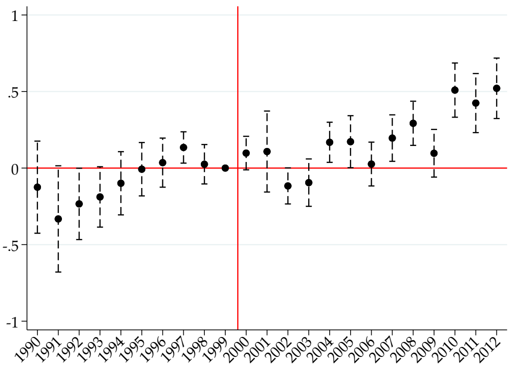
Notes: The dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. All regressions include NUTS-3 region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Ordinary Least Squares.

Table D18: Regional patent count in neighbouring regions: difference-in-differences results (OLS)

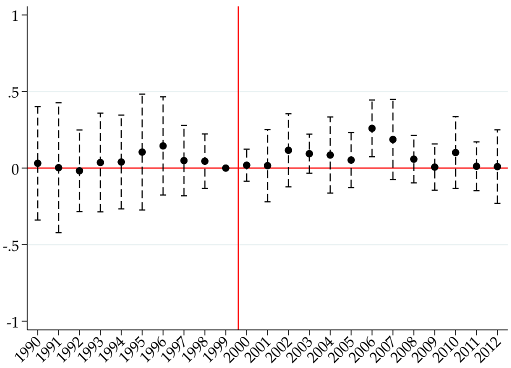
	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	0.176 (0.180)	-0.030 (0.103)	0.042 (0.055)	0.117 (0.124)
Observations	759	2189	8944	2224
R^2	0.918	0.945	0.912	0.931
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patent filings in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Ordinary Least Squares.

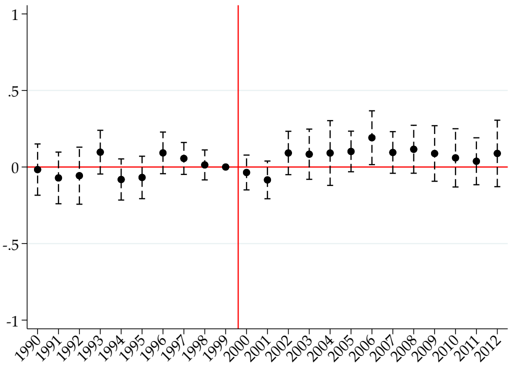
Figure D23: Regional patent count in neighbouring regions: event study results (only granted patents)



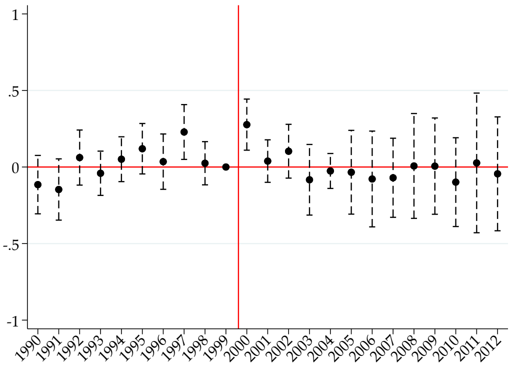
(a) Austria



(b) France



(c) Germany



(d) Italy

Notes: The dependent variable is the number of granted patents filed in NUTS-3 region m in year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. All regressions include NUTS-3 region and year fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the NUTS-3 region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D19: Regional patent count in neighbouring regions: difference-in-differences results (only granted patents)

	Austria (1)	France (2)	Germany (3)	Italy (4)
AFMP × Treated	0.270***	0.036	0.070	-0.025
	(0.043)	(0.090)	(0.056)	(0.128)
Observations	759	2189	8944	2224
Pseudo R^2	0.831	0.931	0.860	0.888
NUTS-3 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of granted patents filed in NUTS-3 region m and year t. For each country, the treated group includes NUTS-3 regions where the pre-AFMP legislation required G-permit holders to reside. The control group includes all other NUTS-3 regions. Robust standard errors clustered at the NUTS-3 level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

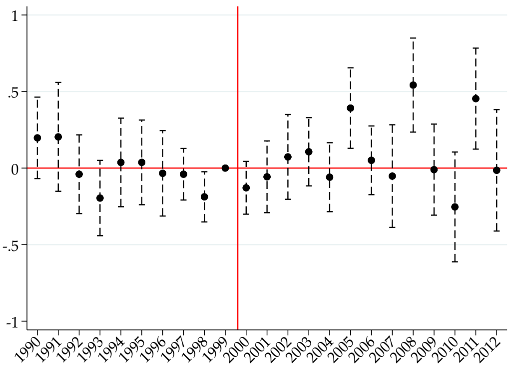
D.5. Inventor-level Analysis: Incumbent Inventors

Table D20: Incumbent inventors' patenting: difference-in-differences results

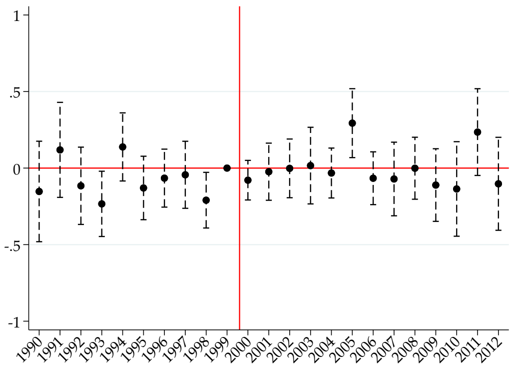
	Patents		**Co-inventors**		**Backward citations to cross-border inventor country prior art**	
	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team
	(1)	(2)	(3)	(4)	(5)	(6)
AFMP × Treated	0.152***	0.064	0.136**	0.135**	0.165*	0.090
	(0.054)	(0.043)	(0.053)	(0.068)	(0.092)	(0.108)
Observations	17490	16999	15533	14591	13881	12746
Pseudo R^2	0.100	0.114	0.273	0.220	0.322	0.295
Inventor FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

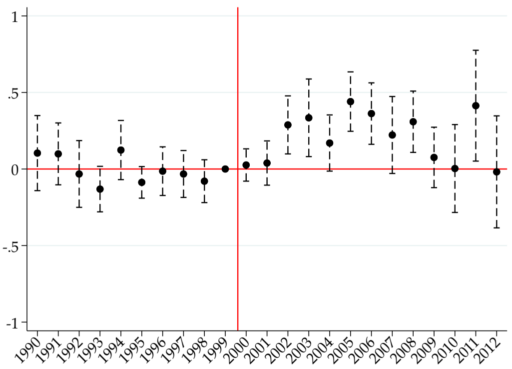
Figure D24: Incumbent inventors' patenting: event-study results (by technology field)



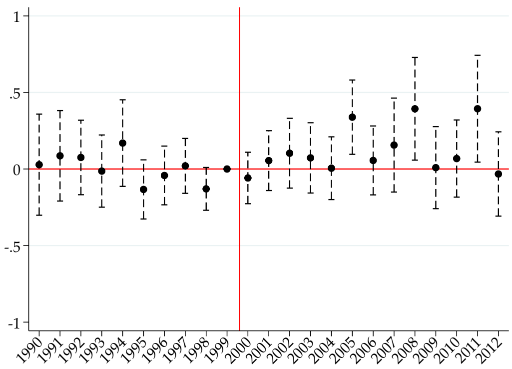
(a) Electrical engineering



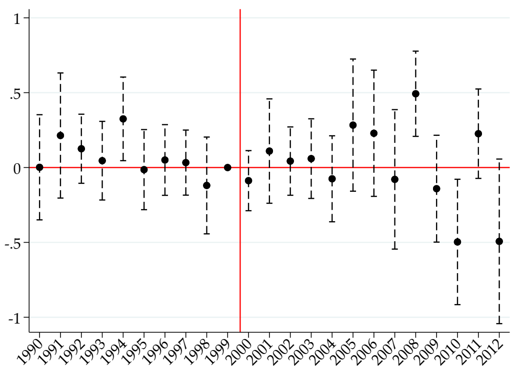
(b) Instruments



(c) Chemicals and pharmaceuticals



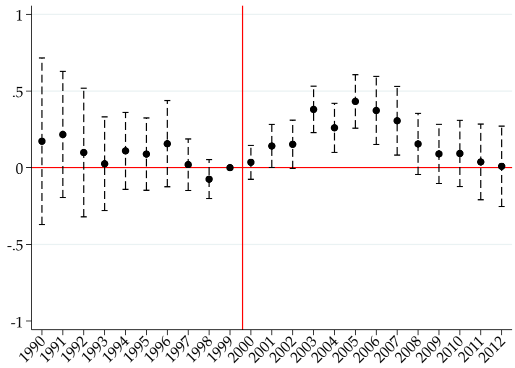
(d) Mechanical engineering



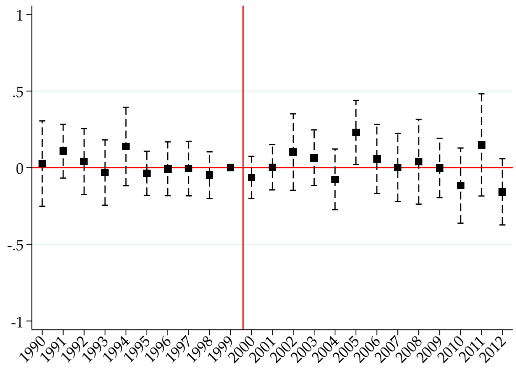
(e) Other

Notes: The dependent variable is the number of patents filed by incumbent inventor i, in spatial mobility region m, in year t. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

