How residence permits affect the labor market attachment of foreign workers: Evidence from a migration lottery in Liechtenstein*

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Abstract

We analyze the impact of obtaining a residence permit on foreign workers' labor market and residential attachment. To overcome the usually severe selection issues, we exploit a unique migration lottery that randomly assigns access to residence permits for (prospective and current) workers with an employment contract in Liechtenstein, which is situated centrally in Europe. Using an instrumental variable approach, our results show that lottery compliers raise their employment probability in Liechtenstein by on average 24 percentage points across outcome periods (2008 to 2018) as a result of receiving a permit. Relatedly, their activity level and employment duration in Liechtenstein increase by on average 20 percentage points and 1.15 years, respectively, over the outcome window. These substantial and statistically significant effects are predominantly driven by individuals not (yet) working in Liechtenstein prior to the lottery rather than by previous cross-border commuters, but even for the latter group (generally living relatively close to the border), important positive employment effects emerge in the longer run. Indeed, we find both the labor market and residential effects to be persistent even several years after the lottery with no sign of fading out. These results suggest that granting resident permits to foreign workers can be effective to foster labor supply, despite the alternative of commuting cross-border from adjacent regions.

Keywords: international migration, cross-border commuting, natural experiment, lottery
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1 Introduction

Many labor markets rely on both locally-born and foreign-born workers. For instance, the share of foreign-born persons in the U.S. labor market corresponds to 17.4% in 2019, amounting to 28.4 million people.[1] World-wide, the number of migrant workers is estimated to be 169 million in 2019, with 22% in North America, 32% in Europe, and 13% Asia (International Labour Oranization (ILO), 2021). While migration from low to higher income countries receives a lot of attention in public and scientific discussions, an immense amount of labor mobility is realized between rather developed nations, likely competing for skilled workers. For example, 54 million people migrated from one developed country to another one in 2013 (Martin, 2013). Attracting and retaining qualified foreign workers may be key for economic growth in industrialized countries, especially in times of population aging and the accompanying decline or stagnation of the native labor force. To address the high demand for such talent, there are various policy tools. These range from admitting cross-border commuters or seasonal workers to granting temporary or permanent residence, or even citizenship. As granting more rights to foreign workers may attract more and better talent, but may also be (perceived as) more costly and contentious, a crucial question for a policy-maker is how far one should go in this direction (e.g. Hainmueller and Hopkins, 2014; Dustmann and Görlach, 2016).

Specifically, we ask *how important are residence permits to attract and retain migrant workers?* Residence is not always a necessary condition for labor supply because in many countries and regions, foreign workers could also commute cross-border. In France, for instance, about 438k workers commute to another country every day for work.[2] Nevertheless, residence permits might be more successful in fostering foreign labor market attachment relative to the alternative of cross-border commuting, in particular if they come with benefits valued by foreign workers like a more favorable income taxation and/or reduced commuting times. The challenge in answering our research question is that the comparison between foreign workers with and without residence permit is generally plagued by selection bias. Driven, for instance, by a host country's

[1] Reported by U.S. Bureau of Labor Statistics, https://www.bls.gov/news.release/forbrn.nr0.htm/labor-force-characteristics-of-foreign-born-workers-summary, retrieved 2021-02-11.

[2] Reported by EUROSTAT, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Statistics_on_commuting_patterns_at_regional_level&oldid=463740, retrieved 2021-02-11.

formal eligibility criteria for residence as well as individual factors determining the inclination to reside in another country, the two groups of foreign workers are typically different to an extent that makes it prohibitively hard to isolate the effect of the residence permit from other factors. To identify the causal effect of interest we would ideally assign residence permits at random, while cross-border commuting remains a viable option.

In this paper, we assess the causal effect of obtaining a residence permit on the labor market and residential attachment of foreign workers based on an annual migration lottery that is unique in Europe. In Liechtenstein, a wealthy microstate that is situated between Austria and Switzerland, two lottery draws for residence permits are held every year. The lottery randomly assigns access to residence permits among applicants from the European Economic Area (EEA) who hold an employment contract with a company in Liechtenstein. This eligibility condition includes both *cross-border commuters* already working in Liechtenstein and *prospective employees* who hold an *employment contract* for a job starting in the near future. The European Economic Area (EEA) is a free trade agreement among all member states of the European Union (EU), plus the three countries, Norway, Iceland, and Liechtenstein.[3] We are the first to link European migration lottery data with administrative data on individual labor market records. There are two draws for each lottery, the pre-draw and the final draw. Participants must win in both parts of the lottery to receive a residence permit. We exploit the random assignment in the *pre-draw* as instrument for the reception of a residence permit that is conditional on actually residing in Liechtenstein in the treatment period. This allows us to assess the local average treatment effect (LATE) of residing in Liechtenstein, which implies being granted a residence permit, among compliers. Compliers, who make up 36% of our sample, are individuals for whom winning the pre-draw of the lottery also entails participating and winning in the final draw and actually residing in Liechtenstein one year later, while losing the pre-draw entails not residing in Liechtenstein one year later. We consider the assignment in the pre-draw of the *first* lottery participation, as it is endogenous whether interested candidates participate multiple times in such a lottery. We apply a flexible instrumental variable (IV) estimator based

[3]The EU member states are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

on inverse probability weighting (IPW). The latter reweighs the outcomes by the inverse of the conditional instrument probability (the likelihood of winning the pre-draw) given the lottery year, the so-called instrument propensity score, in order to balance the distributions of lottery years across complier groups winning and losing the pre-draw. This enables us to control for the fact that the share of lottery winners in the pre-draw changes over the years as a function of lottery applicants, which is important in order to avoid confounding, e.g. due to business cycle effects.

We find that receiving a residence permit boosts the probability of being employed in Liechtenstein by 24 percentage points on average across our outcome periods 2008 to 2018. Likewise, it increases the activity level by 20 percentage points, and the employment duration in Liechtenstein by 1.15 years. Lottery losers also hold an employment contract with a company in Liechtenstein, but do not remain as long in its labor market or even chose to dissolve it before entering. These substantial labor attachment effects remain robust to the inclusion of further covariates in the IPW estimator like gender, age, and nationality. Moreover, we assess the effect of receiving the residence permit on residence in Liechtenstein two and more years after the lottery.[4] The residence probability and the duration increase significantly by 71 percentage points and 3.44 years, respectively, on average (across outcome periods), with little differences between previous cross-border commuters and non-commuters. We also consider the labor market and residential effects separately by year after the lottery and find them to be persistent with no sign of fading out. That is, even in the tenth year after the first lottery participation, the impact on the employment and residence probability is comparable to the respective average effect across all periods and statistically significant at the 5% level, albeit confidence intervals are large due to the smaller sample size. We argue that tax advantages and more convenient commutes are likely the main motivations to reside in Liechtenstein, as confirmed by a survey among foreign workers in Liechtenstein, see Marxer et al. (2016).

When assessing the heterogeneity of the employment effect across previous cross-border commuters and non-commuters who have not worked in Liechtenstein yet when participating in the lottery, we find the LATE to be stronger and statistically significant in the latter group. There-

[4]Lottery losers may participate in future lotteries and then receive a residence permit.

fore, resident permits appear to incentivize potential new labor market entrants to immediately start working in Liechtenstein, which importantly contributes to the overall employment effect. Nevertheless, the permits also seem to keep previously commuting workers in the labor market in the longer run, while hardly affecting their labor supply in the short run (which necessarily follows from the fact that in the first years after the lottery, the vast majority of the control group not receiving a residence permit remains employed in Liechtenstein, too). Therefore, the LATE on employment strongly differs in initial outcome periods between previous commuters and non-commuters, but becomes much more similar in later periods, with the caveat that confidence intervals are generally large in those periods. The analysis of effect heterogeneity hence yields the following findings for the two subgroups: First, randomly denying residence to commuters substantially reduces their labor market attachment in the longer run (which may seem surprising given that they live relatively close by), even if most remain employed during the first few years. We observe that these employment effects on commuters are driven by individuals who entered the labor market quite recently before the lottery. Second, denying residence to workers not employed in Liechtenstein before strongly reduces their labor supply immediately, despite holding a contract with a company in Liechtenstein.

Very broadly speaking, our paper fits into the literature on migration policies and its implication for the local labor market, see e.g. Fasani et al. (2020). More specifically, it is among a relatively scarce number of studies that exploit migration lotteries to convincingly assess the causal effect of residence permits on labor market behavior or related outcomes. Gibson et al. (2011), for instance, investigate a lottery in the Pacific island state of Tonga for residence permits in New Zealand and study welfare effects on household members of families left behind. Gibson et al. (2017) use that same lottery and find positive income effects among migrants themselves. Gibson et al. (2013) use a different lottery, the Samoan Quota, to examine the impact of a household member's immigration to New Zealand on the income and poverty of those left-behind in the Pacific island state of Samoa. Clemens (2013) analyzes a lottery in a specific multinational firm that allocated U.S. visas to Indian software workers and concludes that migration to the U.S. entails a sixfold increase in wages. Mergo (2016) considers the U.S. Diversity Visa lottery for Ethopians and finds that their migration to the U.S. increases welfare

(in particular consumer expenditure) of the families left behind in Ethiopia. Mobarak et al. (2020) examine a visa lottery for low-skilled workers from Bangladesh intending to work in the palm-oil industry in Malaysia; and find that migration leads not only to a substantial income rise among migrants, but also to an increase in the household consumption of the family left behind.

While the previously mentioned studies consider migration from a less developed to a more developed country, a rather unique feature of our lottery study is that it concerns member states of the European Economic Area (EEA). Therefore, our paper contributes to the literature by considering labor migration between rather developed and wealthy countries. This appears important, as industrialized countries face demographic challenges due to an aging population and associated constraints in labor supply which might be mitigated by (skilled) labor migration, which frequently takes place between rather developed nations.

A second important distinction is that we focus on the labor force attachment of individuals that could resume or start working in Liechtenstein even without living there, i.e. by means of cross-border commuting, in particular from nearby Austria or Switzerland, which is actually the most common form of labor in Liechtenstein.[5] Comparable scenarios with opportunities to commute cross-border exist in the border regions of the United States with Canada and Mexico, respectively, and at the outside borders of the EU, e.g. between Poland and the Ukraine as well as between Singapore and Malaysia in Asia. Depending on the legislation, cross-border commuting is regulated more or less restrictively across these countries, see, e.g. Orraca Romano (2015), Francis (2019), and Strzelecki et al. (2021). Similar to our setting, the US records daily inflows of cross-border commuters and conducts an immigration lottery, yet Canadians and Mexicans are excluded from this lottery.[6]

From a policy perspective, it appears interesting to compare the migration lottery with alternative labor migration policies. The economic relevance of such regulations with respect to cross-border commuters is, for instance, studied by Beerli et al. (2021). The authors find for

[5]Indeed, slightly more than 50% of the employees in Liechtenstein commute cross-border. Among the 29k foreigners who work in Liechtenstein, about three thirds (76.9%) commute cross-border (Amt für Statistik Fürstentum Liechtenstein (AS), 2018a).

[6]https://worldpopulationreview.com/country-rankings/green-card-lottery-countries

Switzerland that reducing restrictions for cross-border workers increased the size and productivity of skill-intensive sectors (in particular those with previous skill shortages) such that even the wages of highly educated natives rose, despite the hike in foreign employment. Naguib (2019) focuses rather on heterogeneous effects and finds that travel time to the Swiss border increases the wage mobility of middle-aged workers, but decreases it for less-educated workers. Our paper appears to be the first that investigates the effects of a migration lottery relative to cross-border commuting. Well-known labor migration policies include the EU's "Blue Card" and the American "Green Card" system. The former provides non-permanent residence to candidates with university degree. Similarly, the latter targets highly-skilled workers, but even provides permanent residence. The migration lottery in Liechtenstein is somewhat in between these two by offering residence permits that last for five years, can be renewed, but are contingent on the reason of working in Liechtenstein. In contrast to the Green Card and Blue Card systems, the migration lottery in Liechtenstein does not impose requirements in terms of education or work experience. However, it does require an employment contract with an employer from Liechtenstein, which means that the participants have skills and experience that match the demand.[7] Complementary to this lottery, Liechtenstein's government also regularly grants a similar number of residence permits to employees from the EEA and Switzerland at their discretion, see Marxer (2012). This tool is said to be used for filling key positions in local key employers and hence addresses workers with high qualifications and with an exceptionally strong fit to the labor market.[8] The benefits of this targeted labor migration tool are likely higher than those of the random lottery, but we cannot identify its effects due to the non-random assignment. Finally, granting a long-term or permanent perspective, e.g. through citizenship, might be beneficial not only to attract and keep talent, but also to foster the employees' investment in specific human resources (Dustmann and Görlach, 2016) and to foster integration (Hainmueller et al., 2017).

