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 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, 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

JEL classification: F22, J61.

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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 164 million in 2017, with 23% in North America, 32% in Europe, and 13% Asia.[2] 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 of a given country. To address the high demand for such talent, there are various policy tools, ranging 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 is residence in a country for a worker's integration into its labor market?* 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.[3] 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 formal eligibility criteria for residence as well as individual factors determining the

[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 International Labour Organization, https://migrationdataportal.org/themes/labour-migration, retrieved 2021-02-11.

[3] 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.

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. 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.[4] We are the first to link European migration lottery data with administrative data on individual labor market records. We exploit the random assignment as instrument for the reception of a residence permit that is conditional on actually moving to Liechtenstein. This allows us to assess the local average treatment effect (LATE) of moving among compliers. As there are two draws for each lottery, compliers are winners of the pre-draw of the lottery who also participate and win in the second draw and actually move to Liechtenstein, making up 36% of our sample. 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 on inverse probability weighting (IPW), in which we reweigh the outcomes by the inverse of the conditional instrument probability given the lottery year, the so-called instrument propensity score. This enables us to control for the fact that the share of lottery winners 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 statistically significantly increases the employment probability of compliers by 24 percentage points on average across our outcome periods 2008

[4]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.

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 not to enter it. 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.[5] 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 move to 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. Therefore, resident permits appear to incentivize potential new labor market entrants to immediately start working in Liechtenstein, which very 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 employment decisions in the short run. 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.

Very broadly speaking, our paper fits into the literature on labor migration, see for instance Fasani et al. (2020). More specifically, it is among a relatively scarce number of studies that

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

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. Clemens et al. (2012) analyze a lottery in a specific multinational firm that allocated U.S. visas to Indian software workers and conclude 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 is important, because a large amount of labor mobility is realized between rather developed nations, which are likely competing for qualified workers. 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.[6] 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. 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).

[6]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).

Our paper therefore sheds light on whether residence permits (and the associated amenities like tax reductions) incentivize foreigners to remain in the labor market, which appears an important piece of information for policy makers in a competitive open economy with a high demand for foreign labor, as it is the case in Liechtenstein.[7]

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 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.[8] Complementary to this lottery, Liechtenstein's government also regularly grants a similar num-

[7] 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.

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

ber 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 exceptionally high qualifications.[9] 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).

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.[10] 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 a customs union with Switzerland and since 1995 it is 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 provision of financial and insurance services, which account for 16.2% and 13.3% of the GDP, respectively (Amt für

[9] 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.

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

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 are 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).

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

Source: Amt für Statistik Fürstentum Liechtenstein (AS) (2020); "residing in Liechtenstein" is self-calculated

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.[11]

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). Participants must win in both parts of the lottery to receive a residence permit, which is valid up to five years (Aufenthaltsbewilligung B) an can be extended. Family reunification for spouses, children and parents (if they receive financial support from the lottery participant) is possible at any time.[12]

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 moving there. The drawing of winners is done blindly by hand. This 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

[11] 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).

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

endogenous to the first lottery outcome, 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 is to reside in a neighboring country and commute cross-border.[13] 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.[14] 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.[15] 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).

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 com-

[13] For other participants it can be the case that they will stop working in Liechtenstein or not start working in Liechtenstein, despite holding an employment contract.

[14] Those who are not interested in moving to Liechtenstein are typically Austrian or Swiss citizens who live in their home country.

[15] For example, if a single adult with a relatively low gross income (CHF 60k p.a.) 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% (Brunhart and Buechel, 2016, their Table I). Similarly, if a family consisting of two children and two adults with a gross income of CHF 90k and identical wealth moved from Maienfeld (Canton Graubünden, Switzerland) to nearby Balzers (Liechtenstein) their net disposable income would increase from 45% of their market income to 54% (Brunhart and Buechel, 2016, their Table I). The calculation of net disposable income includes the costs and subsidies of housing, child care, and health insurance, while the quality of such services and other amenities appears comparable between Liechtenstein and the two neighboring countries.

mutes. 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,[16] which might lead to a shorter commuting time for cross-border commuters from Austria.[17] 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). 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 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

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

[17] 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).