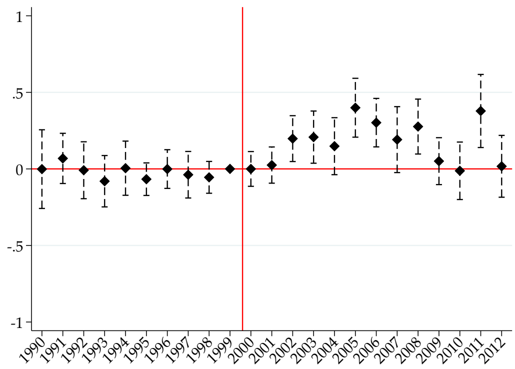
Figure D25: Incumbent inventors' patenting: event-study results (excluding inventors based in Basel or Geneva)



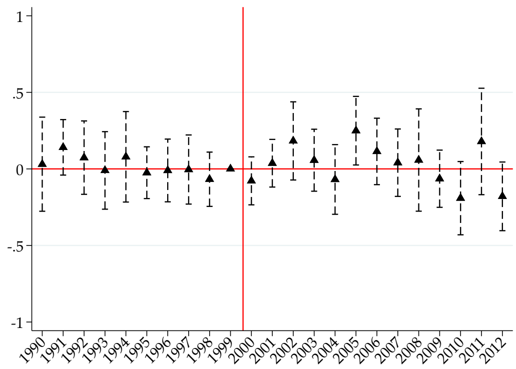
(a) Baseline



(b) Excluding inventors based in Basel



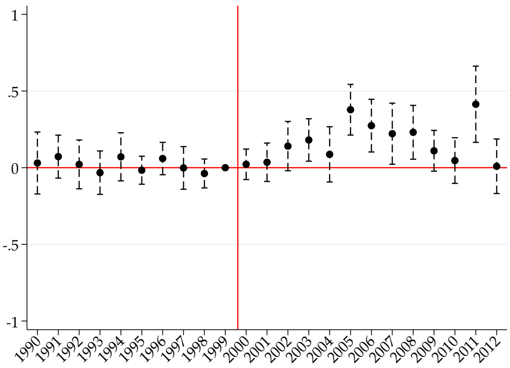
(c) Excluding inventors based in Geneva



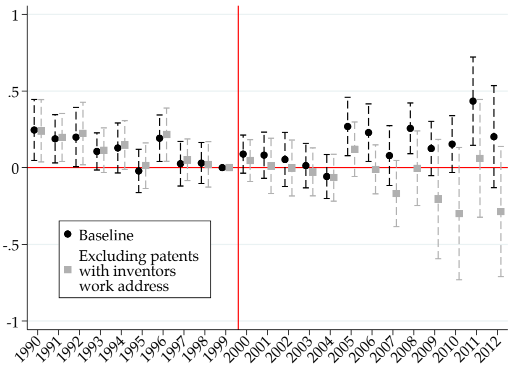
(d) Excluding inventors based in Basel or Geneva

Notes: The dependent variable is the number of patents filed by incumbent inventor i, in spatial mobility region m, in year t. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

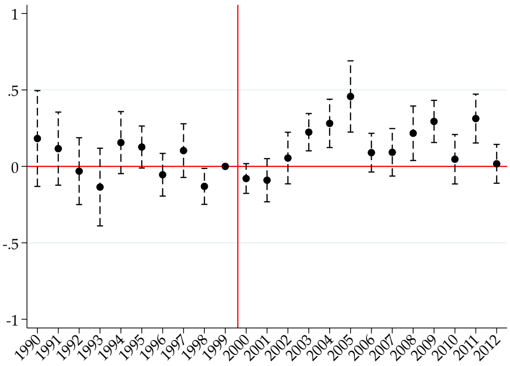
Figure D26: Incumbent inventors' patenting: event-study results (including non-border region inventors in the control group)



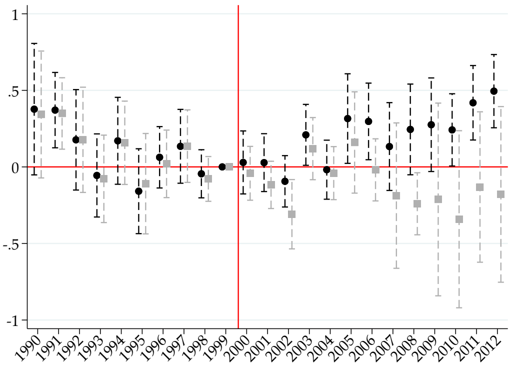
(a) Patents



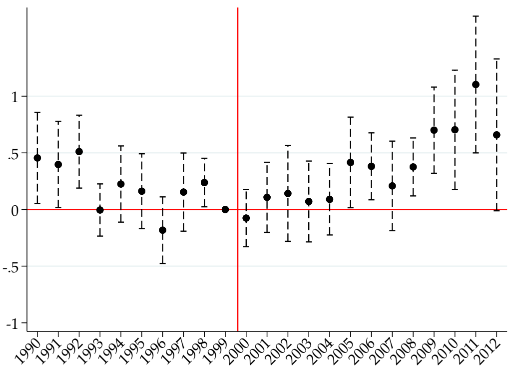
(b) Patents (excl. cross-border inventors)



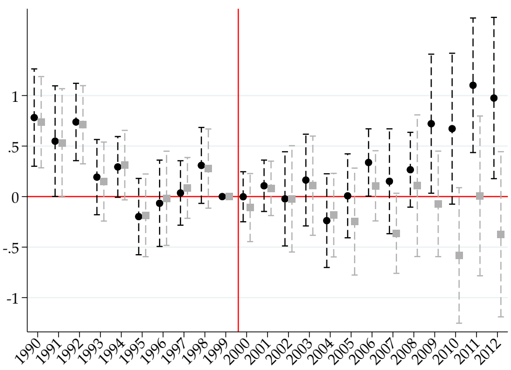
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



(e) Cites to cross-border inventor-country prior-art



(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

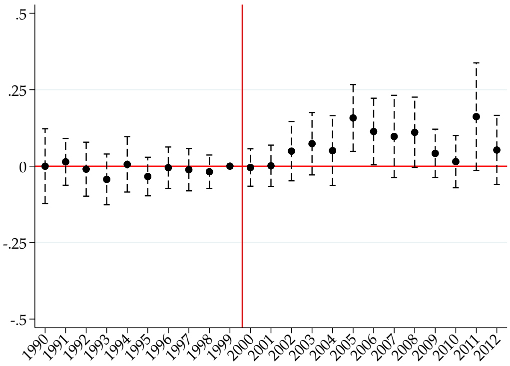
Notes: The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes and all incumbent inventors located in the non-border regions. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. In panels (b), (d), and (f), black dots represent the coefficients from regressions where we exclude patents filed by one or more cross-border inventors; gray squares represent the coefficients from regressions where we exclude both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses, rather than their residential one.