Our paper also relates to the tax-induced migration literature, see, e.g. Kleven et al. (2020) for an overview. Foreign employees with a residence in Liechtenstein pay substantially lower taxes than cross-border commuters. Therefore, cross-border commuters and prospective foreign

[7] Among the biggest employers in Liechtenstein are ThyssenKrupp-Presta, Hilti, Ivoclar Vivadent, Hilcona, LGT, Ospelt, OC Oerlicon, Liechtensteinische Landesbank, and the VP Bank.

[8] For EEA citizens who do not belong to the working population and can finance their livelihood from their own resources, there is another lottery that is conducted at the same time as the lottery we study.

employees have a tax incentive to apply for a residence permit for Liechtenstein. While the majority of the literature focuses on top earners or high achievers (see, e.g. Agrawal and Foremny, 2019, Kleven et al., 2013, Young et al., 2016 and Akcigit et al., 2016), we include all lottery applicants in our analysis. Furthermore, while the aforementioned literature examines the influence of taxes in the destination country on the decision to immigrate, it does not address *how long the destination country can hold on to these immigrants because of tax incentives.* Our paper sheds light on this question by showing whether residence permits (and the associated amenities like tax reductions) incentivize foreigners to remain in the labor market. This appears to be an important piece of information for policy makers in a competitive open economy with a high demand for foreign labor and an aging population, as it is the case in Liechtenstein.

The remainder of the paper is structured as follows. Section 2 provides information about Liechtenstein and its migration lottery. Section 3 introduces our data and provides descriptive statistics. Section 4 discusses the empirical strategy. Section 5 presents and interprets the results. Finally, Section 6 concludes.

2 Institutional background

This section gives a very brief overview of the economy, the labor market, and the migration lottery of Liechtenstein.[9] As illustrated in Figure A.3 in the Supplemental Online Appendix, Liechtenstein is a micro-state situated in Central Europe, between Switzerland in the West and Austria in the East. The official language is German. Liechtenstein's population amounts to almost 40k inhabitants, while its labor force is of roughly the same size – in fact, slightly exceeding the population. Liechtenstein is a small open economy. Since 1923 it has had a customs union with Switzerland and since 1995 it has been a member of the European Economic Area (EEA), which includes all European Union (EU) states plus Norway and Iceland, but not Switzerland. Hence, Liechtenstein has close economic ties with both Switzerland and the European Union. Exports of goods and services, excluding trade with and via Switzerland, account for 55% of its GDP. Its most important industries are mechanical engineering and the

[9] More details about the institutional background are provided in Supplemental Online Appendix A.1.

provision of financial and insurance services, which account for 16.2% and 13.3% of the GDP, respectively (Amt für Statistik Fürstentum Liechtenstein (AS), 2018c). Liechtenstein is among the wealthiest countries in the world with a nominal GDP per employed person of about 200k USD. The official currency in Liechtenstein is the Swiss Franc (CHF), which had an average exchange rate of 1.04 USD/CHF in the last decade.

The labor market in Liechtenstein is characterized by a low unemployment rate and a large demand for foreign labor. The strong economic growth in recent decades in combination with the small size of the country fueled an ongoing employment expansion. Table 1 documents the increase in the number of employees from 1980 onwards and also distinguishes between employees residing in Liechtenstein and cross-border commuters, which have grown even faster than the total labor force. Since 2010 there have been more cross-border commuters in the work force than employees residing in Liechtenstein. Most employees work in the service sector (61.9%) followed by the industrial sector (37.4%).

Wages in Liechtenstein are relatively high when compared to other Western European countries, which is most likely an important pull factor for attracting foreign labor. The median gross wage per month is about 7k USD, which is similar to the level of neighboring Switzerland, and substantially higher than in most EU countries, including neighboring Austria. The gross median income of cross-border commuters (CHF 6,723) is similar to that of residents (CHF 6,612) (Amt für Statistik Fürstentum Liechtenstein (AS), 2018b). Cross-border commuters are predominantly male (64.4%), working in the tertiary sector (55%), living in Switzerland or Austria (96%), and holders of a citizenship of a member country of the EEA (62.2%) (AS, 2018b).

One important reason for the high share of cross-border commuters among the labor force is regulated access to residence permits in Liechtenstein. Despite being a member of the EEA, Liechtenstein is permitted to restrict residence of EEA citizens in Liechtenstein. However, by the EEA treaty, Liechtenstein is required to issue at least 56 residence permits for the purpose of employment every year, half of which must be assigned by a lottery.[10]

[10]Despite the restrictive rules for immigration to Liechtenstein there is an inflow of 17.0 (net inflow of 4.3) immigrants per 1,000 inhabitants (Amt für Statistik Fürstentum Liechtenstein (AS), 2019b). The dominant formal purpose for immigration to Liechtenstein is family reunification. The fraction of foreigners among the residents in Liechtenstein is 34% (Amt für Statistik Fürstentum Liechtenstein (AS), 2020).

Table 1: Number of employees in Liechtenstein

	Employees in Liechtenstein		
Year	Residing in Liechtenstein	Cross-border commuters	Total
1980	11,543	3,297	14,840
1990	13,020	6,885	19,905
2000	15,605	11,192	26,797
2010	16,764	17,570	34,334
2017	17,362	21,299	38,661
2018	17,597	22,038	39,635

Note: The table shows the development of the number of (i) employees who reside in Liechtenstein, (ii) the number of cross-border commuters, and (iii) the total number of employees from 1980 to 2018. The number of cross-border commuters and the total number stem from the Amt für Statistik Fürstentum Liechtenstein (AS) (2020). The number of employees residing in Liechtenstein is self-calculated. Around 3% of employees residing in Liechtenstein are workers with a short-term residence permit (maximum 12 months).

Holding at least one lottery per year is required by law (see Law on the Free Movement of Persons for EEA and Swiss nationals (2009), section 39, 1). Usually, two lotteries take place per year, one in spring and one in fall (Ausländer- und Passamt, 2020). Each lottery consists of two stages, namely the pre-draw and the final draw (Landesverwaltung Fürstentum Liechtenstein, 2009, section 37, 2). Winning the pre-draw of the lottery will serve as our instrument in the empirical analysis. Participants must win in both parts of the lottery to receive a residence permit ("Aufenthaltsbewilligung B"), which is valid up to five years and can be extended. Family reunification for spouses, children and parents (if they receive financial support from the lottery participant) is possible at any time.[11]

Requirements for participation include holding an EEA citizenship and paying the participation fees in time. In the final draw, participants must also provide an employment contract of more than one year with a minimum activity level of 80% or, else, an authorized permanent cross-border business activity in case of self-employment (Ausländer- und Passamt, 2019b). After winning both the pre-draw and the final draw, the lottery participant is required to relocate within six months to Liechtenstein, otherwise the residence permit expires (Landesverwaltung Fürstentum Liechtenstein, 2009, section 37, 2). For this reason, our treatment is defined based on residing in Liechtenstein in the year after the lottery, as obtaining the permit is tied to actually residing there. The drawing of winners in each lottery is done blindly by hand. This

[11] https://www.llv.li/inhalt/117535/amtsstellen/fur-angehorige-eines-ewr-und-ch-staatsangehorigen

procedure is monitored by at least one judge.

Lottery losers of either stage may participate again in subsequent lotteries, while multiple applications to the very same lottery are not allowed (Landesverwaltung Fürstentum Liechtenstein, 2009, section 38, 1) c)). As the decision to repeatedly take part in the lottery is most likely endogenous, our main evaluation strategy relies on the first lottery participation of an individual in our data window. Furthermore, as participation in the final draw is conditional on succeeding in the pre-draw, we base our instrumental variable approach on the *pre-draw* alone.

The incentives to participate in the lottery are arguably related with the costs and benefits of residing in Liechtenstein. For most lottery participants, the relevant alternative when losing the lottery is to reside in a neighboring country and commute cross-border. However, some might decide to stop working or to not even start working in Liechtenstein, despite holding an employment contract. Furthermore, some lottery losers might enter Liechtenstein at a later point in time, e.g. by repeatedly applying for the lottery and eventually winning it or by marrying a resident of Liechtenstein. In a survey of cross-country commuters to Liechtenstein Marxer et al. (2016, p. 57) ask about the reasons to move to Liechtenstein, given the presumption that the respondents would move there in the future. The top answer is "taxes and duties" (86% of respondents), which is even ticked more often than "proximity to the workplace" (80% of respondents), while all other categories are ticked by less than 22% of respondents.[12] Indeed, taxes are substantially lower in Liechtenstein than in Switzerland such that the net disposable income of given gross incomes and household types is about 10 percentage points higher in Liechtenstein (Brunhart and Buechel, 2016). In Austria taxes are even substantially higher than in Switzerland such that the net disposable income there is likely even lower, despite the lower costs of living. Accordingly, Marxer et al. (2016) find that 31% of the cross-border commuters living in Switzerland and 75% of those living in Austria are not satisfied with their tax system; while there is a particularly low willingness to move to Liechtenstein for those (comparably few) cross-border commuters who pay taxes in Liechtenstein (these are employees who reside in Austria and work in Liechtenstein's public sector).

[12]Those who are not interested in residing in Liechtenstein are typically Austrian or Swiss citizens who live in their home country.

The second motivation to participate in the lottery, living closer to the workplace, appears obvious, but must be put into perspective: most cross-border commuters have quite short commutes. 59% of them travel less than 30 minutes to work and only 6% more than 1 hour (Marxer et al., 2016, p. 36). Furthermore, Liechtenstein's accession to Schengen in 2008 led to the abolition of systematic border controls in 2011,[13] which might lead to shorter commuting time for cross-border commuters from Austria.[14] Still, residing in Liechtenstein can lead to more convenient commutes, be it because of even shorter commuting times, fewer bus or train changes when using public transport, or different means of transport (e.g. biking instead of driving).[15]

Given these advantages of residing in Liechtenstein over commuting to Liechtenstein, we note that financial incentives are probably the most important factor for participating in the lottery, while distance to the workplace also matters. Moreover, there can be stronger integration into the local society and additional amenities which need not be fully anticipated by those willing to migrate.

3 Data

This section provides a description of our data set and the key variables along with descriptive statistics. Our data base was created by linking records from the migration lottery with employment statistics in Liechtenstein. The lottery records cover all lottery participants from 2003 to 2019. In particular, they include information on when and how often an individual applied to the migration lottery. This enables us to define the instrument based on whether an applicant has won the pre-draw or not in the first lottery participation. In addition, the data contain personal characteristics such as the year of birth, nationality, and gender, which are asked in the application form for the lottery.

The employment statistics cover the years 2005 to 2018. Every employer in Liechtenstein is

[13] https://ec.europa.eu/home-affairs/sites/default/files/e-library/docs/schengen_brochure/schengen_brochure_dr3111126_de.pdf

[14] We capture a potential effect of the abolition of systematic border controls in 2011 by controlling for year dummies in our estimation (see Section 5).

[15] Indeed, the cross-border commuters in the survey consistently name aspects of more convenient commute among the main advantages; and the less satisfied they are with their current transport situation, the more they are willing to move to Liechtenstein (Marxer et al., 2016, p. 45).

obliged to report new employment entries and exits on a monthly base. At the end of each year, companies receive a list of their reported employees for proofreading and are obliged to resubmit a corrected version (Amt für Statistik Fürstentum Liechtenstein (AS), 2019a). The employment statistics contain variables characterizing the labor market behavior of the applicants. This includes information on whether an individual has worked in Liechtenstein in the year prior to lottery participation and whether she or he has started or continued dependent employment or self-employment in the years after lottery participation. For each year, also the activity level in percent is reported, with 100% corresponding to fulltime employment and 0% to being without employment in Liechtenstein,[16] as well as the country of residence. Finally, several personal characteristics are observed that are also available in the migration lottery records, namely the year of birth, nationality, and gender. Whenever there are differences in these variables across the two data sources, we prioritize the employment statistics which we suspect to be of higher quality, as they are repeatedly provided and checked. In contrast, the lottery records only contain information that was originally handwritten in the application form. Linking both data sets is based on a unique personal identifier and the created data base is fully anonymized.