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 or self-employment in the years after lottery participation. For each year, also the activity level in percent is reported, 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 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.[18] 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, 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 for their first-time lottery participation starting in the year 2007.[19] 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.[20] 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 second draw and are compliers if they indeed move to Liechtenstein. Any other winners of the pre-draw lottery are non-compliers. In particular, 38% of the second-draw participants do not win and hence do not obtain a residence permit.

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 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 has moved to Liechtenstein ($D = 1$), which is conditional on the

[18] 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.

[19] Since we had no data available for the winners in the second draw in 2006.

[20] 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.

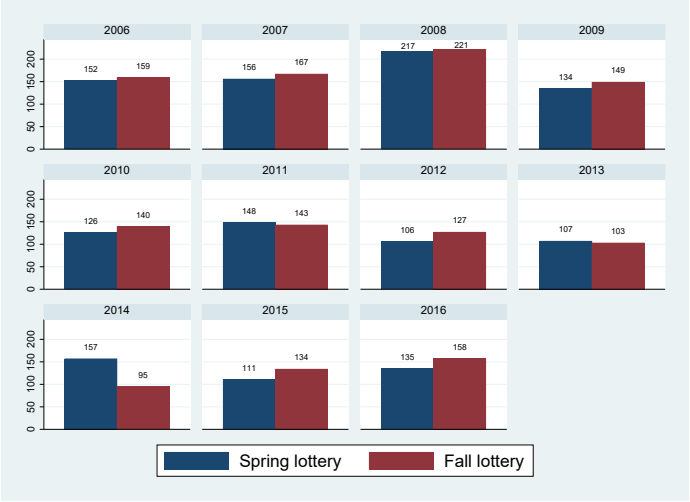


Figure 1: Annual number of first lottery participation

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

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

Note: First lottery participation from 2007 onwards, because we had no data about the second draw winners for 2006.

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 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.

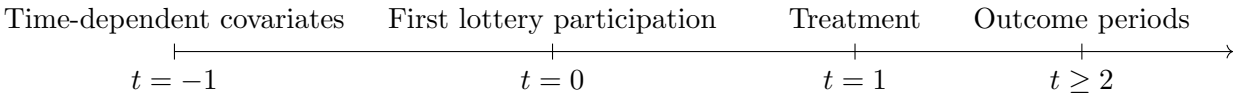


Figure 2: Timeline of measured variables

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 ($Z = 0$) of the first lottery 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 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 37 to 38 years old.[21]

In contrast to the observed characteristics, the probability of missing information in nationality and age is statistically significantly different across winners and losers, 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 statistics, in which case there is no missing information. For those not working in Liechtenstein prior to the lottery, we need to rely on the variables from the migration lottery, in which missings do

[21] In this context, we note that Swiss nationals are not allowed to participate in the lottery. 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.

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 the age in the year of the lottery, this is dependent on entering the labor market in Liechtenstein at some point in time. As lottery losers enter the labor market less frequently than lottery 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: 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	37.25	9.25	37.49	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					

Sources: Lottery data (2005 - 2016) and employment statistics (2005 - 2016); calculations are our own.

Table 3 also reports the year dummies for the first lottery participation across instrument values, 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 see 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 decrease over time. We note that the activity level is defined to be zero for those who do not work in Liechtenstein, as an alternative definition that discards these observations by conditioning on employment in Liechtenstein would introduce Heckman (1976)-type sample selection bias. On average, lottery participants are employed with a probability of 44% and work at a 40% level. 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.