Table D21: Incumbent inventors' patenting: difference-in-differences results (including non-border region inventors in the control group)

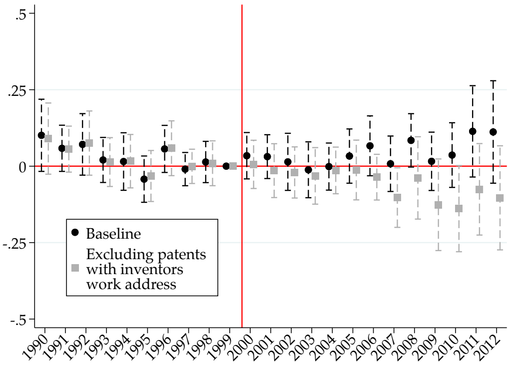
	Patents		**Co-inventors**		**Backward citations to cross-border inventor country prior art**	
	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team
	(1)	(2)	(3)	(4)	(5)	(6)
AFMP × Treated	0.134**	0.040	0.099*	0.088	0.156	0.070
	(0.053)	(0.042)	(0.053)	(0.068)	(0.096)	(0.110)
Observations	21841	21343	19248	18270	17377	16212
Pseudo R^2	0.103	0.116	0.271	0.221	0.329	0.310
Inventor FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes and all incumbent inventors located in the non-border regions. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

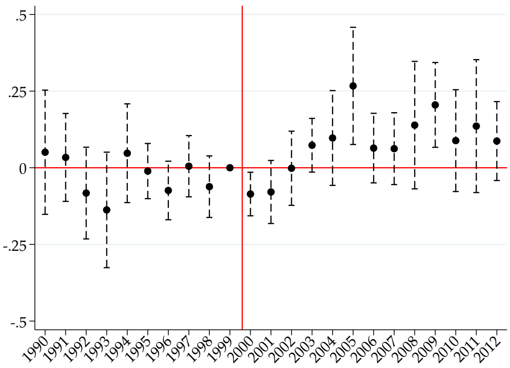
Figure D27: Incumbent inventors' patenting: event-study results (OLS)



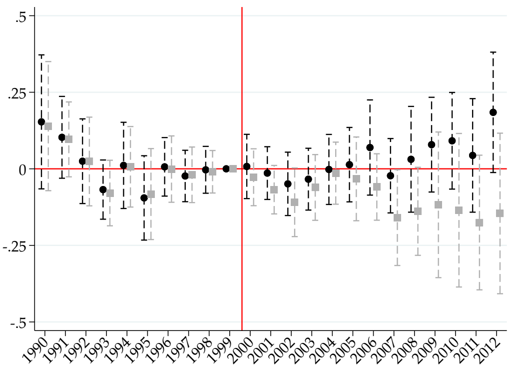
(a) Patents



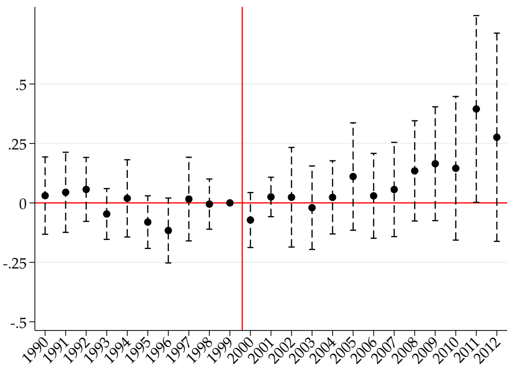
(b) Patents (excl. cross-border inventors)



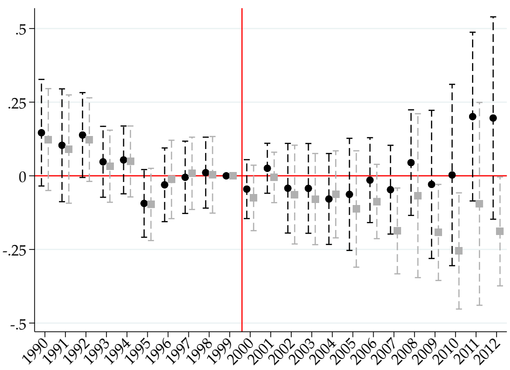
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



(e) Cites to cross-border inventor-country prior-art



(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

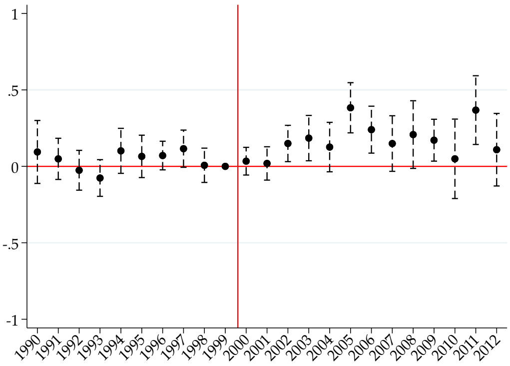
Notes: In panels (a) and (b) the dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patents filed by inventor i in spatial mobility region m in year t. In panels (b) and (c) the dependent variable is the logarithmic transformation ($log(1 + coinventors)$) of the number of distinct co-inventors collaborating with inventor i in spatial mobility region m in year t. In panels (e) and (f) the dependent variable is the logarithmic transformation ($log(1 + citations)$) of the number of citations to cross-border inventor-countries' prior art made by inventor i in spatial mobility region m in year t (for the definition of prior art see Table D2 and Table D3). The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Ordinary Least Squares. In panels (b), (d), and (f), black dots represent the coefficients from regressions where we exclude patents filed by one or more cross-border inventors; gray squares represent the coefficients from regressions where we exclude both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses, rather than their residential one.

Table D22: Incumbent inventors' patenting: difference-in-differences results (OLS)

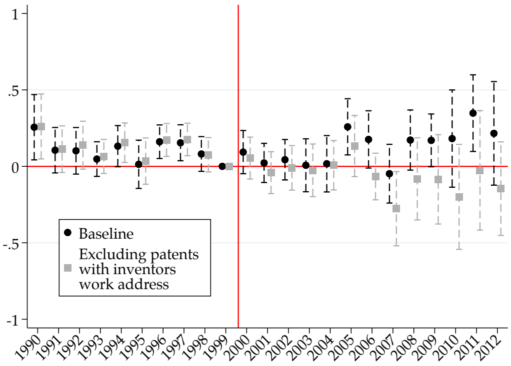
	Patents		**Co-inventors**		**Backward citations to cross-border inventor country prior art**	
	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team
	(1)	(2)	(3)	(4)	(5)	(6)
AFMP × Treated	0.064**	0.015	0.064	0.013	0.061	-0.027
	(0.031)	(0.017)	(0.043)	(0.026)	(0.042)	(0.029)
Observations	17490	17490	17490	17490	17490	17490
R^2	0.393	0.486	0.635	0.557	0.454	0.439
Inventor FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. In columns (1) and (2) the dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patents filed by inventor i in spatial mobility region m in year t. In columns (3) and (4) the dependent variable is the logarithmic transformation ($log(1 + coinventors)$) of the number of distinct co-inventors collaborating with inventor i in spatial mobility region m in year t. In columns (5) and (6) the dependent variable is the logarithmic transformation ($log(1 + citations)$) of the number of citations to cross-border inventor-countries' prior art made by inventor i in spatial mobility region m in year t (for the definition of prior art see Table D2 and Table D3). The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Ordinary Least Squares.

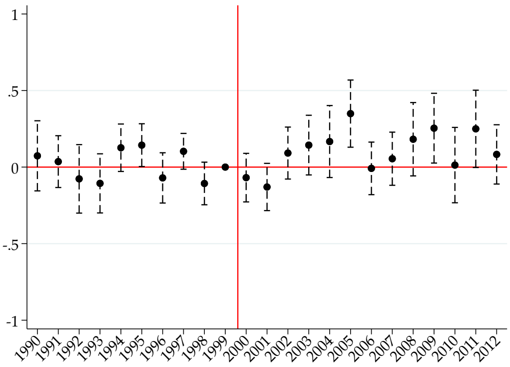
Figure D28: Incumbent inventors patenting: event study results (alternative location assignment: inventor residential address)



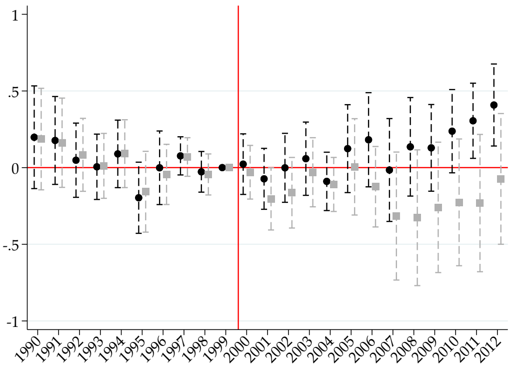
(a) Patents



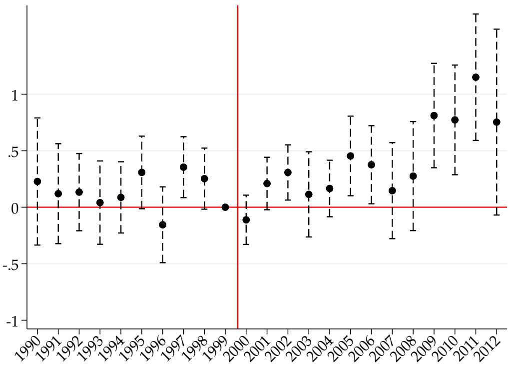
(b) Patents (excl. cross-border inventors)



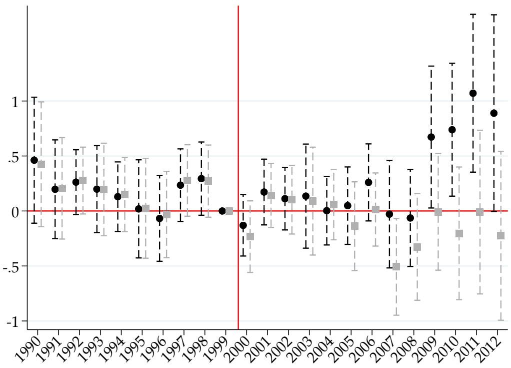
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