In total, the migration lottery data contain 9,906 observations from 2003 to 2019. While each lottery draw is random, the possibility to repeatedly participate in case of losing might induce a selection problem, as more persistent applicants who participate more than once in the lottery likely differ in terms of their characteristics from the initial pool of applicants. We overcome this concern by exclusively considering the first lottery participation in our data window, which reduces the sample to 5,091 observations. Hence, we compare individuals who won when first participating in the lottery with those who lost, but might have participated again and won in a later lottery. This strategy yields conservative effects in the sense that they likely provide a lower bound to those of a hypothetical comparison of winning vs. losing and being prevented from any further lottery participation. Since the employment statistics are only available from 2005 onwards, we restrict the sample of first lottery participants to the years 2006 or later, in order to observe the labor market state of each applicant in the year prior to the lottery. This will be

[16] Including individuals without employment in the activity level variable may not appear intuitive. However, as we use activity level as outcome variable, discarding observations without employment in Liechtenstein would introduce Heckman (1976)-type sample selection bias in our econometric analysis.

important for our analysis of effect heterogeneity across previous cross-border commuters and newly attracted workers. Another sample restriction comes from the fact that the last period in which outcomes are observed in the employment statistics is 2018. This requires us to consider 2016 as last lottery year, because outcomes are measured at the earliest 2 years after the lottery, as it will become clear from the discussion further below. Figure 1 shows the annual number of the first lottery participants from 2006 to 2016, separately for the spring and fall lotteries. Moreover, Figure 1 indicates that this number varies across years, which is also true for the number of all lottery participants, with a peak during the financial crisis in 2008.[17] Thus, the odds of winning change over time, as the amount of lottery-assigned permits is not deterministic in the number of (first) applications. This implies that the lottery year is a likely confounder of our instrument variable assignment in the pre-draw, as the year is likely associated with labor market outcomes through the business cycle. We therefore control for lottery year dummies in our IV approach and include the additional control variables age, nationality, and gender in a robustness check. In sum, our evaluation data set contains 3,145 participants, out of which 350 win the pre-draw in their first participation.

Table 2 reports the proportion of winners and losers in the pre-draw and final draw respectively for their first-time lottery participation starting in the year 2007.[18] In total 2,834 participants take part in the first draw of whom 2,513 lose the first draw and 321 win the first draw. 76% of the pre-draw winners participate in the final draw. The remaining 23% consist of individuals who do not participate in the final draw because their plans have changed or they did not have an employment contract in Liechtenstein and could not secure one within a deadline of less than three months, or because they are not allowed to participate in the final round.[19] Of the pre-draw winners that do participate in the final draw, 151 individuals – that is 62% of the participants in the final draw, and 47% of the winners of the pre-draw – win the final draw and

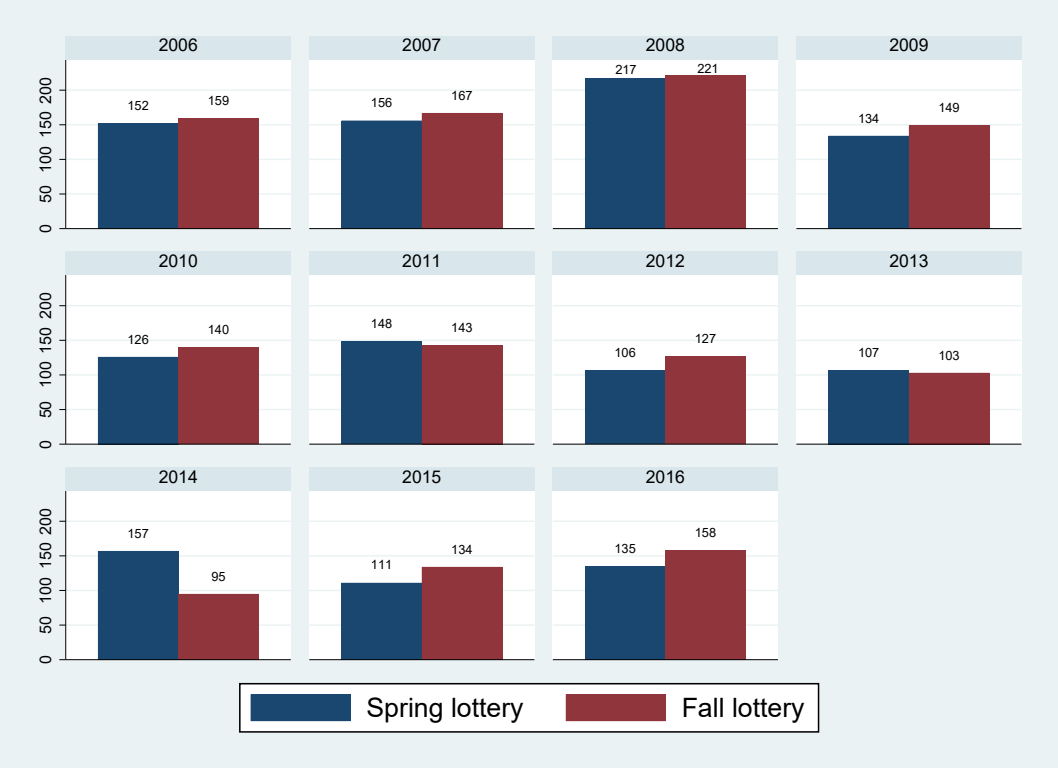
[17]The high number of lottery applications during the financial crisis may partly be driven by more applications from individuals previously not working in Liechtenstein, aiming to escape the crisis-induced deteriorating labor market conditions in their home country, as suggested by descriptive statistics in Table A.3 below. Furthermore, the higher number might partly be caused by cross-border commuters suspecting a larger chance of losing employment when being a commuter rather than a resident, in line with findings in Kuptsch (2012) that migrants face disproportionately higher risks of job loss in case of economic woes.

[18]Since we had no data available for the winners in the final draw in 2006.

[19]The latter group includes participants whose participation form for the pre-draw was submitted incomplete or late, as they were nevertheless included in the pre-draw such that they had the opportunity to appeal against the decision that their submission was invalid.

are compliers if they indeed reside in Liechtenstein. Any other winners of the pre-draw lottery are non-compliers. In particular, 38% of the final draw participants do not win and hence do not obtain a residence permit. Among the lottery losers about one third (34%) apply at least once more in a future lottery (within our data window).

Figure 1: Annual number of first lottery participation



Note: The figure depicts the annual number of first lottery participation from 2006 to 2016, separately for the spring and fall lotteries. The number varies across years, which is also true for the number of all lottery participants, with a peak during the financial crisis in 2008. No sudden change in the number of lottery participants is observed during the appreciation of the Swiss franc in 2015.

Figure 2 provides a time line for the measurement of the key variables in our analysis, with t denoting a specific year. The instrument, namely the lottery assignment in the pre-draw, which we henceforth denote by Z (with $Z = 1$ for winning and $Z = 0$ for losing), is measured in the year of the first lottery participation, which is our baseline period ($t = 0$). The treatment (denoted by D), namely whether someone resides Liechtenstein ($D = 1$), which is conditional on the possession of a residence permit, or not ($D = 0$), is measured one year later ($t = 1$). The outcome periods start two years after the lottery ($t \geq 2$) and continue until

Table 2: The number and proportion of winners and losers for first-time lottery participants.

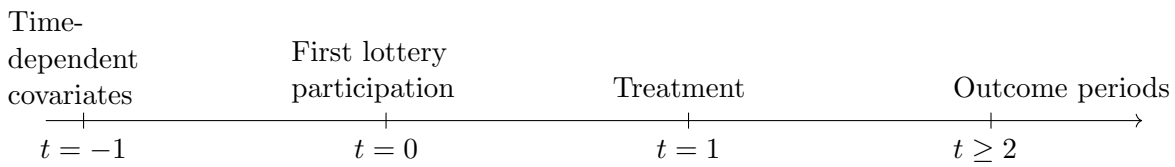
	Observations	Proportion of participants pre-draw	Proportion of winners pre-draw	Proportion of participants final draw
Participants pre-draw	2,834	100%		
Losers pre-draw	2,513	89%		
Winners pre-draw	321	11%	100%	
Non-participants final draw	75	3%	23%	
Participants final draw	245	9%	76%	100%
Losers final draw	94	3%	29%	38%
Winners final draw	151	5%	47%	62%

Note: The table presents the number and proportion of winners and losers for first-time participants (i.e. only the first lottery application of each applicant is counted). The total sum of participants in the pre-draw sums up to 3,145. However, no data was available on the final draw winners in 2006, such that we excluded all 311 observations from that year, and end up with 2,834 observations. The number of winners in the pre-draw (321) does not exactly sum up to the number of non-participants in the final draw (75) and the number of participants in the final draw (245) in the two following lines. The reason for this imbalance is missing information in the data, whether one person has participated in the final draw or not.

the end of the data window for the respective observation, at most up to 12 years after the lottery for someone participating in 2006 with the final outcome being observed in 2018. All in all, our evaluation sample includes 20,009 outcome observations. Personal characteristics (e.g. nationality) are generally measured in the year prior to the first lottery participation ($t = -1$), even though those variables that are independent from or deterministic in time (gender and age) may also be obtained from different periods. In some cases there are differences between the personal characteristics in the migration lottery records (stemming from the application form) and the employment statistics (regularly provided by the employer). As the data quality of the employment statistics appears to be higher than that of the lottery records, priority is given to the former when measuring these characteristics. We henceforth denote the control variables by X, which either only contain period dummies for the lottery years in the main specification, or also additional characteristics in our robustness checks.

To check for violations of the random assignment of residence permits through the lottery, Table 3 reports descriptive statistics on personal characteristics separately for winners ($Z = 1$) and losers ($Z = 0$) in the pre-draw of the first lottery participation in our evaluation sample. For either group, the mean and the standard deviation (std.dev) of the variables are reported as well as the mean differences across groups along with t-values and p-values. Among those

Figure 2: Time line of measured variables



Note: The figure depicts the time line for the measurement of the key variables in our analysis, where t denotes a specific year. The instrument, winning the pre-draw, is measured in the year of the first lottery participation, which is our baseline period ($t = 0$). The treatment, residing in Liechtenstein, which is conditional on the possession of a residence permit, or not, is measured one year later ($t = 1$). The outcome periods start two years after the lottery ($t \geq 2$) and continue until the end of the data window for the respective observation, at most up to 12 years after the lottery participation.

with non-missing information in the respective personal characteristics, age, gender, and the various dummy variables for nationality do not differ importantly or statistically significantly (at any conventional level of significance) across groups, thus pointing to a fair lottery. We also see from the table that the majority of the lottery participants is male, of either Austrian or German nationality, and on average 36 to 37 years old.[20] With a share of about 30%, women are indeed under-represented among lottery participants when, e.g. compared to the overall working populations (aged 20 to 64) of Austria or Germany, in which female employees accounted for more than 45% in 2019.[21] This conclusion even holds when comparing lottery participants to cross-border commuters to Liechtenstein who participated in the survey of Marxer et al. (2016), among which the female share amounts to 36%. Furthermore, lottery participants tend to be somewhat younger than those cross-border commuters, whose average age is approximately 40 years.

In contrast to the observed characteristics, the probability of missing information in nationality and age is statistically significantly different across winners and losers in the pre-draw, albeit very small in absolute terms (amounting to only 1 percentage point). This difference is, however, most likely caused by an imbalance in missingness across our two data sources rather than a failure of the lottery. To see this, note that for any individual already working in Liechtenstein prior to the lottery participation, we have access to information from the employment

[20] In this context, we note that Swiss nationals are not allowed to participate in the lottery, because Switzerland is not part of the EEA. The reason that their share amounts to 1% in our data is most likely due to holding a second citizenship from the EEA but reporting the Swiss nationality in the employment statistics.

[21] See the gender equality index of the European Institute for Gender Equality at https://eige.europa.eu/gender-equality-index/2019/domain/work/AT, accessed in Oct 2022.

statistics, in which case there is no missing information. For those not working in Liechtenstein prior to the lottery, we have to rely on the variables coming from the application process of the migration lottery, in which missings do occur. Albeit some of the missing information can be filled based on the employment statistics in later (i.e. treatment or outcome) periods, in particular for determining gender or the age in the year of the lottery, this is dependent on entering the labor market in Liechtenstein at some point in time. As pre-draw losers enter the labor market less frequently than pre-draw winners, their share of missing covariates is endogenously higher even under a satisfaction of randomized assignment. This issue does not affect our main results since we do not drop any observations with missing covariate information, in order to avoid jeopardizing randomization through an endogenously selected subsample.

Table 3 also reports the year dummies for the first lottery participation across instrument values in the pre-draw, providing information about variation in the ratio of pre-draw winners and losers across different years. For year 2008, the mean difference in dummies is statistically significant at the 1% level, owing to the large number of lottery applicants in that year (see Figure 1), a likely consequence of the financial crisis of 2007-2008. Such potential business cycle-related confounding motivates controlling for period dummies in our IV approach.

Table A.1 in the Supplemental Online Appendix reports the statistics on the outcomes of the first lottery in our evaluation sample over the each outcome period and pooled over the time. For each outcome, the mean and the standard deviation (std.dev) are reported. We note that the probability of residing in Liechtenstein is rather stable over time and amounts to an average probability of 15% among lottery participants. The probability of being employed and the activity level (100% for fulltime and 0% for no employment) decrease over time. On average, lottery participants are employed with a probability of 44% and work at a 40% level, which is a weighted average of individuals with different activity levels, for instance working fulltime (100%) or not working at all. Contrarily, the years employed and residing in Liechtenstein increase over time. On average, a lottery participant resides in Liechtenstein for half a year and is employed there for two years.