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 move to Liechtenstein in the year after the lottery by winning. Following Abadie (2003), we assume that our lottery Z is a valid and relevant instrument conditional on covariates X, which 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 for instance Rubin (1974). We denote by $Y(z,d)$ the potential outcome (e.g. hypothetical employment) 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 is as good as random given X and thus not associated with other factors affecting the treatment and/or the outcome. 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 other through the treatment, 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 moving 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 move to Liechtenstein in the year after the lottery if losing it, but would not move if winning. Since lottery losers are generally

not allowed to move to 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, both lottery winners and losers do exist. Indeed we find in our data that 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 is relevant in the sense that it affects the treatment decision conditional on X. As discussed in Section 5 below, winning the pre-draw does indeed importantly and statistically significantly affect the decision to move to 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 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, 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 Z on the decision to reside in Liechtenstein one year after the first lottery participation 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

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

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. First, the average LATE estimates when pooling all outcome periods; second, the outcome period-specific LATE estimates; and third, an analysis of effect heterogeneity.[23] 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 LATE estimates for pooled outcome periods. The upper panel reports

[23] 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.

the effects 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. We find that having moved to 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, which is measured in percent and by definition zero if not working in Liechtenstein, 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] The intermediate panel reports the first-stage effect of the instrument on the treatment, which implies that 36% of the participants in the 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. A back-of-the-envelope calculation suggests that this is the case for 43% of the non-compliers, while 35% did not or could not participate in the final draw and only 13% are winners of the final draw who do not move to Liechtenstein. The p-value of the first-stage is close to zero and the instrument is therefore strongly associated with the treatment, thus supporting the relevance assumption postulated in (4.4). For completeness, the lower panel of Table 4 reports the intention-to-treat effect (ITT) of the instrument on the outcome, which is smaller than the corresponding LATE due to the presence of non-compliers for whom the effect is zero by definition (if defiers do not exist). In many policy evaluations, the ITT may actually appear more policy-relevant than the LATE 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 has hence control over the fraction of compliers. Hence, the LATE seems to be the more

[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 five statistically significant effects in Table 4 remain significant.

relevant effect in our study. 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.

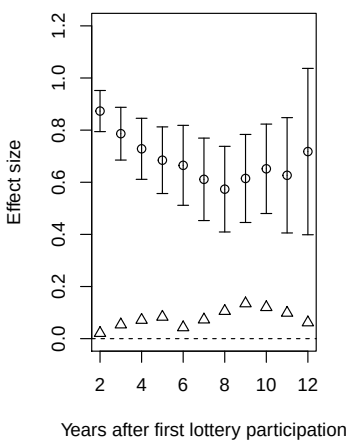
Table 4: Empirical results based on first participation and year dummies

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
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
First-stage					
Effect			0.36		
Standard error			0.03		
P-value			0.00		
ITT					
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
Number of observations			20,009		
Trimmed observations			0		

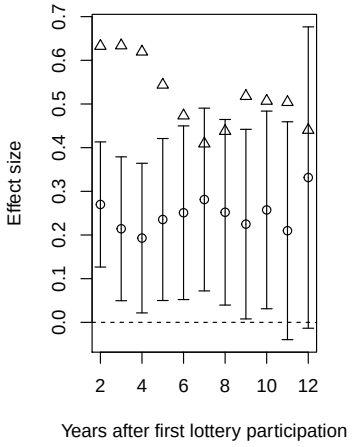
Note: Standard errors are estimated by cluster bootstrapping.

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 cases, the findings are all qualitatively similar to our main results.