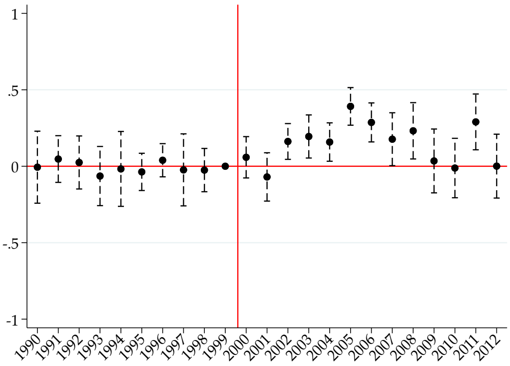
(e) Cites to cross-border inventor-country prior-art



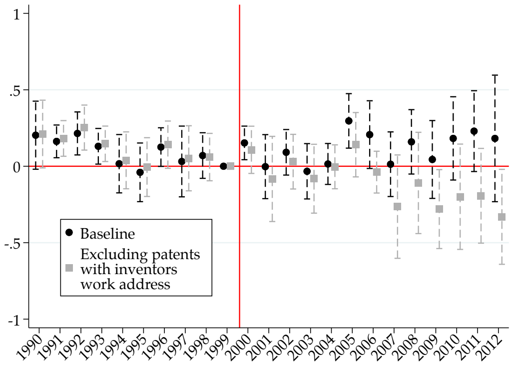
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: Inventors are assigned to their spatial mobility region of residence instead of the spatial mobility region associated with their R&D location. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. In panels (b), (d), and (f), black dots represent the coefficients from regressions excluding patents from one or more cross-border inventors; gray squares represent the coefficients from regressions excluding both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses.

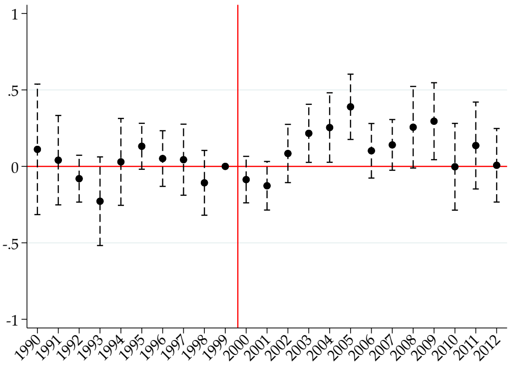
Figure D29: Incumbent inventors patenting: event study results (alternative location assignment: applicant location)



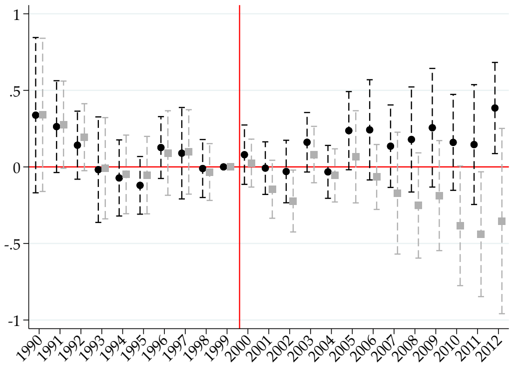
(a) Patents



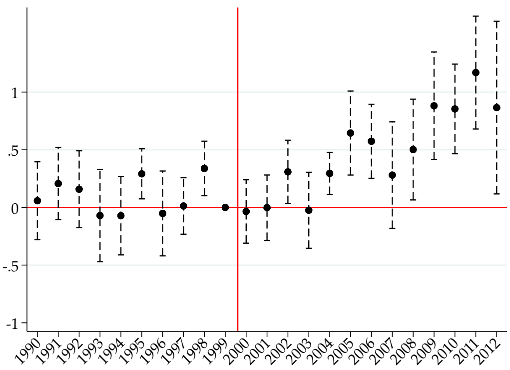
(b) Patents (excl. cross-border inventors)



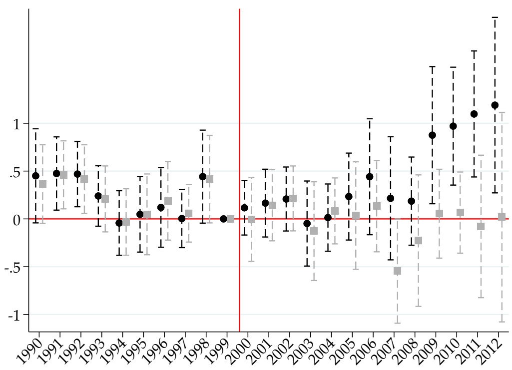
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



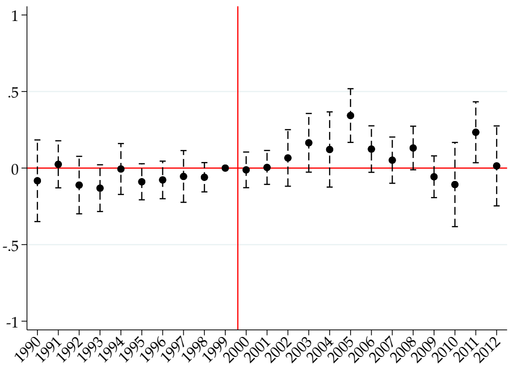
(e) Cites to cross-border inventor-country prior-art



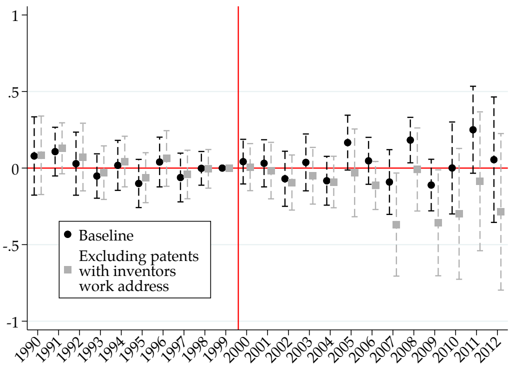
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: Inventors are assigned to the applicant's spatial mobility region instead of the spatial mobility region associated with their R&D location. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. In panels (b), (d), and (f), black dots represent the coefficients from regressions where we exclude patents filed by one or more cross-border inventors; gray squares represent the coefficients from regressions where we exclude both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses, rather than their residential one.

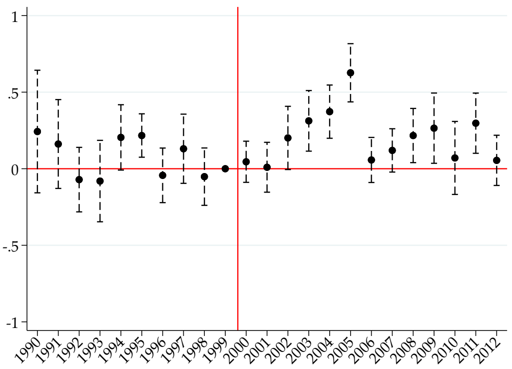
Figure D30: Incumbent inventors' patenting: event study results (only granted patents)



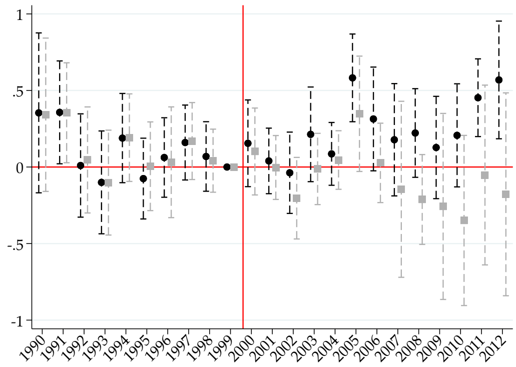
(a) Patents



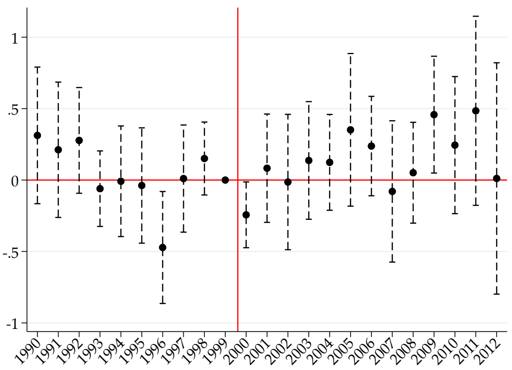
(b) Patents (excl. cross-border inventors)



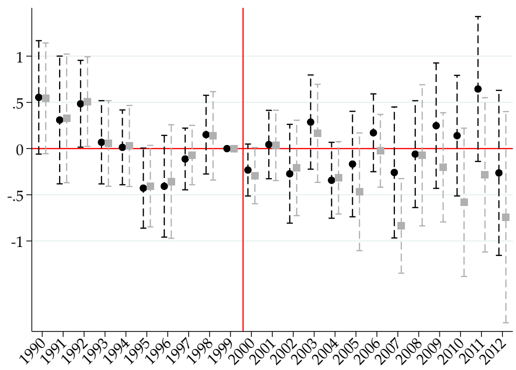
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



(e) Cites to cross-border inventor-country prior-art



(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: The sample is based only on information from granted patents. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood. In panels (b), (d), and (f), black dots represent the coefficients from regressions where we exclude patents filed by one or more cross-border inventors; gray squares represent the coefficients from regressions where we exclude both patents filed by one or more cross-border inventors *and* patents reporting the inventors' work addresses, rather than their residential one.