Table 3: Descriptive statistics of covariates: First participation from 2006 to 2016

	$Z = 1$		$Z = 0$					
	mean	std.dev	mean	std.dev	mean difference	t-value	p-value	observations
Female	0.29	0.45	0.30	0.46	-0.01	-0.51	0.61	3,145
Nationality								
Missing Dummy	0.00	0.00	0.02	0.13	-0.02	-6.76	0.00	3,145
Austria	0.38	0.49	0.37	0.48	0.01	0.40	0.69	3,100
Germany	0.39	0.49	0.42	0.49	-0.02	-0.88	0.38	3,100
Italy	0.06	0.24	0.07	0.26	-0.01	-0.88	0.38	3,100
Switzerland	0.01	0.09	0.01	0.08	0.00	0.53	0.59	3,100
Others	0.16	0.37	0.14	0.34	0.02	1.11	0.27	3,100
Age								
Missing Dummy	0.01	0.09	0.02	0.15	-0.01	-2.52	0.01	3,145
Age	36.25	9.25	36.49	9.62	-0.24	-0.46	0.65	3,078
First lottery participation								
Dummy 2006	0.09	0.29	0.10	0.30	-0.01	-0.31	0.76	3,145
Dummy 2007	0.09	0.29	0.10	0.30	-0.01	-0.57	0.57	3,145
Dummy 2008	0.09	0.29	0.14	0.35	-0.05	-2.97	0.00	3,145
Dummy 2009	0.10	0.30	0.09	0.28	0.01	0.84	0.40	3,145
Dummy 2010	0.06	0.24	0.09	0.28	-0.02	-1.74	0.08	3,145
Dummy 2011	0.11	0.31	0.09	0.29	0.01	0.85	0.39	3,145
Dummy 2012	0.09	0.28	0.07	0.26	0.02	1.02	0.31	3,145
Dummy 2013	0.08	0.28	0.06	0.25	0.02	1.17	0.24	3,145
Dummy 2014	0.10	0.30	0.08	0.27	0.03	1.50	0.13	3,145
Dummy 2015	0.09	0.28	0.08	0.27	0.01	0.75	0.45	3,145
Dummy 2016	0.08	0.28	0.09	0.29	-0.01	-0.73	0.46	3,145
Number of observations	350		2,795					

Note: The table presents the descriptive statistics of the covariates used in our analysis. The number of first lottery participants between 2006 and 2016 amounts to 3,145 observations. We report the statistics separately for pre-draw winners (Z = 1) and pre-draw losers (Z = 0) in the year prior to the lottery. The data come from the migration lottery and employment statistics, the calculations are done by ourselves.

4 Econometric approach

In this section, we discuss our instrumental variable (IV) approach for evaluating local average treatment effect (LATE), see Imbens and Angrist (1994) and Angrist et al. (1996), among lottery compliers, i.e. among those who are induced to reside in Liechtenstein in the year after the lottery by winning. Following Abadie (2003), we assume that our lottery assignment in the pre-draw, denoted by the indicator Z (1 for winning in the pre-draw and 0 otherwise), is a valid and relevant instrument for residing in Liechtenstein in the period after the lottery, denoted by the treatment indicator D (1 for residing in Liechtenstein and 0 otherwise) conditional on covariates X. The covariates either include the lottery year dummies (main specification) or both the year dummies and additional personal characteristics (robustness check). To formally state the identifying assumptions, we make use of the potential outcome notation, see e.g. Rubin (1974). We denote by $Y(z,d)$ the potential outcome (e.g. hypothetical employment in post-treatment periods) under specific instrument and treatment states $z,d \in \{1,0\}$, and by $D(z)$ the potential treatment state as a function of the instrument assignment.

Conditional IV validity, as formally stated in equation (4.1), consists of two parts: The first part (i) implies that the lottery assignment in the pre-draw is as good as random given X (i.e. observed characteristics like the lottery year dummies) and thus not associated with other factors affecting the treatment namely residing in Liechtenstein one period after lottery assignment, and/or the outcome, e.g. post-treatment employment. For reasons discussed in Section 3, this appears plausible conditional on the year dummies. The second part (ii) states that the lottery assignment must not have a direct effect on the outcome (like post-treatment employment) other through the treatment of residing in Liechtenstein, such that the IV exclusion restriction holds. This assumption is satisfied if winning or losing the lottery does not directly affect the employment decision conditional on the residence decision. Hence, the assumption excludes, for instance, that winning or losing the lottery induces sufficiently strong feelings of appreciation or disappointment that would make the participant change her labor market status.

$$
\begin{aligned}
&(i) \quad Z \perp (D(1), D(0), Y(1,1), Y(1,0), Y(0,1), Y(0,0)) | X \\
&(ii) \quad \Pr(Y(1,d) = Y(0,d) = Y(d) | X) = 1 \quad \text{for } d \in \{1,0\}
\end{aligned} \tag{4.1}
$$

Equation (4.2) formalizes the conditional monotonicity assumption, which rules out the existence of so-called defiers, i.e. of individuals that would reside in Liechtenstein in the year after the lottery if losing it, but would not reside in Liechtenstein if winning. Since lottery losers are generally not allowed to reside Liechtenstein,[22] this assumption holds by design in our context.

$$
\Pr(D(0) > D(1) | X) = 0 \tag{4.2}
$$

Equation (4.3) is a common support assumption, implying that for any value of X (i.e. any lottery year), both pre-draw winners and losers do exist. Indeed we find in our data that pre-draw winners and losers appear in any lottery year and as well across age groups, nationalities and gender.

$$
0 < \Pr(Z = 1 | X) < 1 \tag{4.3}
$$

Finally, equation (4.4) states that the instrument winning the pre-draw is relevant in the sense that it affects the treatment (residing in Liechtenstein one year after the lottery) conditional on X (year dummies). As discussed in Section 5 below, winning the pre-draw does indeed importantly and statistically significantly affect the decision to reside in Liechtenstein given the control variables.

$$
\Pr(D = 1 | Z = 1, X) - \Pr(D = 1 | Z = 0, X) \neq 0 \tag{4.4}
$$

Under these assumptions, the LATE is nonparametrically identified, see Frölich (2007), for instance, by reweighing observations based on the inverse of the conditional instrument probability $\Pr(Z = 1|X)$, known as the instrument propensity score. Equation (4.5) presents the

[22] Exceptions are that someone gets married or has a child with a resident of Liechtenstein.

identification result based on such an inverse probability weighting (IPW) approach as suggested in Frölich (2007) and Tan (2006). It is worth noting that the numerator provides the intention-to-treat effect (ITT) or reduced form effect of the lottery assignment Z on the outcome Y (e.g. employment), which is a weighted average of the LATE on compliers and a zero effect of Z among non-compliers (whose treatment does not react to the instrument). The denominator consists of the first-stage effect, i.e. the impact of the lottery assignment in the pre-draw, Z, on residence in Liechtenstein one year after the lottery, D.

$$LATE = \frac{E[Y \cdot Z/\Pr(Z=1|X) - Y \cdot (1-Z)/(1-\Pr(Z=1|X))]}{E[D \cdot Z/\Pr(Z=1|X) - D \cdot (1-Z)/(1-\Pr(Z=1|X)]} \tag{4.5}$$

For the estimation of (4.5), we use the 'lateweight' command of the 'causalweight' package (Bodory and Huber, 2018) for the statistical software R, with 1999 bootstrap replications for computing the standard error and the default trimming rule of dropping observations with propensity scores smaller than 0.05 or larger than 0.95 to ensure common support in the sample. The instrument propensity score $\Pr(Z=1|X)$ is estimated by means of a probit specification. However, we point out that our estimator is fully nonparametric when controlling for lottery period dummies only, which amounts to a fully saturated model. Our estimator is semiparametric when additionally controlling for further covariates and in particular age, whose inclusion in the linear index of the probit model imposes parametric assumptions on $\Pr(Z=1|X)$ (but in contrast to two-stage least squares neither on the treatment, nor on the outcome model).

5 Results

This section provides the empirical results. We first present the average LATE estimates when pooling all outcome periods, second, the outcome period-specific LATE estimates, third, an analysis of effect heterogeneity across subgroups, and finally, we conduct an approximate cost benefit analysis to draw some policy conclusions. In all these analyses the instrument is defined in terms of an individual's first lottery participation in our data window. We also briefly discuss the results when considering the second and third (rather than the first) lottery participation as instrument and present the results of these further analyses in Supplemental Online

Appendix A.3.

5.1 Average effects

Pooling the outcome periods provides a weighted average of effects over different complier groups and outcome periods, in which compliers who first participate in the lottery in an earlier period obtain a larger weight due to having a longer outcome window than compliers participating in a later period. Furthermore, earlier outcome periods obtain a larger weight than later ones, as earlier outcome periods (e.g. two years after first lottery participation, $t = 2$) are also observed for first lottery participants in later periods, while the observability of later outcome periods (e.g. ten years after first lottery participation, $t = 10$) is conditional on a relatively early participation in the lottery. While pooling and its implied weighting of observations might be considered as hampering the interpretability of the results, our outcome period-specific results presented further below suggest that the LATEs on the binary employment and residence decision as well as the activity level (in %) are quite persistent across different choices of t. Given that the effects are quite stable across periods, pooling yields a concise and informative LATE and at the same time entails a higher statistical power (or a smaller standard error) than outcome period-specific estimations that rely on a relatively small subsample of the data.

Table 4 reports the first-stage, intention-to-treat (ITT), and LATE estimates for pooled outcome periods when controlling for lottery period dummies. The upper panel provides the first-stage effect of the instrument on the treatment along with bootstrap-based standard error and p-values obtained from t-tests. As an individual might be observed in multiple outcome periods, we cluster observations on the personal identifier by using the cluster or block bootstrap (which resamples individuals with all related observations in any outcome period rather than single observations) when computing standard errors for any effect considered. The first-stage estimate implies that 36% of observations in our sample are compliers. The group of non-compliers largely consists of participants who won the pre-draw of the lottery but not the final draw.[23] The p-value of the first-stage is close to zero and the instrument is therefore strongly

[23] A back-of-the-envelope calculation suggests that this is the case for 46% of the non-compliers, while 37% did not or could not participate in the final draw and only 17% are winners of the final draw who do not reside in Liechtenstein.

associated with the treatment, thus supporting the relevance assumption postulated in (4.4).

The intermediate panel of Table 4 reports the intention-to-treat effect (ITT) of the instrument on the outcome. We note that the ITT is smaller than the corresponding LATE discussed further below due to the presence of non-compliers for whom the effect is zero by definition (since defiers do not exist). The ITT results suggest that winning the lottery increases the probability of residing in Liechtenstein by on average 25 percentage points and the employment probability in Liechtenstein by 9 percentage points across all outcome periods. The corresponding ITT on the activity level, which is measured in percent and by definition zero if not working in Liechtenstein, is roughly 7 percentage points. All effects are highly statistically significant. As no extremely high (>0.95) or extremely low (<0.05) probabilities of winning the lottery occur in any year of first lottery participation, no observation was trimmed such that the estimates are based on all 20,009 pooled observations, as indicated at the bottom of Table 4. In many policy evaluations, the ITT may actually appear more policy-relevant than the LATE discussed below because the number of compliers can typically not be controlled by the policy maker. In our context, however, the government sets the number of winners of both draws of the lottery and thus has to a large extent control over the fraction of compliers. Hence, the LATE seems to be the more relevant effect in our study.

The lower panel provides the LATEs (along with standard errors and p-values), which correspond to the ratio of the respective ITT and the first-stage effect. We find that residing in Liechtenstein one year after the first lottery participation increases the probability of residing in Liechtenstein by 71 percentage points and the probability of being employed in Liechtenstein by 24 percentage points among compliers when averaging over all outcome periods. Similarly, the effect on the activity level amounts to almost 20 percentage points. Furthermore, the duration of residing and being employed in Liechtenstein increases by 3.44 and 1.15 years on average, respectively, across the outcome periods, which start with $t = 2$ and are restricted by the time window of the data set. These important labor market and residential effects are highly statistically significant, as p-values are close to zero.[24]

[24]Since testing multiple hypotheses can lead to detecting more statistically significant results than actually exist (the so-called false-positive rate (Benjamini and Hochberg, 1995)), we apply the Benjamini-Hochberg (B-H) procedure. We use the command "BH" from the R-package "sgof" and set alpha equal to 0.05. We find that all

Table 4: Empirical results based on first participation and year dummies

First-stage					
Effect	0.36				
Standard error	0.03				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.25	0.09	7.06	1.23	0.41
Standard error	0.03	0.03	2.92	0.15	0.15
P-value	0.00	0.00	0.02	0.00	0.01
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.71	0.24	19.72	3.44	1.15
Standard error	0.05	0.08	7.43	0.27	0.39
P-value	0.00	0.00	0.01	0.00	0.00
Number of observations	20,009				
Trimmed observations	0				

Note: The table presents the empirical results based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The first-stage corresponds to the effect of winning the pre-draw on residing in Liechtenstein. The intention-to-treat effect (ITT) is the effect of winning the pre-draw on an outcome. The local average treatment effect (LATE) is the effect of residing in Liechtenstein on an outcome among compliers. The standard errors are estimated by cluster bootstrapping.