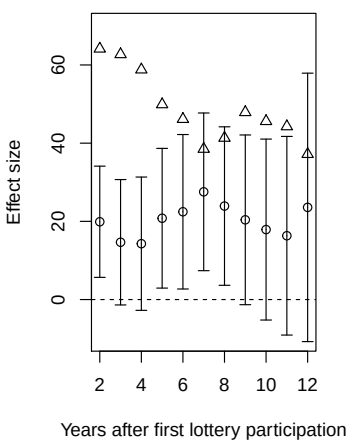
In a next step, we investigate the effects in specific outcome periods defined relative to the year of the first lottery participation. Figure 3 displays the estimates for the various outcomes from period $t = 2$ (i.e. two years after the lottery) up to period $t = 12$. The dots represent the period-specific LATEs and the bands correspond to the pointwise 95% confidence intervals based on the standard bootstrap. The triangles depict the estimated mean potential outcome among compliers under non-treatment, see for instance Huber and Wüthrich (2019) for a discussion



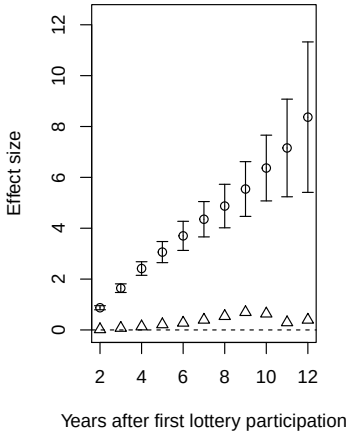
(a) Residing (binary)



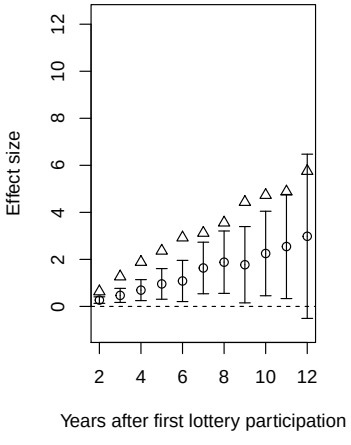
(b) Employed (binary)



(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

Figure 3: Effects over years. Dots represent LATEs, bands correspond to 95% confidence intervals, triangles depict the counterfactuals (i.e., mean potential outcomes among compliers under non-treatment)

of its computation. The triangles hence provide the relevant counter-factual of not moving to Liechtenstein. Against this backdrop we can judge the relative importance of the LATEs. 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. Relatedly, 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 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.

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. 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 see from the tables that the majority of applicants is male, on average 36 to 38 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%).[25]

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. 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 Germans cross-border commuters are the most frequent applicants in our data, they are still underrepresented, as 55% of the cross-border commuters with EEA na-

[25] 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.

tionality 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. Additionally, we use the cross-border survey to draw conclusions about what the average educational level might be in our evaluation data, in which information on education is not available. Marxer et al. (2016) report that cross-border commuters are on average highly educated, as 57.5% of them hold a degree from a higher education institution. Based on these findings, we suspect that cross-border commuters applying for the migration lottery have an average education that is likely considerably higher than that of the general population in Austria, Switzerland, and Liechtenstein.

Table 5: Effects among non-commuters

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
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
First-stage					
Effect			0.28		
Standard error			0.05		
P-value			0.00		
ITT					
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
Number of observations			10,081		
Trimmed observations			0		

Note: 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 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).[26] 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. For the latter group, we find that a residence permit leads to an increase in the employment probability of 34%, in the activity level of almost 30%, and in the employment duration of 1.56 years in the outcome periods.[27] 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.

Table 6: Effects among cross-border commuters

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
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
First-stage					
Effect			0.42		
Standard error			0.04		
P-value			0.00		
ITT					
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
Number of observations			9,928		
Trimmed observations			0		

Note: Standard errors are estimated by cluster bootstrapping.

To further investigate the heterogeneous effects on the labor market attachment of (a) non-commuters and (b) cross-border commuters, Figure 4 plots the period-specific LATEs on the employment probabilities for the respective group over time by means of dots. In analogy to Figure 3, the graphs also include the mean potential complier outcomes under non-treatment by period as triangles. It is worth noting 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

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

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

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 initially very large effects of an almost 50% increase in the employment probability decrease over time, but remain quite sizable at around 20% 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. The effects, however, increase over time to stabilize at roughly 20% and are even statistically significant at the 10% level in periods 7 and 8. Taken at face value, this implies that resident permits are very effective for keeping previously commuting workers in the labor market in the longer run. 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.