Table D23: Incumbent inventors' patenting: difference-in-differences results (only granted patents)

	Patents		**Co-inventors**		**Backward citations to cross-border inventor country prior art**	
	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team	Baseline	Excluding patents with cross-border inventors in team
	(1)	(2)	(3)	(4)	(5)	(6)
AFMP × Treated	0.130**	0.032	0.145**	0.124	0.086	-0.040
	(0.052)	(0.042)	(0.064)	(0.085)	(0.087)	(0.107)
Observations	14315	13837	12747	11889	11344	10364
Pseudo R^2	0.086	0.106	0.266	0.217	0.305	0.295
Inventor FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

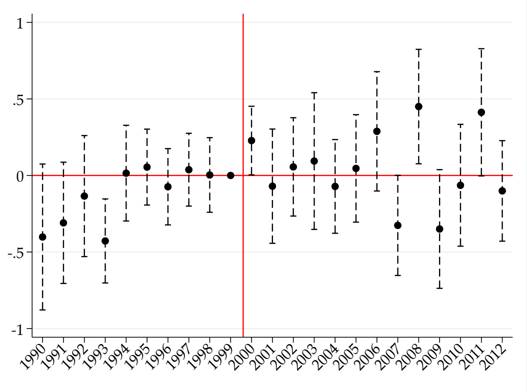
Notes: *** p<0.01, ** p<0.05, * p<0.1. The sample is based only on information from granted patents. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

Table D24: Incumbent inventors' patent characteristics: difference-in-differences results

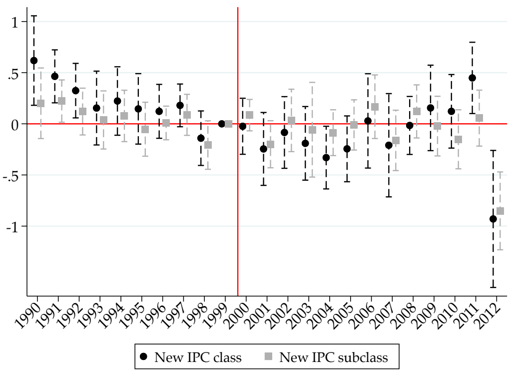
	Patents with novel terms (1)	Patents with new IPC class (2)	Patents with new IPC subclass (3)	Patents with new IPC group (4)	Patents with new IPC subgroup (5)
AFMP × Treated	0.110	-0.189***	-0.040	0.180*	0.179**
	(0.087)	(0.068)	(0.072)	(0.096)	(0.080)
Observations	12098	17457	17467	17477	17490
R^2	0.105	0.162	0.117	0.087	0.089
Inventor FE	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. In column (1) the dependent variable is the number of patents filed by inventor i in spatial mobility region m in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t-1$. In columns (2), (3), (4), and (5), the dependent variable is the number of patents filed by inventor i in spatial mobility region m in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t-1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

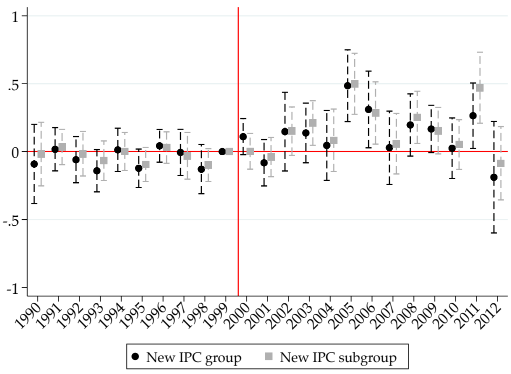
Figure D31: Incumbent inventors' patent characteristics: event study results (including non-border region inventors in the control group)



(a) Patents with novel terms



(b) Patents with new IPC class or subclass



(c) Patents with new IPC group or subgroup

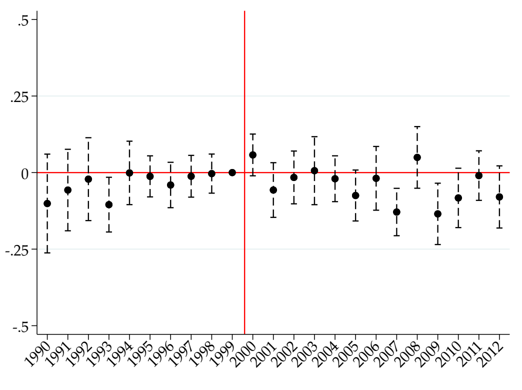
Notes: In panel (a), the dependent variable is the number of patents filed by inventor i in spatial mobility region m in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t-1$. In panels (b) and (c), the dependent variable is the number of patents filed by inventor i in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t-1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes and all incumbent inventors located in the non-border regions. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

Table D25: Incumbent inventors' patent characteristics: difference-in-differences results (including non-border region inventors in the control group)

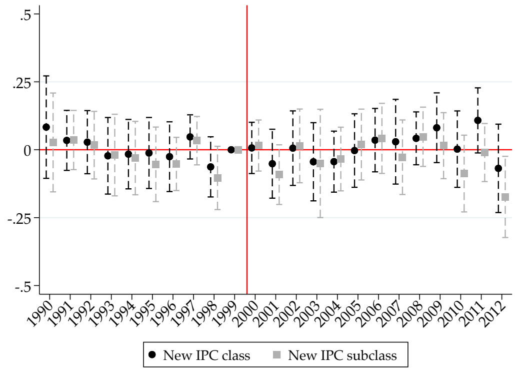
	Patents with novel terms (1)	Patents with new IPC class (2)	Patents with new IPC subclass (3)	Patents with new IPC group (4)	Patents with new IPC subgroup (5)
AFMP × Treated	0.114	-0.212***	-0.044	0.162*	0.164**
	(0.076)	(0.060)	(0.067)	(0.093)	(0.079)
Observations	14913	21834	21837	21837	21841
R^2	0.109	0.158	0.117	0.089	0.089
Inventor FE	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. In column (1) the dependent variable is the number of patents filed by inventor i in spatial mobility region m in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t-1$. In columns (2), (3), (4), and (5), the dependent variable is the number of patents filed by inventor i in spatial mobility region m in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t-1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes and all incumbent inventors located in the non-border regions. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

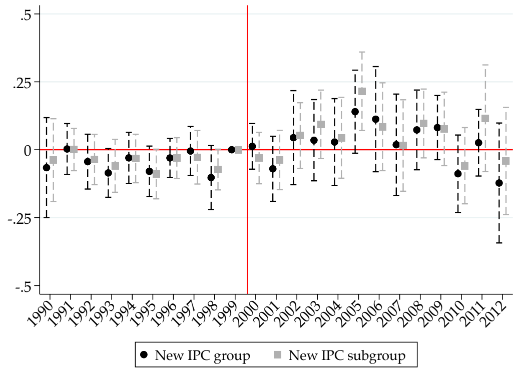
Figure D32: Incumbent inventors' patent characteristics: event study results (OLS)



(a) Patents with novel terms



(b) Patents with new IPC class or subclass



(c) Patents with new IPC group or subgroup

Notes: In panel (a), the dependent variable is the logarithmic transformation ($log(1 + patents)$) of number of patents filed by inventor i in spatial mobility region m in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t - 1$. In panels (b) and (c), the dependent variable is the logarithmic transformation of number of patents filed by inventor i in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t - 1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. All regressions include inventor, year, and region fixed effects. Vertical bars represent 95% confidence intervals. The coefficient for our baseline year 1999 is set to zero and shown without confidence interval. Robust standard errors are clustered at the spatial mobility region level. Estimations by Ordinary Least Squares.