Table A.4 in Supplemental Online Appendix A.3 provides the results for pooled outcome periods when including age, gender, nationality, and missing dummies for these variables as covariates in addition to the lottery period dummies. The effect estimates are rather similar and again highly statistically significant. Furthermore, Tables A.5 to A.8 in Supplemental Online Appendix A.3 report the estimates for pooled outcome periods when considering the second and third lottery participation (rather than the first one) as instrument, respectively, when either using the lottery period dummies alone or additionally the personal characteristics as control variables. Also in these analyses, the findings are all qualitatively similar to our main results.

5.2 Effects over time

In a next step, we investigate the LATEs in specific outcome periods defined relative to the year of the first lottery participation when controlling for lottery period dummies. Figure 3 displays the estimates for the various outcomes from period $t = 2$ (i.e. two years after the lottery) up to period $t = 12$. The dots represent the period-specific LATEs and the bands correspond to the pointwise 95% confidence intervals based on the standard bootstrap. The triangles depict

five statistically significant effects in Table 4 remain significant.

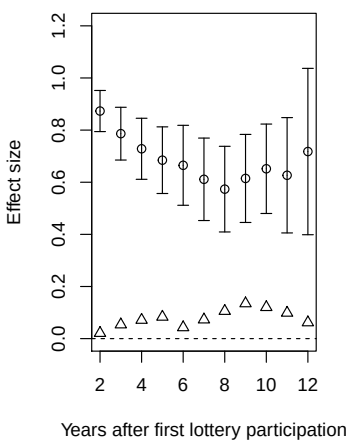
the estimated mean potential outcome among compliers under non-treatment when controlling for lottery period dummies, which is identified when replacing any Y by $Y \cdot (1-D)$ and any D by $(1-D)$ in equation (4.5).[25] The triangles hence provide the counterfactual outcomes among compliers when not residing in Liechtenstein one year after the first lottery participation. For instance, in Figure 3 (a) in year three after the first lottery participation, 5% of compliers in the control group (see triangle) have taken residency in Liechtenstein, e.g. because they won in a subsequent lottery (after losing in the first lottery) or got married to and/or had a child with a resident in Liechtenstein.[26] The LATE is 79% such that 84% of compliers in the treatment group are residing in Liechtenstein three years after their first lottery participation.

The effects on the binary residence and employment dummies as well as the activity level are positive throughout all periods and statistically significant at the 5% level in most cases. However, many of the effects are imprecisely estimated in particular in later outcome periods with a limited number of observations, which results in wider confidence intervals. Nevertheless, the positive point estimates appear to be quite persistent with no sign of fading out at the end of the data window. Furthermore, we see from Figure 3 (b) and (c) that the effects on binary employment (which does not take the actual activity level like full- or part-time employment into consideration) and on the activity level (ranging from 0% for no employment to 100% for fulltime jobs) are generally quite similar. This suggests that residence permits mainly affect the extensive margin of employment (working vs. not working), rather than the intensive margin (changing the activity level conditional on already being employed). Related to the effects on the employment and residence dummies, the LATEs on the durations of residing or being employed in Liechtenstein from $t = 2$ on monotonically increase as we consider later outcome periods and due to the persistence of the residence and labor market decisions over time, they appear to roughly follow a linear path. Panel (f) of Figure 3 provides the number of observations per outcome period as well as the number of trimmed observations, which is equal to zero just as for

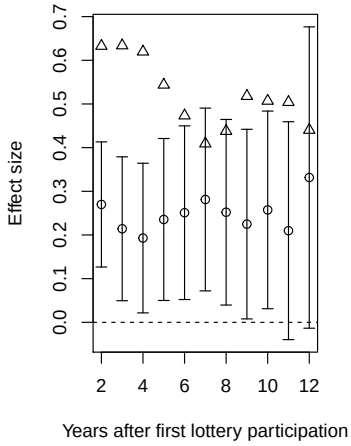
[25] See, e.g. Section 2.2 in Huber and Wüthrich (2019) for a more detailed discussion about the computation of potential outcomes among compliers.

[26] Analogously, compliers who lost the lottery and are employed in Liechtenstein in year three after the first lottery participation (see Figure 3 (b)) may, for instance, comprise the following groups: workers who entered Liechtenstein anyway (e.g. through a subsequent lottery), previous commuters who continue to commute after losing the lottery, and new labor market entrants who began commuting instead of residing in Liechtenstein after losing the lottery.

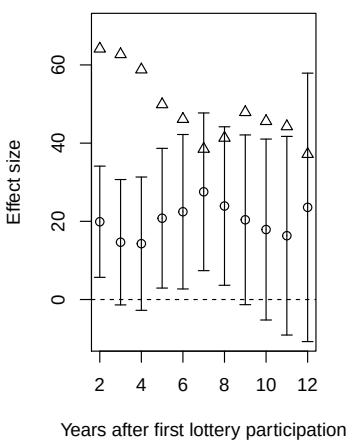
Figure 3: Effects over years



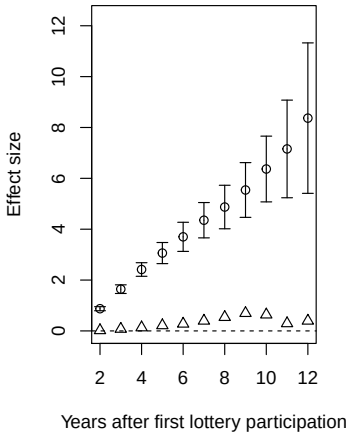
(a) Residing (binary)



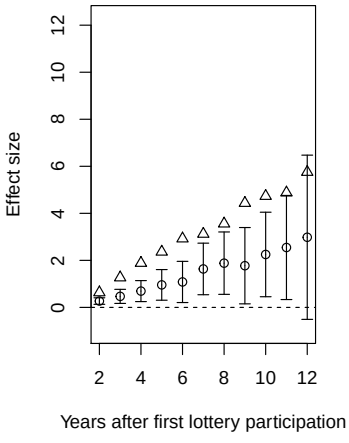
(b) Employed (binary)



(c) Activity level (%)



(d) Years residing



(e) Years employed

	Observations	trimmed
t=2	3,145	0
t=3	2,852	0
t=4	2,607	0
t=5	2,355	0
t=6	2,145	0
t=7	1,912	0
t=8	1,621	0
t=9	1,355	0
t=10	1,072	0
t=11	634	0
t=12	311	0

(f) Number of observations

Note: The figure presents the effects over years for each outcome variable. Dots represent LATEs, bands correspond to 95% confidence intervals, triangles depict the counterfactuals (i.e. mean potential outcomes among compliers under non-treatment). Hence, the effects (dots) come on top of the levels (triangles). The subfigure (f) presents the number of observations over time.

the pooled estimations. We also inspected the plots when controlling for age, gender, nationality, and missing dummies in addition to the lottery period dummies and obtained similar results.

5.3 Heterogeneity analysis

Approximately half of the observations in our evaluation data consist of participants that had already worked as cross-border commuters one year prior to their first lottery, the other half of potentially new foreign workers was not employed in, and thus not commuting to, Liechtenstein in the previous year, but may have started to commute only recently or are about to start working in Liechtenstein. Tables A.2 and A.3 in the Supplemental Online Appendix report descriptive statistics about personal characteristics separately for cross-border commuters and non-commuters in our evaluation sample. We note from the tables that the majority of applicants is male, on average 35 to 37 years old, and of either Austrian or German nationality. However, the share of the nationalities differs in both groups: German is the most frequent nationality among the non-commuters (on average 47%), whereas the Austrian nationality dominates among the cross-border commuters (on average 44%).[27]

In a next step, we check whether cross-border commuters who apply for the lottery are in terms of their personal characteristics similar to or different from cross-border commuters to Liechtenstein in general.[28] For this reason, we compare the average age, gender, and nationality of the cross-border commuters in our sample with those respective average values in the administrative statistics (Amt für Statistik Fürstentum Liechtenstein (AS), 2018a, 2019a). Male (71% versus 74%) and younger (37 years versus 41 years) occur more frequently in our lottery data. While Austrian and German cross-border commuters are the most frequent applicants in our data, they are still underrepresented, as 55% of the cross-border commuters with EEA nationality are Austrian and 24% German. Intuitively, Austrians (and Germans) who can commute from their home country are less likely to apply for the lottery than cross-border commuters with other nationalities. The study of Marxer et al. (2016) sheds more light on the self-selection

[27] As mentioned in Section 3, nationality is missing for some non-commuters, due to missing information in the lottery data that could not be compensated by information in the employment statistics.

[28] See Huber and Nowotny (2013) for an empirical study on which personal characteristics drive the willingness to commute and migrate across borders in regions of the Czech Republic, Hungary, and Slovakia that are situated close to Austria. The intention to commute or migrate is, for instance, found to be significantly negatively associated with age and being a female, and significantly positively associated with being single or feeling deprived when comparing the own social status to peers. Also higher education has a positive correlation, which is, however, not significant at the 5% level. Therefore, personal factors most likely play a role for the question which type of workers respond to specific incentives like cross-border work permits or residence permits, even though it needs to be pointed out that the findings in Huber and Nowotny (2013) do not necessarily directly carry over to the context of Liechtenstein.

into the lottery, as the authors directly ask current cross-border commuters whether they are willing to move to Liechtenstein and why.[29] The willingness to move to Liechtenstein tends to be larger for cross-border commuters with any of the following characteristics: working full time rather than part-time, earning a rather lower wage, as well as being dissatisfied in their country of residence with respect to taxes and duties, public services, costs of living, infrastructure, and transport connections (Marxer et al., 2016). It is also reported that the cross-border commuters are on average highly educated, as 57.5% of them hold a degree from a higher education institution, while there is no clear correlation between education and stated willingness to move to Liechtenstein. In our data set, information about education is unfortunately not available.

Table 5: Effects among non-commuters

First-stage					
Effect	0.28				
Standard error	0.05				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.20	0.10	8.35	0.93	0.44
Standard error	0.04	0.04	4.13	0.21	0.23
P-value	0.00	0.03	0.04	0.00	0.06
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.71	0.34	29.78	3.31	1.56
Standard error	0.13	0.15	13.83	0.60	0.79
P-value	0.00	0.02	0.03	0.00	0.05
Number of observations	10,081				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of non-commuters (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The data comes from the migration lottery and employment statistics, the calculations are done by ourselves. The standard errors are estimated by cluster bootstrapping.

From a policy perspective, it appears interesting whether treatment effects are heterogeneous across cross-border commuters and non-commuters, i.e. if residence permits are rather effective for attracting new or keeping existing foreign workers that have already decided to enter Liechtenstein's labor market at an earlier point in time. If permits were more effective among one rather than the other group, policy makers might want to consider to adapt the targeting of immigration policies accordingly. For this reason, Tables 5 and 6 report the results

[29] The stated willingness to move to Liechtenstein is indeed highly correlated with the self-declared former application to become a resident.

with pooled outcome periods separately for applicants working (cross-border commuters) and not working (non-commuters) in Liechtenstein one year prior to the lottery. In both subsamples, the residence permit has a similarly positive and highly significant effect on the compliers' probability to reside in Liechtenstein (71 vs. 69 percentage points) and their residence duration (3.31 vs. 3.46 years).[30] In contrast, we find heterogeneous effects for the LATEs on the labor market outcomes: The effects for previous cross-border commuters are positive but statistically insignificant, whereas the impacts are considerably larger and significant at conventional levels for people not (yet) working in Liechtenstein one year prior to the first lottery participation. For the latter group, we find that a residence permit leads to an increase in the employment probability of 34 percentage points, in the activity level of almost 30 percentage points, and in the employment duration of 1.56 years in the outcome periods.[31] We therefore conclude that the policy is more effective in raising labor supply among individuals previously not working in Liechtenstein than among cross-border commuters, while effects on residential choices are similar among both groups.

Within commuters, we also investigate whether the effects depend on the duration of the previous employment in Liechtenstein. To this end, we estimate the LATEs for commuters working in Liechtenstein for at least two years prior to the lottery participation (thus excluding very recent commuters). For this subsample of 5,328 observations, the employment effects are close to zero and far from being statistically significant. In contrast, we find a strong effect on the residence probability of 66 percentage points which is highly statistically significant. Findings are qualitatively similar when computing the LATEs for commuters working in Liechtenstein for at least three or four years, respectively. This suggests that within commuters, the labor market effects of a residence permit are driven by individuals who started to work in Liechtenstein rather recently and not by those already commuting for several years (and thus being possibly more committed to keep on commuting when losing the lottery).

To further investigate the heterogeneous effects on the labor market attachment of (a) non-

[30] These effects remain statistically significant after running the B-H procedure for multiple hypothesis testing with an alpha of 0.5.

[31] These effects remain statistically significant after running the B-H procedure for multiple hypothesis testing with an alpha of 0.5.