(a) Non-commuters

(b) Commuters

Figure 4: 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

6 Conclusion

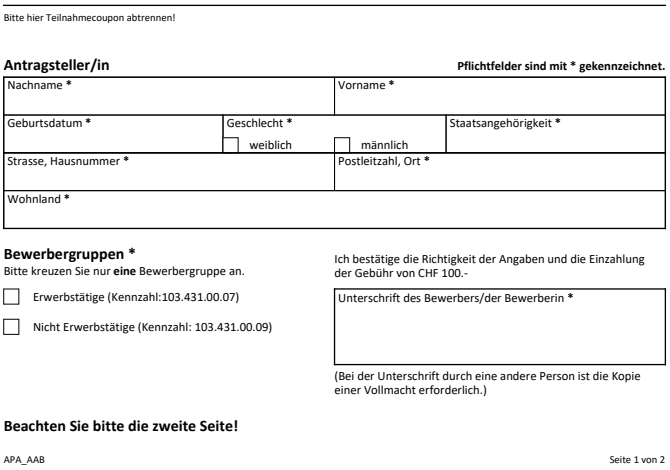
In this paper, we analyzed the effect of a residence permit on the labor supply and residential decisions of foreign workers by an instrumental variable approach exploiting a migration lottery in Liechtenstein. Our results pointed to substantial effects on the labor market and residential attachment of compliers, whose migration decision complies with the permit assignment in their first lottery. We also 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 decisions in the short run. Overall, 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, the tax revenues in Liechtenstein, or social and political integration. 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 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 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)).



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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Figure A.1: Participation voucher (of 2019). Interested candidates fill out this form to participate in the pre-draw
Source: Ausländer- und Passamt (2019a)

Figure A.2: Final draw (of spring lottery 2016) monitored by a judge
Source: Michael Zanghellini, Liechtensteiner Volksblatt

A.2 Additional information

Figure A.3: Map of Liechtenstein (Source: 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

Sources: Employment statistics (2006 - 2018); 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	37.40	9.11	36.35	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					

Sources: Lottery data (2005 - 2016) and employment statistics (2005 - 2016).

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	37.06	9.46	38.74	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					

Sources: Lottery data (2005 - 2016) and employment statistics (2005 - 2016).

A.3 Further analyses and robustness checks

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

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
			LATE		
Effect	0.70	0.21	16.70	3.43	1.02
Standard error	0.06	0.08	7.54	0.27	0.39
P-value	0.00	0.01	0.03	0.00	0.01
			First-stage		
Effect			0.35		
Standard error			0.03		
P-value			0.00		
			ITT		
Effect	0.25	0.07	5.88	1.21	0.36
Standard error	0.03	0.03	2.86	0.15	0.15
P-value	0.00	0.01	0.04	0.00	0.02
Number of observations			20,009		
Trimmed observations			392		

Note: Standard errors are estimated by cluster bootstrapping.
Only observations whose first lottery participation was after 2005 are included.