Table D26: Incumbent inventors' patent characteristics: difference-in-differences results (OLS)

	Patents with novel terms (1)	Patents with new IPC class (2)	Patents with new IPC subclass (3)	Patents with new IPC group (4)	Patents with new IPC subgroup (5)
AFMP × Treated	-0.002	0.001	0.004	0.062	0.074
	(0.016)	(0.027)	(0.032)	(0.055)	(0.050)
Observations	17490	17490	17490	17490	17490
R^2	0.385	0.402	0.353	0.299	0.311
Inventor FE	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓

Notes: *** p<0.01, ** p<0.05, * p<0.1. In column (1) the dependent variable is the logarithmic transformation ($log(1 + patents)$) of the number of patents filed by inventor i in spatial mobility region m in year t containing at least one novel term in their abstract, relative to all EPO patents filed in Switzerland up to the previous year $t - 1$. In columns (2), (3), (4), and (5), the dependent variable is the logrithmic transformation of the number of patents filed by inventor i in spatial mobility region m in year t containing at least one new IPC class, subclass, group, or subgroup relative to all EPO patents filed by inventor i up to the previous year $t - 1$. The treated group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes incumbent inventors located in border regions whose driving distance from the closest border crossing is above 20 minutes. Robust standard errors clustered at the spatial mobility region level are given in parentheses. Estimations by Ordinary Least Squares.

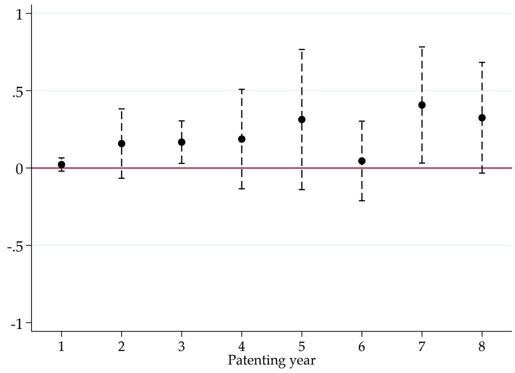
D.6. Inventor-level Analysis: Junior Inventors

Table D27: Junior inventors' patenting: difference-in-differences results by patenting year

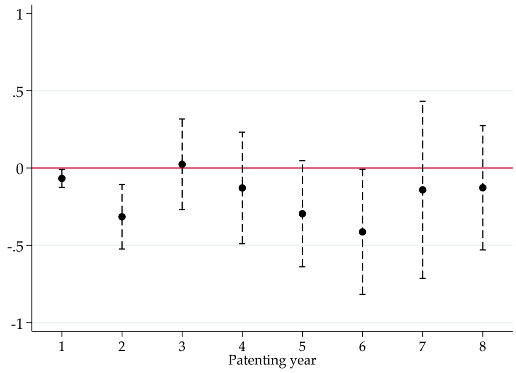
	Patenting year							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(a) Patents								
AFMP × Treated	0.009	0.125	0.185**	0.267	0.336	0.089	0.410**	0.303
	(0.024)	(0.124)	(0.072)	(0.165)	(0.232)	(0.150)	(0.199)	(0.199)
Observations	7201	860	671	528	473	405	358	337
Pseudo R^2	0.003	0.031	0.034	0.037	0.055	0.042	0.078	0.092
(b) Patents (excl. cross-border inventors)								
AFMP × Treated	-0.070**	-0.326***	0.057	-0.054	-0.326*	-0.407*	-0.167	-0.180
	(0.033)	(0.121)	(0.149)	(0.173)	(0.170)	(0.213)	(0.292)	(0.225)
Observations	7201	860	671	528	473	405	358	337
Pseudo R^2	0.009	0.055	0.052	0.065	0.082	0.074	0.106	0.095
(c) Co-inventors								
AFMP × Treated	-0.000	-0.017	0.073	0.226	0.246	0.095	0.187	0.217
	(0.076)	(0.141)	(0.172)	(0.165)	(0.207)	(0.171)	(0.203)	(0.188)
Observations	7184	852	669	522	471	390	358	332
Pseudo R^2	0.065	0.130	0.186	0.186	0.187	0.201	0.215	0.208
(d) Co-inventors (excl. cross-border inventors)								
AFMP × Treated	-0.194*	-0.596**	-0.399*	-0.295	-0.448	-0.459	-0.451*	-0.077
	(0.101)	(0.248)	(0.224)	(0.214)	(0.278)	(0.534)	(0.258)	(0.217)
Observations	7176	847	669	515	461	385	349	325
Pseudo R^2	0.059	0.130	0.147	0.153	0.128	0.191	0.198	0.149
(e) Cit. to cross-border inventor-country								
AFMP × Treated	0.031	-0.221	-0.102	0.389	0.505*	-1.065**	-0.350	-0.106
	(0.167)	(0.351)	(0.251)	(0.402)	(0.275)	(0.443)	(0.405)	(0.540)
Observations	7105	808	634	489	448	369	333	317
Pseudo R^2	0.104	0.223	0.223	0.173	0.252	0.220	0.195	0.307
(f) Cit. to cross-border inventor-country (excl. cross-border inventors)								
AFMP × Treated	-0.094	-0.462	0.043	0.550	-0.193	-1.640**	-0.315	-0.853
	(0.199)	(0.508)	(0.317)	(0.436)	(0.450)	(0.637)	(0.579)	(0.521)
Observations	7105	808	634	485	434	369	329	313
Pseudo R^2	0.095	0.237	0.229	0.220	0.275	0.250	0.199	0.301

Notes: *** p<0.01, ** p<0.05, * p<0.1. The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology fixed effects. Robust standard errors are clustered at the spatial mobility region level and shown in parentheses. Estimations by Poisson pseudo-maximum-likelihood.

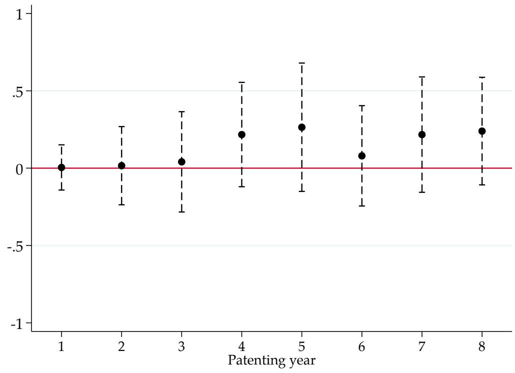
Figure D33: Junior inventors' patenting: difference-in-differences results by patenting year (including non-border region inventors in the control group)



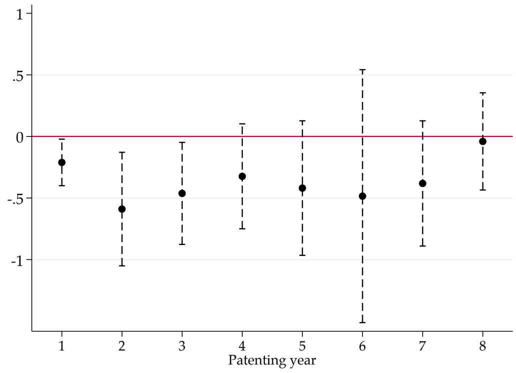
(a) Patents



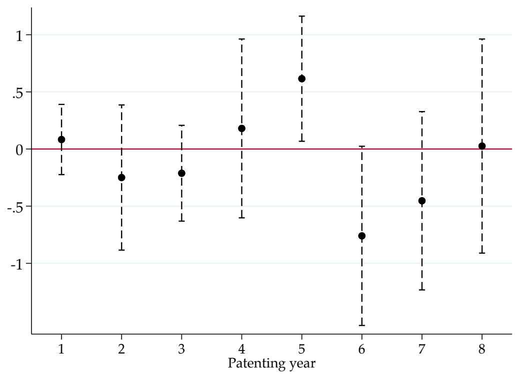
(b) Patents (excl. cross-border inventors)



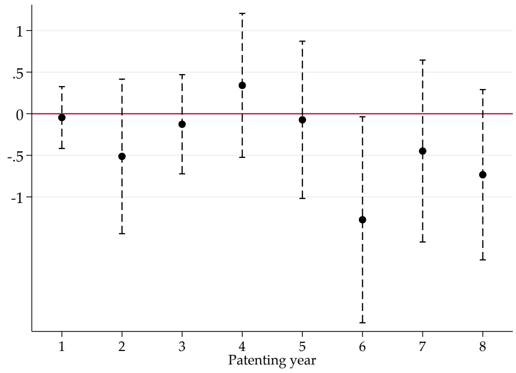
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