Table 6: Effects among cross-border commuters

First-stage					
Effect	0.42				
Standard error	0.04				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.29	0.05	2.86	1.47	0.24
Standard error	0.04	0.04	3.75	0.20	0.18
P-value	0.00	0.23	0.45	0.00	0.20
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.69	0.11	6.75	3.46	0.56
Standard error	0.06	0.09	8.83	0.28	0.42
P-value	0.00	0.21	0.44	0.00	0.18
Number of observations	9,928				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of cross-border-commuters (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The data comes from the migration lottery and employment statistics, the calculations are done by ourselves. The standard errors are estimated by cluster bootstrapping.

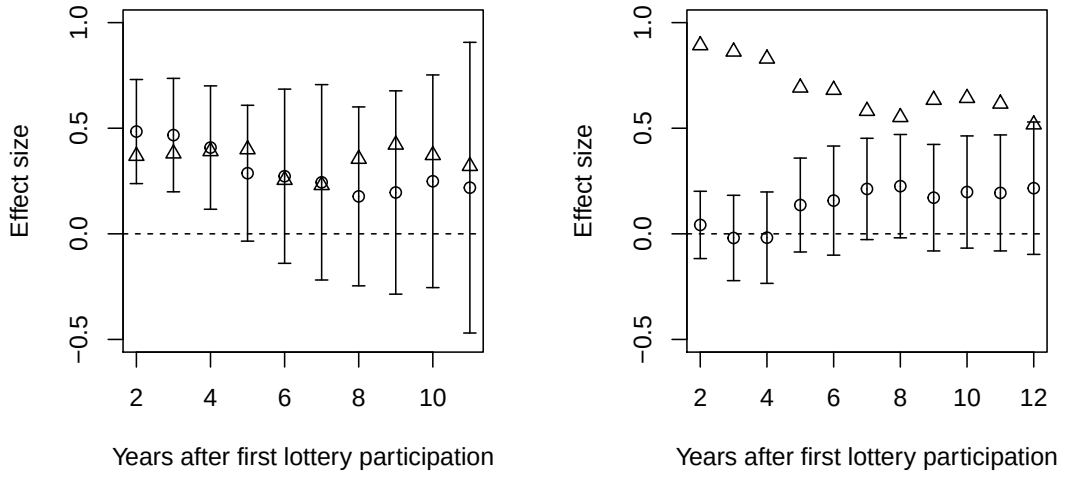
commuters and (b) cross-border commuters, Figure 4 plots the period-specific LATEs on the employment probabilities for the respective group over time as dots. In analogy to Figure 3, the graphs also include the mean potential outcomes of compliers under non-treatment, depicted as triangles. Note that we omit period $t = 12$ for the non-commuters due to a very small number of observations, which entails confidence intervals that are too wide to present them in a meaningful way in the figure. We find for the non-commuters in the periods right after the first lottery participation positive and statistically significant effects at the 1% level for the periods 2 to 4 and at the 10% level in period 5. The initial effects of an almost 50 percentage points increase appear very substantial and need to be considered against the backdrop of less than 50% in the control group working in Liechtenstein two years after the lottery and later. Hence, among compliers not being granted a residence permit, a substantial share either exit Liechtenstein's labor market right after starting their job or actually do not start to work in Liechtenstein, despite holding an employment contract with a company in Liechtenstein. The initially very large effects of an almost 50 percentage point increase in the employment probability decrease over time, but remain quite sizeable at around 20 percentage points even in later periods, even though the confidence intervals are admittedly large in those periods. This suggests that the

residence permit triggers a very strong immediate labor supply response which somewhat levels off over time.

For the commuters, exactly the opposite pattern arises. The employment effects are initially very close to zero and therefore suggest that for individuals already working in Liechtenstein, the resident permit hardly affects their labor supply in the short run. This is a necessary consequence of the fact that in the first years after the lottery, the vast majority of the control group not receiving a residence permit remains employed in Liechtenstein, as it can be seen from the triangles in panel (b) of Figure 4. The effects, however, increase over time to stabilize at roughly 20 percentage points and are even statistically significant at the 10% level in periods 7 and 8, in which about 60% of the compliers in the control group are still employed in Liechtenstein. Taken at face value, this implies that the labor market exit of about 40% of cross-border commuters six years after their first lottery participation can be cut by half when initially granting them a residence permit. Hence, resident permits are very effective for keeping previously commuting workers in the labor market in the longer run when more and more commuters without residence permit leave the local labor market. The LATE estimates in the later periods are in fact rather similar to those of the non-commuters. Therefore, the striking differences in the average LATEs over all periods between the commuting and non-commuting groups are mainly driven by the differential effects in initial periods. Taken together, the short-term effects on employment are particularly large for groups with a non-existent or short labor market history in Liechtenstein, but the long-term effects are similar for groups with a longer history.

We point out that the non-commuters in Figure 4(a) may differ with respect to their distance to Liechtenstein. Distance, which we do not observe, correlates with nationality, yielding two potentially different groups of workers: Firstly, Austrians who may live relatively close to Liechtenstein (in particular in the federal state of Vorarlberg) and who could commute rather easily if they lost the lottery, possibly from their current residence. Secondly, Non-Austrians (e.g. Germans or Italians) who live further away from Liechtenstein and for whom moving to the border region (e.g. to the municipality of Feldkirch in Austria) is possible but likely involves more effort and (monetary or psychological) costs. For this reason, we analyse the heterogeneous effects separately for Austrians and non-Austrians in Tables A.9 and A.10 provided in the

Figure 4: Effects over years on employment (binary) separately for cross-border commuters and non-commuters



(a) Non-commuters (b) Commuters

Note: The figure presents the effects over years on employment (binary) separately for cross-border commuters and non-commuters. Dots represent LATEs, bands correspond to 95% confidence intervals, triangles depict the counterfactuals (i.e. mean potential outcomes among compliers under non-treatment). Hence, the effects (dots) come on top of the levels (triangles).

Supplemental Online Appendix. In line with our conjecture about differential opportunity costs across nationalities, we find that the effects of a resident permit on the labor market outcomes among Austrians is statistically insignificant and somewhat smaller than that for Non-Austrians. For the latter group, the increase in the employment probability and the activity level of 22 and 18 percentage points, respectively, are statistically significant at the 5 and 10% levels, respectively. In conclusion, residence permits tend to be more effective for attracting foreign talent from more distant places than from closer ones from which it is easy to commute.

As a final heterogeneity analysis, we investigated whether the impact of the residence permit differs across age. Tables A.11 and A.12 in the Appendix present the results separately for relatively older (38 years and older) and younger (37 years and younger) workers. Both age groups increase their labor market attachment when obtaining a residence permit. However, the effect sizes are considerably larger for older workers (with increases in the employment probability and the activity level of 44 and 29 percentage points, respectively) and statistically

significant at the 5% level, rather than at the 10% level as for younger workers (with increases in the employment probability and the activity level of 15 and 16 percentage points, respectively). This finding might be explained by a decreasing (labor) mobility in age, see e.g. Fries-Tersch et al. (2020), when assuming that older workers are less willing to commute cross-border in case they lose in the lottery.

5.4 Approximative cost and benefit analysis

This section aims at approximating an applicant's costs and benefits of participating in the lottery in order to draw some policy conclusions. In a first step, we estimate the willingness to pay (WTP) to reside in Liechtenstein, which is arguably based on three categories of benefits: financial benefits, a more convenient commute, and other amenities. Concerning the financial benefits, Brunhart and Buechel (2016) have shown that the net disposable income of a household is typically 10 percentage points higher in Liechtenstein than in Switzerland, which holds for various household types.[32] For example, if a single adult with a relatively low market income (CHF 60,000) and no wealth moved from Sevelen (Canton St. Gallen, Switzerland) to neighboring Vaduz (Liechtenstein), her net disposable income would increase from 38% of her market income to 49%, an increase of about CHF 6,800 per year. Similarly, if a family consisting of two children and two adults with a market income of CHF 90,000 and wealth of also CHF 90,000 (which generates additional market income of CHF 3,600) moved from Maienfeld (Canton Graubünden, Switzerland) to nearby Balzers (Liechtenstein), their net disposable income would increase from 45% of their market income to 54%, an increase of about CHF 8,600 per year.[33] The main reason for the increase in net disposable income when moving from Switzerland to Liechtenstein are lower taxes, which in the former examples would reduce from 12.4% to 3.9% for the single adult and from 4.2% to 1.2% for the family.

Concerning the convenience of commuting, the alternative to residing in Liechtenstein is residing in a neighboring country (Austria or Switzerland) and to commute across the border.

[32] The calculation of net disposable income includes, among other things, the costs of health insurance, the subsidies of child care and the costs and subsidies of housing. The calculations use the year 2013, which is in the middle of our outcome periods 2019-2018, while other years would yield very similar results.

[33] Both examples are presented in Table I of Brunhart and Buechel (2016). As the authors show, the results in these examples are not untypical in any way.

Marxer et al. (2016) have elicited the commuting times in a survey, indicating that 59% of cross-border commuters have a commuting time below 30 minutes. However, those interested in residing in Liechtenstein might be a selective sample in terms of commuting time and in this context, it is worth noting that the dissatisfaction with living in one and working in the other country is particularly high among those with a commuting time of 60 minutes and more. For those residing in Liechtenstein, commuting times are short. Many employers are situated in the centrally located municipalities of Schaan and Vaduz and the distance by car or bus to these places is hardly larger than 30 minutes from any village in the country. And even when commuting from the most northern village of Ruggell to the most southern village of Balzers it would take less than 30 minutes by car, which is still the most common modal choice. We point out that a more convenient commute can also imply a change of the mode of transport (rather than a reduction in time), e.g. being able to use a bicycle instead of a car or bus.

Concerning other amenities, the survey of Marxer et al. (2016) asked cross-border commuters to assess trade-offs in possible upsides and downsides of moving to Liechtenstein and to indicate their potential willingness to move. While, financial benefits and an easier commute are top on the list, some respondents also judged Liechtenstein to have a better infrastructure. Furthermore, in the open questions, some participants mentioned that they would integrate more and identify more with the country if they could reside in Liechtenstein. Since the latter aspects as well as the convenience of commuting are difficult to quantify, we abstract from them in our estimation of the WTP and focus on financial incentives only, implying that the estimate might be a lower bound of the actual WTP.

Let us conduct a back-of-the-envelope calculation. Due to an increase in net disposable income by around 10 percentage points (Brunhart and Buechel, 2016), an applicant with an annual wage of CHF 80k (approximately corresponding to the median wage) would benefit by around CHF 8k per year. The average WTP to move to Liechtenstein should thus correspond to the net present value of obtaining CHF 8k for each year from moving to Liechtenstein until leaving the labor market in Liechtenstein (or until taking residence in Liechtenstein later in the alternative scenario that residence is not granted immediately). Assuming that benefits arrive one year after the lottery (i.e. in $t = 1$) and end after ten years (in $t = 10$) and that the discount

rate amounts to 4%, residence in Liechtenstein has a net present value of CHF 64k for a median earner. For a winning applicant whose wage is at the first wage quantile (CHF 61k) or the third quantile (CHF 108k), this net present value amounts to CHF 49k or 87k, respectively.

Compared to these benefits, the costs of participating in the lottery are low. Considering the application fee for the lottery of CHF 100 for the pre-draw and CHF 500 for the final draw, as well as the probabilities of participating in the final draw provided in Table 2, the expected costs per participation are CHF 143. When accounting for the probability of winning of 5.3% as given in Table 2, a risk neutral participant expects a net gain from investing in the lottery if her utility of winning (i.e. WTP) is above CHF 2,7k. Hence, financially it is clearly worthwhile for most cross-border commuters to participate in the lottery. The break-even point is already reached in the first year of residing in Liechtenstein.[34]

This leads us to the discussion of some policy implications. First, we consider the possibility of raising the fee for participating in the lottery. To this end, let us assume that instead of a fee of CHF 100 for the pre-draw and an additional fee of 500 for the final draw, there exists only a single fee of CHF 600 for the participation in the pre-draw. This would increase the expected costs of participation substantially (to CHF 600) and in turn make a risk neutral decision maker choose to participate only if her or his WTP for residing in Liechtenstein is above CHF 11,3k (compared to the 2,7k under the current fee regime). Given the change in the net disposable income calculated by Brunhart and Buechel (2016), this higher fee would still be very attractive for the median earner as the break-even point would already be attained in the second year of residence. However, it would deter those from participating with a particularly low WTP. Increasing the fees would hence be one step towards a more efficient rationing scheme for residence permits. However, such a policy finds its limits in the agreement with the EEA (see Law on the Free Movement of Persons for EEA and Swiss nationals (2009), section 39, 1) which binds Liechtenstein to give "equal access" to EEA citizens.[35]

A second policy intervention could relax the restrictive migration policy. In the survey of

[34] As a caveat, it is unclear to which extent the potential participants can correctly predict these incentives, as they, for instance, might possibly underestimate the (very substantial) financial benefits.