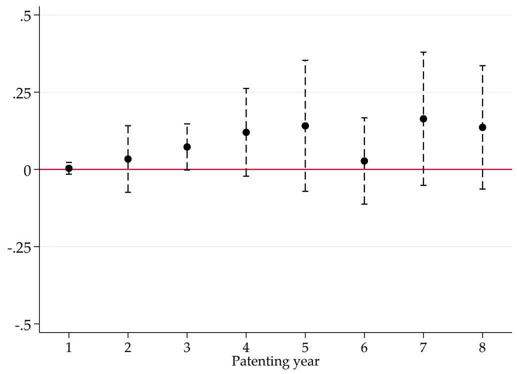
(e) Cites to CBI-country prior-art



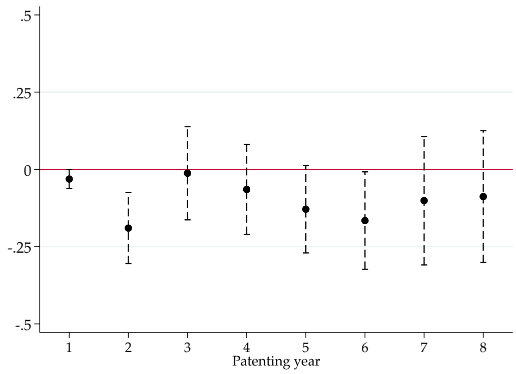
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes and all inventors who filed their first patent in the non-border region. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

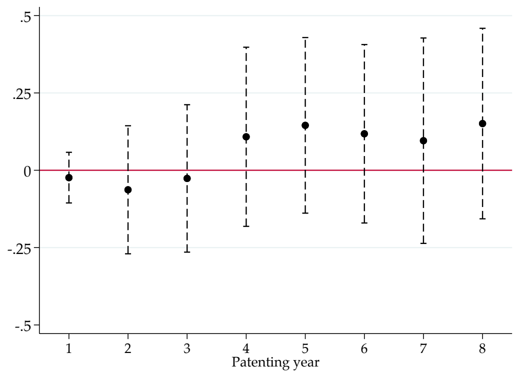
Figure D34: Junior inventors' patenting: difference-in-differences results by patenting year (OLS)



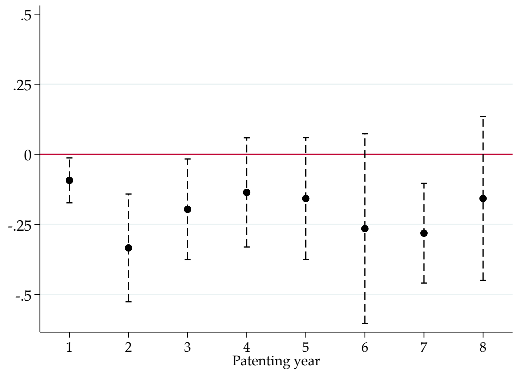
(a) Patents



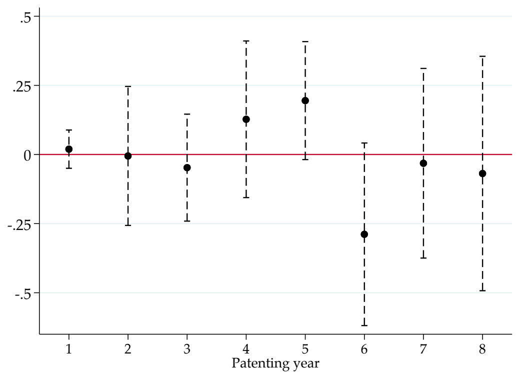
(b) Patents (excl. cross-border inventors)



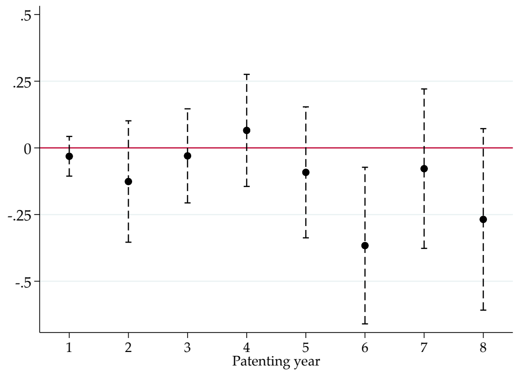
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



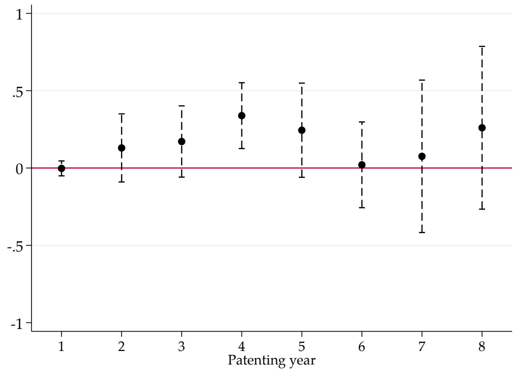
(e) Cites to CBI-country prior-art



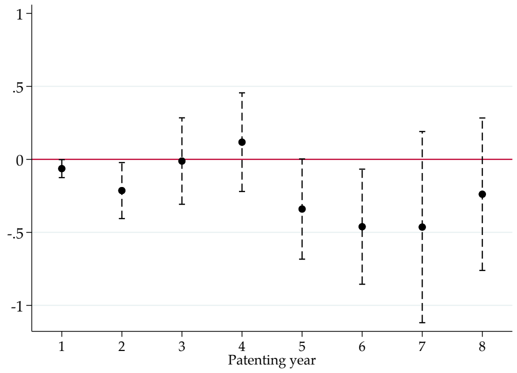
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Ordinary Least Squares.

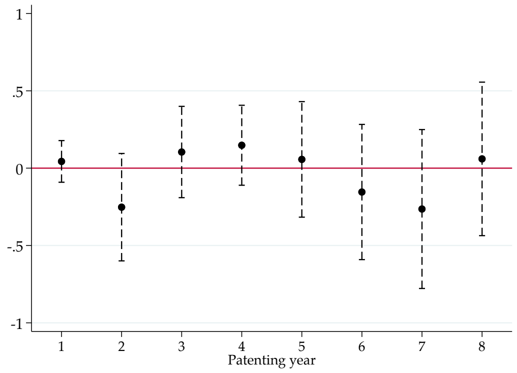
Figure D35: Junior inventors' patenting: difference-in-differences results by patenting year (alternative location assignment: inventor residential address)



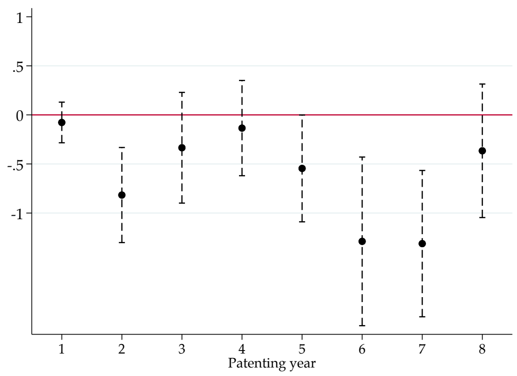
(a) Patents



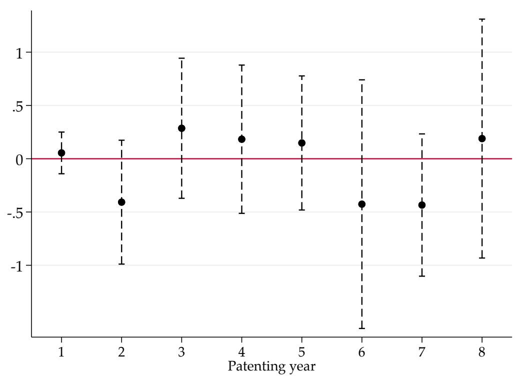
(b) Patents (excl. cross-border inventors)



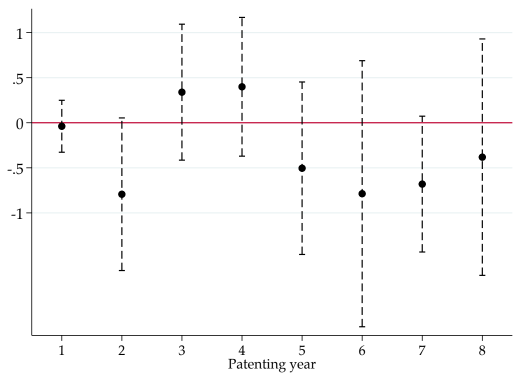
(c) Distinct co-inventors



(d) Distinct co-inventors
(excl. cross-border inventors)



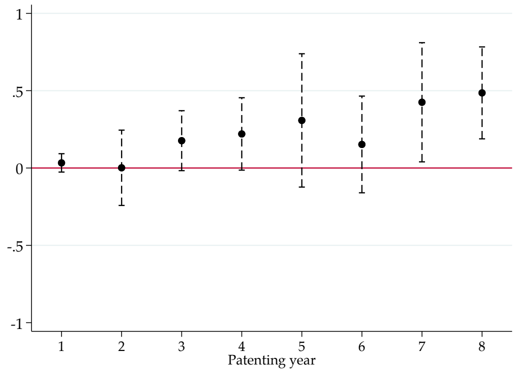
(e) Cites to CBI-country prior-art



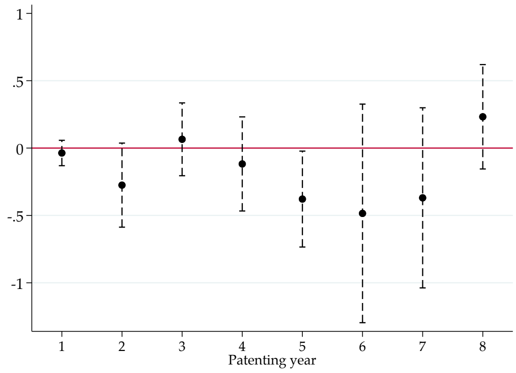
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: Inventors are assigned to their spatial mobility region of residence instead of the spatial mobility region associated with their R&D location. The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

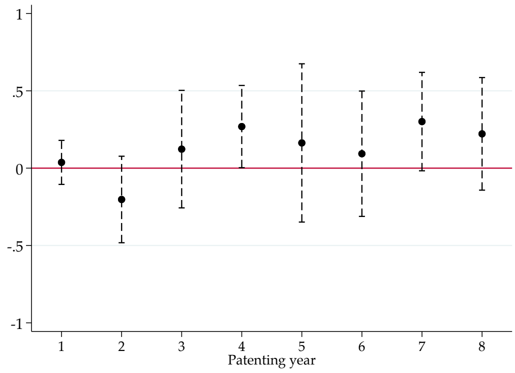
Figure D36: Junior inventors' patenting: difference-in-differences results by patenting year (alternative location assignment: applicant location)



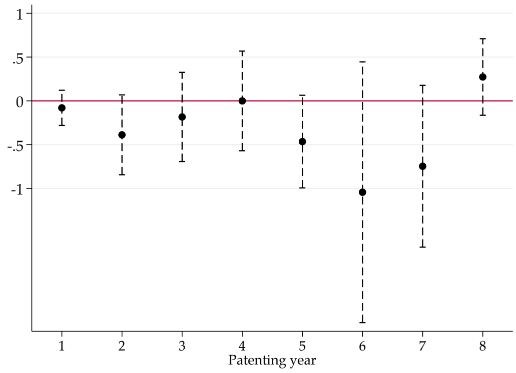
(a) Patents



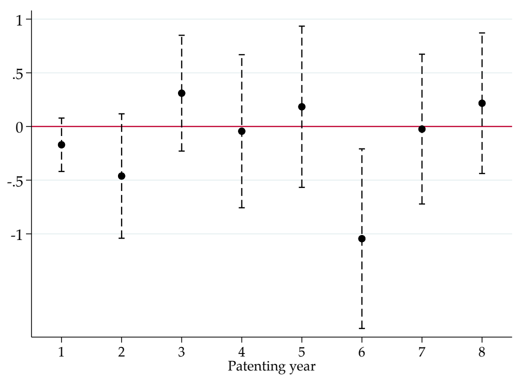
(b) Patents (excl. cross-border inventors)



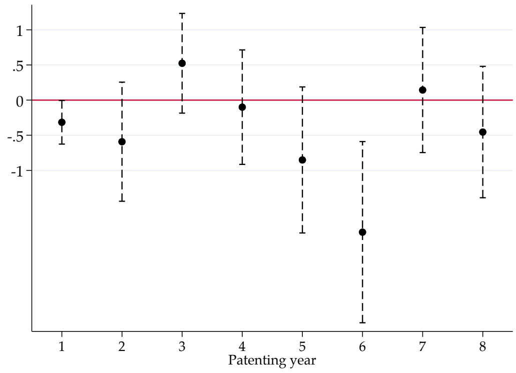
(c) Distinct co-inventors



(d) Distinct co-inventors
(excl. cross-border inventors)



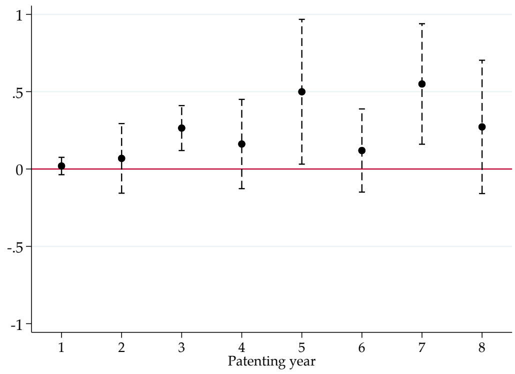
(e) Cites to CBI-country prior-art



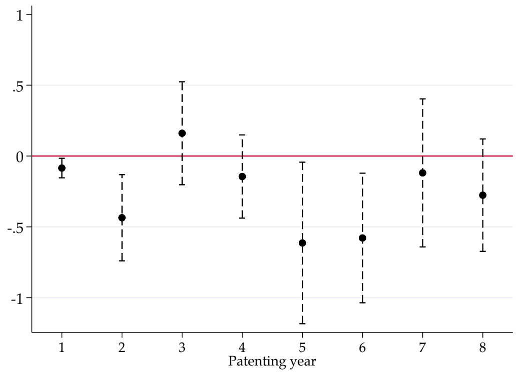
(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: Inventors are assigned to the applicant's spatial mobility region instead of the spatial mobility region associated with their R&D location. The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

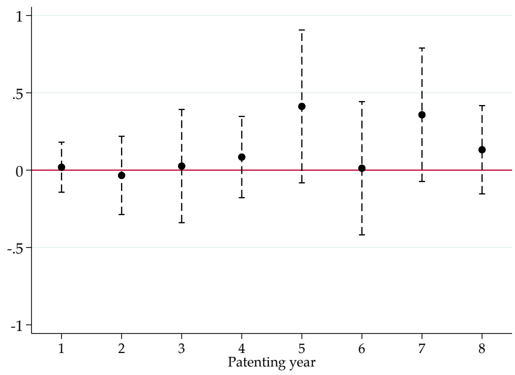
Figure D37: Junior inventors' patenting: difference-in-differences results by patenting year (only granted patents)



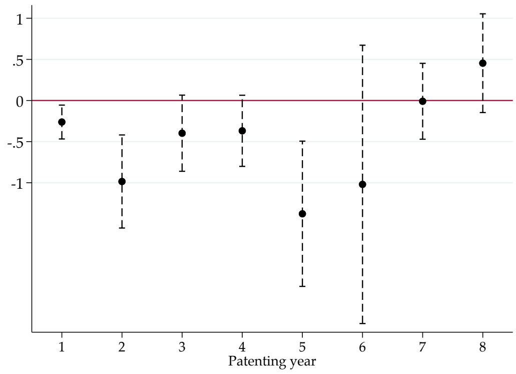
(a) Patents



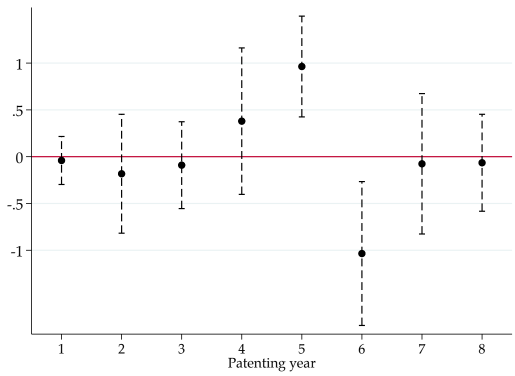
(b) Patents (excl. cross-border inventors)



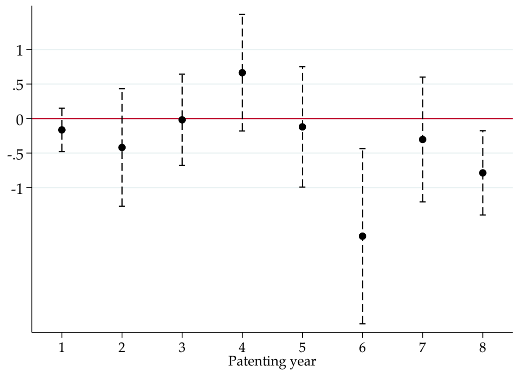
(c) Distinct co-inventors



(d) Distinct co-inventors
(excl. cross-border inventors)



(e) Cites to CBI-country prior-art



(f) Cites to cross-border inventor-country prior-art (excl. cross-border inventors)

Notes: The sample is based only on information from granted patents. The treated group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is below or equal to 20 minutes. The control group includes inventors who filed their first patent in border regions whose driving distance from the closest border crossing is above 20 minutes. For each patenting year $\tau \in \{1, \ldots, 8\}$, we report the difference-in-differences estimate β_τ from the interaction $AFMP_{c(i)} \times Treated_{m(i)}$, where $AFMP_{c(i)}$ is equal to 1 for inventors first patenting in 1999–2000 and 0 for inventors first patenting in 1990–1993. All regressions include region, calendar year, and technology field fixed effects. Vertical bars represent 95% confidence intervals. Robust standard errors are clustered at the spatial mobility region level. Estimations by Poisson pseudo-maximum-likelihood.

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