[35] Parallel to this lottery, a similar number of residence permits is granted directly by the government to fill key positions in Liechtenstein's labor market. Despite the somewhat nontransparent procedure of how these permits are allocated, the rationing is likely more efficient than a random allocation by a lottery.

Marxer et al. (2016, p. 56), 44% of the responding cross-border commuters indicated that they would move or rather move to Liechtenstein if they could freely choose their country of residence. Multiplying this fraction by the number of cross-border commuters in 2018, namely 22,000, we obtain an estimated 9,600 foreign workers who would move to Liechtenstein, not to mention any family members who might accompany the workers. Such additional residents may on the one hand increase public costs (e.g., for schooling or infrastructure), but would on the other hand also contribute to local consumption and to tax revenues. Based on our LATE estimate, which indicates that a residence permit increases the employment probability by 24 percentage points, our calculation suggests that the labor market in Liechtenstein might lose roughly 2,300 of the 9,600 foreign workers willing to move due to not providing access to a residence permit. However, we point out that this is only a rough approximation, as the lottery compliers might not be representative of the total of commuters who are willing to relocate in terms of their labor market behavior. An alternative to grant residence permits is to compensate those who commute cross-border with higher wages or with direct subsidies. The calculations of the net disposable income by Brunhart and Buechel (2016) imply that compensations had to be in the range of CHF 6k to 11k tax-free subsidies per year to make them equally well off financially. Considering that there are additional benefits of residence such as the more convenient commute, compensations would need to be rather higher. Our findings suggest that if Liechtenstein wanted to increase the number of foreign workers while at the same time ensuring a more efficient allocation of residence permits in terms of WTP, then a policy recommendation is to increase both the number of lottery winners and the fees.

6 Conclusion

In this paper, we analyzed the effect of a residence permit on the labor supply and residential decisions of foreign workers. We used a non-parametric instrumental variable approach exploiting a migration lottery in Liechtenstein. Our results show substantial effects on the labor market and residential attachment of compliers, whose migration decision complies with the permit assignment in their first lottery.

The main mechanisms are tax advantages and a more convenient commute, as these are the two main reasons to move to Liechtentstein for cross-border commuters (Marxer et al., 2016). For policy-makers in Liechtenstein our results imply that there is a trade-off between restricting the share of foreign residents (which seems to be a political goal) and powering its labor market with foreign talent. Our findings are informative for policy-makers in other regions with cross-border commuting opportunities, such as the border region of the USA with Canada or Mexico, the EU outside borders, e.g. between Poland and the Ukraine, or the case of Singapore and Malaysia. Of the two main mechanisms, tax advantages and more convenient commute, the second one may be at work and rather stronger in each of these examples, because commuting times to Liechtenstein are quite short. Finally, for policy-makers in any region or country that is interested in attracting and retaining foreign talent, our results suggest that financial incentives and a convenient commute can significantly support this goal.[36]

Moreover, we found the labor market effects to be more strongly driven by individuals previously not working in Liechtenstein than by previous cross-border commuters. In particular, resident permits appear to incentivize potential new labor market entrants to actually start working in Liechtenstein, which very importantly contributes to the overall effect. However, the permits also seem to keep previously commuting workers in the labor market in the longer run, while hardly affecting their employment in the short run (which follows from the fact that in the first years after the lottery, the vast majority of the control group not receiving a residence permit remains employed in Liechtenstein, too). Therefore, the employment effect among compliers strongly differs in initial outcome periods between previous commuters and non-commuters, but becomes more comparable in later periods (albeit statistical precision is low). Summing up, we find that denying residence to commuters substantially reduces their long term local labor market attachment, even if most remain employed in the short run. We also point out that the effects on commuters are driven by individuals who entered the labor market rather recently prior to the lottery. Furthermore, denying residence to individuals who did not work in Liechtenstein before strongly reduces their labor supply immediately, despite holding a contract with a company in Liechtenstein.

[36] Alternative mechanisms, such as social integration into a country, might also contribute to the positive effects of residence permits in Liechtenstein, as well as in these examples.

Moreover, our results pointed to stronger effects at the extensive margin of labor supply due to additional employment contracts rather than the intensive margin due to an increase in the hours worked (even though it is not feasible to strictly disentangle the two). In future research following up on our findings, one would ideally link the migration lottery data with tax or other administrative data to examine the effect of resident permits on the income (at least) of current cross-border commuters, on their social and political integration, or on the tax revenues in Liechtenstein. This would, however, be conditional on an expansion of access to anonymized administrative data for research purposes by the local authorities.

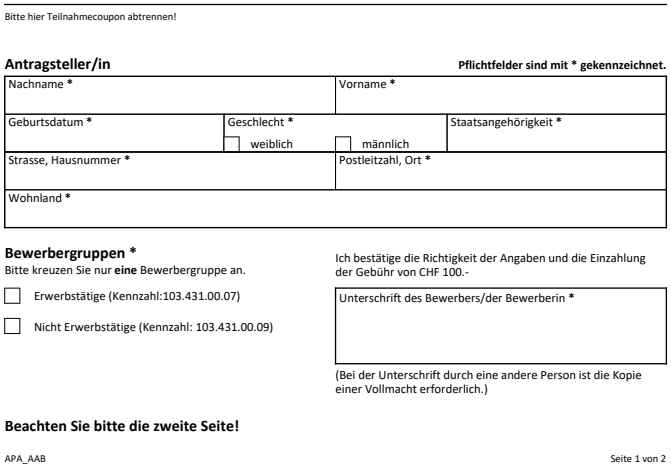
A Supplemental Online Appendix

A.1 Detailed institutional background

This section provides information about the conditions of participation in the lottery and the draw in more detail. Lottery participants must hold an EEA citizenship and transfer the required application documents as well as the participation fees prior to a specific deadline (Landesverwaltung Fürstentum Liechtenstein, 2009, section 38). The amount of the fee varies between the pre-draw (100 CHF) and the final draw (500 CHF) (Ausländer- und Passamt, 2020). Persons with an entry ban, posing a threat to public safety, or providing false statements are already excluded from the first draw of the lottery (Landesverwaltung Fürstentum Liechtenstein, 2009, section 38, 3).

In the final draw, participants must be of full age and must not hold a permanent residence permit (Ausländer- und Passamt, 2019b). Importantly, they must also provide an employment contract of more than one year with a minimum activity level of 80% or an authorized permanent cross-border business activity in case of self-employment (Ausländer- und Passamt, 2019b). After winning both the pre-draw and the final draw, the lottery participant must relocate to Liechtenstein within six months, otherwise the residence permit expires (Landesverwaltung Fürstentum Liechtenstein, 2009, section 37, 2). For this reason, our treatment is defined based on residing in Liechtenstein in the year after the lottery, as obtaining the permit is tied to actually moving there. The drawing procedure can be described as follows. All submitted applications (see Figure A.1) are put into a box and even include participants not fulfilling all conditions (to give them the chance to appeal against a later denial of a residence permit due to a violation of the conditions). In the presence of a national judge and media representatives, the winners of both draws are blindly drawn from the box and the person who draws announces the total number of winners as well as their nationality (see Figure A.2). Lottery losers of the final draw may participate again in subsequent lotteries, while multiple applications to the very same lottery are not allowed (Landesverwaltung Fürstentum Liechtenstein, 2009, section 38, 1) c)).

Figure A.1: Participation voucher



Bitte hier Teilnahmecoupon abtrennen!

Antragsteller/in — **Pflichtfelder sind mit * gekennzeichnet.**

Nachname *		Vorname *
Geburtsdatum *	Geschlecht * ☐ weiblich ☐ männlich	Staatsangehörigkeit *
Strasse, Hausnummer *		Postleitzahl, Ort *
Wohnland *		

Bewerbergruppen *
Bitte kreuzen Sie nur **eine** Bewerbergruppe an.

☐ Erwerbstätige (Kennzahl:103.431.00.07)

☐ Nicht Erwerbstätige (Kennzahl: 103.431.00.09)

Ich bestätige die Richtigkeit der Angaben und die Einzahlung der Gebühr von CHF 100.-

Unterschrift des Bewerbers/der Bewerberin *

(Bei der Unterschrift durch eine andere Person ist die Kopie einer Vollmacht erforderlich.)

Beachten Sie bitte die zweite Seite!

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Note: The figure presents the participation voucher (of 2019). Interested candidates fill out this form to participate in the pre-draw. The voucher stems from Ausländer- und Passamt (2019a).

Figure A.2: Final draw monitored by a judge

Note: The image shows exemplary the final draw of the spring lottery in 2016, which is monitored by a judge. The image comes from Michael Zanghellini, Liechtensteiner Volksblatt.

A.2 Additional information

Figure A.3: Map of Liechtenstein

Note: The figure presents the geographic position of Liechtenstein in Europe. The neighboring cantons in Switzerland are St. Gallen and Graubünden; the neighboring state in Austria is Vorarlberg. The image stems from Liechtenstein Marketing.

Table A.1: Descriptive statistics of outcomes: First participation from 2006 to 2016

	Residing (binary)		Employed (binary)		Activity level (%)		Years residing		Years employed		Observations
	mean	std.dev	mean	std.dev	mean	std.dev	mean	std.dev	mean	std.dev	
t = 2	0.13	0.34	0.55	0.50	51.94	48.75	0.13	0.34	0.55	0.50	3,145
t = 3	0.15	0.35	0.51	0.50	47.32	48.63	0.28	0.67	1.06	0.95	2,852
t = 4	0.15	0.36	0.47	0.50	43.19	48.18	0.43	0.99	1.52	1.39	2,607
t = 5	0.15	0.36	0.43	0.50	39.92	47.63	0.57	1.30	1.93	1.82	2,355
t = 6	0.14	0.35	0.40	0.49	36.53	46.79	0.70	1.60	2.30	2.23	2,145
t = 7	0.15	0.35	0.38	0.49	34.66	46.24	0.85	1.93	2.68	2.66	1,912
t = 8	0.14	0.35	0.36	0.48	32.20	45.48	0.98	2.21	2.99	3.06	1,621
t = 9	0.14	0.35	0.35	0.48	31.07	45.09	1.12	2.52	3.36	3.48	1,355
t = 10	0.14	0.35	0.34	0.47	30.06	44.51	1.23	2.80	3.69	3.86	1,072
t = 11	0.15	0.36	0.32	0.47	28.33	43.61	1.55	3.26	4.00	4.26	634
t = 12	0.18	0.38	0.34	0.48	29.57	43.93	2.02	3.83	4.58	4.75	311
Pooled	0.15	0.35	0.44	0.50	40.14	47.71	0.64	1.74	2.03	2.54	20,009

Note: The table presents the descriptive statistics of the outcome variables used in our analysis. The number of first lottery participants between 2006 and 2016 amounts to 3,145 observations in the second year after the lottery participation (t = 2) and decreases over time. Pooling all the outcome periods results in 20,009 observations. The outcomes are defined as follows: "Residing (binary)" indicates whether a person lives in Liechtenstein (=1) or not (=0). "Employed (binary)" informs about the employment status yes (=1) or no (=0) of a person in Liechtenstein. "Activity level (%)" measures the workload in per cent, whereby 0% denotes no employment and 100% represents a full time employment in Liechtenstein. "Years residing" or "Years employed" respectively, count the years of living or working in Liechtenstein. The instrument, winning the pre-draw, is measured in the year of the first lottery participation, which is the baseline period (t = 0). The treatment, moving to Liechtenstein, which is conditional on the possession of a residence permit, or not, is measured one year later (t = 1). The outcome periods start two years after the lottery (t $\geq$ 2) and continue until the end of the data window for the respective observation, at most up to 12 years after the lottery participation. The period t = 2 is based on the lottery years 2006 to 2016, whereas t = 12 is only based on 2006. The data come from the employment statistics, calculations are our own.

Table A.2: Descriptive statistics for cross-border commuters: First participation from 2006 to 2016

	$Z = 1$		$Z = 0$					
	mean	std.dev	mean	std.dev	mean difference	t-value	p-value	observations
Female	0.28	0.45	0.29	0.45	-0.01	-0.25	0.81	1,615
Nationality								
Austria	0.45	0.50	0.44	0.50	0.01	0.24	0.81	1,615
Germany	0.36	0.48	0.36	0.48	0.00	0.13	0.90	1,615
Italy	0.05	0.21	0.08	0.26	-0.03	-1.70	0.09	1,615
Switzerland	0.02	0.12	0.01	0.07	0.01	1.08	0.28	1,615
Others	0.12	0.33	0.12	0.32	0.00	0.19	0.85	1,615
Age	36.40	9.11	35.35	8.99	1.05	1.50	0.13	1,615
First lottery participation								
Dummy 2006	0.08	0.28	0.09	0.28	-0.00	-0.17	0.87	1,615
Dummy 2007	0.08	0.27	0.09	0.29	-0.02	-0.79	0.43	1,615
Dummy 2008	0.10	0.30	0.13	0.34	-0.04	-1.50	0.13	1,615
Dummy 2009	0.10	0.31	0.09	0.28	0.02	0.74	0.46	1,615
Dummy 2010	0.06	0.24	0.09	0.29	-0.03	-1.43	0.15	1,615
Dummy 2011	0.09	0.29	0.09	0.29	0.00	0.02	0.98	1,615
Dummy 2012	0.08	0.28	0.08	0.27	0.01	0.30	0.77	1,615
Dummy 2013	0.09	0.29	0.08	0.27	0.01	0.59	0.56	1,615
Dummy 2014	0.13	0.34	0.09	0.29	0.04	1.52	0.13	1,615
Dummy 2015	0.08	0.28	0.07	0.26	0.01	0.43	0.67	1,615
Dummy 2016	0.09	0.29	0.10	0.29	-0.00	-0.11	0.92	1,615
Number of observations	193		1,422					

Note: The table presents the descriptive statistics of the covariates used in the analysis for the subgroup of cross-border commuters. The number of first lottery participants between 2006 and 2016 amounts to 1,615 observations. We report the statistics separately for pre-draw winners (Z = 1) and pre-draw losers (Z = 0) in the year prior to the lottery.

Table A.3: Descriptive statistics for non-commuters: First participation from 2006 to 2016

	$Z = 1$		$Z = 0$					
	mean	std.dev	mean	std.dev	mean difference	t-value	p-value	observations
Female	0.29	0.46	0.31	0.46	-0.02	-0.43	0.67	1,530
Nationality								
Missing Dummy	0.00	0.00	0.03	0.18	-0.03	-6.82	0.00	1,530
Austria	0.29	0.45	0.29	0.45	0.00	0.03	0.97	1,485
Germany	0.43	0.50	0.48	0.50	-0.05	-1.21	0.23	1,485
Italy	0.08	0.27	0.07	0.25	0.01	0.35	0.72	1,485
Switzerland	0.00	0.00	0.01	0.08	-0.01	-2.83	0.00	1,485
Others	0.20	0.40	0.16	0.36	0.05	1.42	0.16	1,485
Age								
Missing Dummy	0.02	0.14	0.05	0.21	-0.03	-2.22	0.03	1,530
Age	36.06	9.46	37.74	10.12	-1.67	-2.06	0.04	1,463
First lottery participation								
Dummy 2006	0.11	0.31	0.11	0.32	-0.00	-0.17	0.86	1,530
Dummy 2007	0.11	0.32	0.11	0.32	0.00	0.04	0.97	1,530
Dummy 2008	0.09	0.29	0.16	0.36	-0.07	-2.71	0.01	1,530
Dummy 2009	0.10	0.30	0.09	0.29	0.01	0.45	0.65	1,530
Dummy 2010	0.06	0.24	0.09	0.28	-0.02	-1.02	0.31	1,530
Dummy 2011	0.12	0.33	0.09	0.28	0.03	1.18	0.24	1,530
Dummy 2012	0.10	0.29	0.07	0.25	0.03	1.13	0.26	1,530
Dummy 2013	0.07	0.26	0.05	0.22	0.02	1.00	0.32	1,530
Dummy 2014	0.07	0.26	0.06	0.24	0.01	0.31	0.76	1,530
Dummy 2015	0.10	0.29	0.08	0.27	0.02	0.65	0.51	1,530
Dummy 2016	0.07	0.26	0.09	0.29	-0.02	-1.06	0.29	1,530
Number of observations	157		1,373					

Note: The table presents the descriptive statistics of the covariates used in the analysis for the subgroup of non-commuters. The number of first lottery participants between 2006 and 2016 amounts to 1,530 observations. We report the statistics separately for pre-draw winners (Z = 1) and pre-draw losers (Z = 0) in the year prior to the lottery.

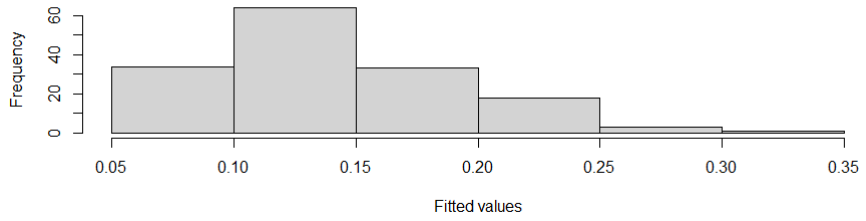
A.3 Further analyses and robustness checks

Table A.4: Empirical results based on first participation and further covariates

First-stage					
Effect	0.35				
Standard error	0.03				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.25	0.07	5.93	1.20	0.35
Standard error	0.03	0.03	2.91	0.15	0.15
P-value	0.00	0.02	0.04	0.00	0.02
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.70	0.21	16.87	3.41	0.99
Standard error	0.06	0.08	7.71	0.27	0.39
P-value	0.00	0.01	0.03	0.00	0.01
Number of observations	20,009				
Trimmed observations	388				

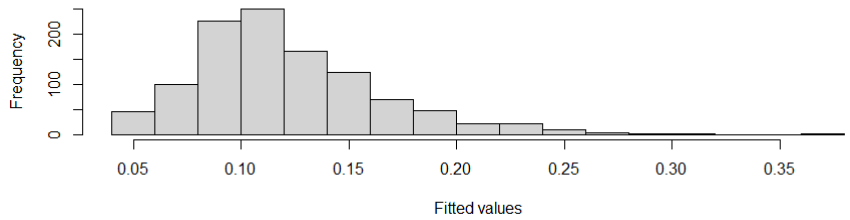
Note: The table presents the empirical results based on the first lottery participation and controls for the following covariates: Female, nationality, age and year of the first lottery. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The standard errors are estimated by cluster bootstrapping.

Figure A.4: Propensity score for the subgroup of pre-draw winners in their second participation



Note: The figure presents the propensity score for the subgroup of pre-draw winners in their second participation.

Figure A.5: Propensity score for the subgroup of pre-draw losers in their second participation



Note: The figure presents the propensity score for the subgroup of pre-draw losers in their second participation.

Table A.5: Empirical results based on second participation and year dummies

First-stage					
Effect	0.40				
Standard error	0.07				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.31	0.12	10.84	1.28	0.51
Standard error	0.06	0.06	5.13	0.29	0.26
P-value	0.00	0.03	0.03	0.00	0.05
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.78	0.31	27.39	3.24	1.29
Standard error	0.12	0.15	13.91	0.53	0.72
P-value	0.00	0.04	0.05	0.00	0.07
Number of observations	6,771				
Trimmed observations	1,251				

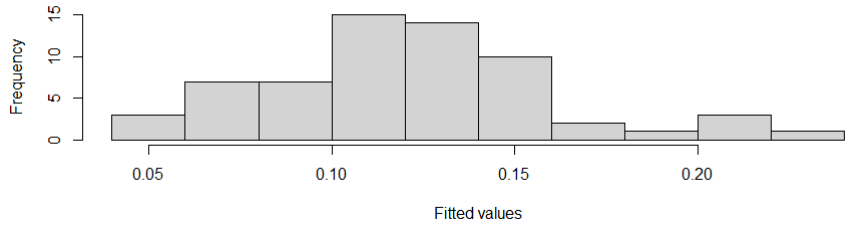
Note: The table presents the empirical results based on the second lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The standard errors are estimated by cluster bootstrapping.

Table A.6: Empirical results based on second participation and further covariates

First-stage					
Effect	0.37				
Standard error	0.06				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.26	0.09	9.47	1.07	0.34
Standard error	0.06	0.05	4.89	0.26	0.23
P-value	0.00	0.09	0.05	0.00	0.14
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.70	0.24	25.26	2.86	0.92
Standard error	0.11	0.14	13.16	0.48	0.64
P-value	0.00	0.09	0.05	0.00	0.15
Number of observations	6,771				
Trimmed observations	1,726				

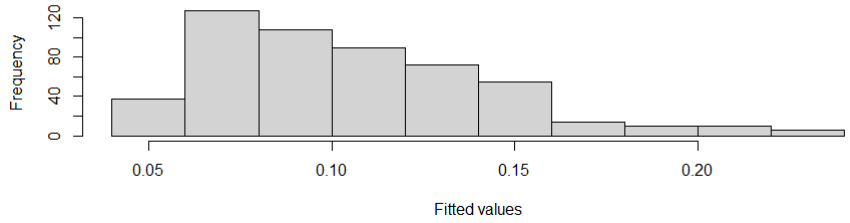
Note: The table presents the empirical results based on the second lottery participation and controls for the following covariates: Female, nationality, age and year of the first lottery. Only observations whose first lottery participation was between 2006 and 2016 are included. The standard errors are estimated by cluster bootstrapping.

Figure A.6: Propensity score for the subgroup of pre-draw winners in their third participation



Note: The figure presents the propensity score for the subgroup of pre-draw winners in their third participation.

Figure A.7: Propensity score for the subgroup of pre-draw losers in their third participation



Note: The figure presents the propensity score for the subgroup of pre-draw losers in their third participation.

Table A.7: Empirical results based on third participation and year dummies

First-stage					
Effect	0.61				
Standard error	0.10				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.47	0.13	9.21	1.81	0.53
Standard error	0.10	0.09	8.26	0.53	0.39
P-value	0.00	0.16	0.27	0.00	0.17
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.77	0.22	15.19	2.99	0.88
Standard error	0.17	0.18	16.16	0.89	0.82
P-value	0.00	0.22	0.35	0.00	0.28
Number of observations	3,369				
Trimmed observations	1,088				

Note: The table presents the empirical results based on the third lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The standard errors are estimated by cluster bootstrapping.

Table A.8: Empirical results based on third participation and further covariates

First-stage					
Effect	0.48				
Standard error	0.11				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.41	0.13	8.55	1.82	0.63
Standard error	0.10	0.10	9.24	0.50	0.45
P-value	0.00	0.18	0.35	0.00	0.16
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.85	0.28	17.91	3.80	1.32
Standard error	0.20	0.21	18.69	0.95	1.01
P-value	0.00	0.18	0.34	0.00	0.19
Number of observations	3,369				
Trimmed observations	1,192				

Note: The table presents the empirical results based on the third lottery participation and and controls for the following covariates: Female, nationality, age and year of the first lottery. Only observations whose first lottery participation was between 2006 and 2016 are included. The standard errors are estimated by cluster bootstrapping.

Table A.9: Effects among Austrians

First-stage					
Effect	0.35				
Standard error	0.05				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.26	0.06	4.52	1.30	0.30
Standard error	0.05	0.05	4.49	0.24	0.24
P-value	0.00	0.22	0.31	0.00	0.20
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.75	0.17	12.95	3.71	0.87
Standard error	0.08	0.13	12.54	0.41	0.65
P-value	0.00	0.20	0.30	0.00	0.18
Number of observations	7,326				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of Austrians (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The standard errors are estimated by cluster bootstrapping.

Table A.10: Effects among Non-Austrians

First-stage					
Effect	0.36				
Standard error	0.04				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.24	0.08	6.34	1.15	0.34
Standard error	0.04	0.04	3.90	0.20	0.21
P-value	0.00	0.05	0.10	0.00	0.10
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.66	0.22	17.59	3.19	0.95
Standard error	0.08	0.10	10.06	0.38	0.53
P-value	0.00	0.03	0.08	0.00	0.07
Number of observations	12,375				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of Non-Austrians (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The standard errors are estimated by cluster bootstrapping.

Table A.11: Effects among workers $\geq$ 38 years

First-stage					
Effect	0.28				
Standard error	0.05				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.23	0.12	8.16	1.18	0.60
Standard error	0.05	0.05	4.45	0.26	0.24
P-value	0.00	0.01	0.07	0.00	0.01
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.83	0.44	29.29	4.23	2.15
Standard error	0.10	0.16	14.73	0.59	0.79
P-value	0.00	0.01	0.05	0.00	0.01
Number of observations	8,186				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of workers equal to or older than 38 years (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The standard errors are estimated by cluster bootstrapping.

Table A.12: Effects among workers $\leq$ 37 years

First-stage					
Effect	0.42				
Standard error	0.04				
P-value	0.00				
ITT					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.28	0.06	6.59	1.34	0.31
Standard error	0.04	0.04	3.87	0.20	0.20
P-value	0.00	0.11	0.09	0.00	0.12
LATE					
Outcomes	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
Effect	0.66	0.15	15.51	3.15	0.72
Standard error	0.07	0.09	8.74	0.34	0.44
P-value	0.00	0.09	0.08	0.00	0.10
Number of observations	11,409				
Trimmed observations	0				

Note: The table presents the empirical results for the subgroup of workers equal to or older than 37 years (one year prior to the lottery). As in Table 4, the analysis is based on the first lottery participation and controls for year dummies. Only observations whose first lottery participation was between 2006 and 2016 are included. The number of observations differs from the number of lottery applicants in Table 3 because several outcome periods of each lottery participant are pooled in this table. The standard errors are estimated by cluster bootstrapping.

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