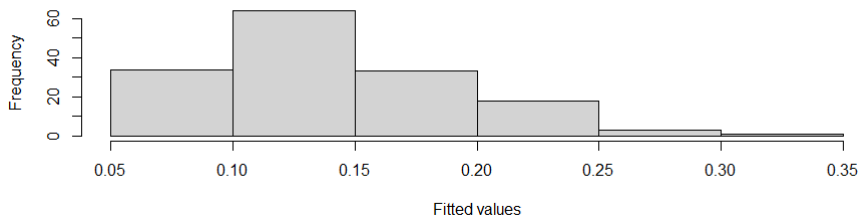

Figure A.4: Second participation; Propensity score; Assignment=1

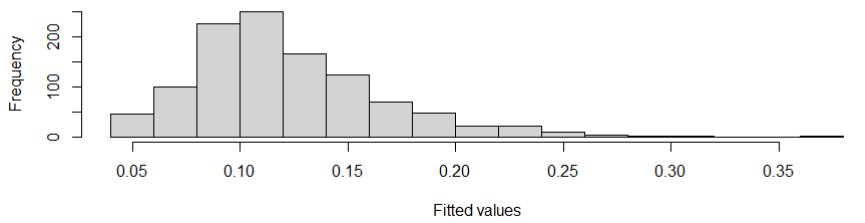

Figure A.5: Second participation; Propensity score; Assignment=0

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

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
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
First-stage					
Effect			0.40		
Standard error	0.06	0.07	0.07	0.07	0.07
P-value			0.00		
ITT					
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
Number of observations			6,771		
Trimmed observations			1,251		

Note: Standard errors are estimated by cluster bootstrapping.
Only observations whose first lottery participation was after 2005 are included.

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

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
Effect	0.70	0.25	26.16	2.81	0.84
Standard error	0.11	0.14	13.58	0.47	0.66
P-value	0.00	0.07	0.05	0.00	0.20
First-stage					
Effect			0.38		
Standard error			0.06		
P-value			0.00		
ITT					
Effect	0.26	0.09	9.82	1.06	0.32
Standard error	0.06	0.05	5.02	0.25	0.25
P-value	0.00	0.08	0.05	0.00	0.20
Number of observations			6,771		
Trimmed observations			1,727		

Note: Standard errors are estimated by cluster bootstrapping
Only observations whose first lottery participation was after 2005 are included.

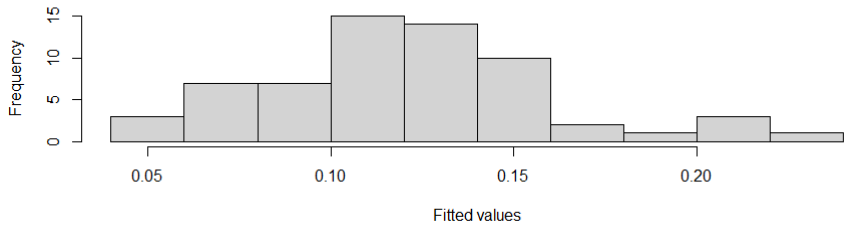

Figure A.6: Third participation; Propensity score; Assignment=1

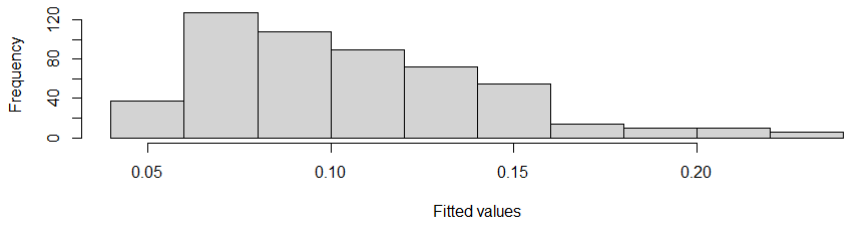

Figure A.7: Third participation; Propensity score; Assignment=0

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

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
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
First-stage					
Effect			0.61		
Standard error			0.10		
P-value			0.00		
ITT					
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
Number of observations			3,369		
Trimmed observations			1,088		

Note: Standard errors are estimated by cluster bootstrapping.
Only observations whose first lottery participation was after 2005 are included.

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

	Outcomes				
	Residing (binary)	Employed (binary)	Activity level (%)	Years residing	Years employed
LATE					
Effect	0.80	0.24	13.87	3.58	0.98
Standard error	0.18	0.20	18.68	0.94	0.98
P-value	0.00	0.22	0.46	0.00	0.32
First-stage					
Effect			0.50		
Standard error	0.10	0.11	0.10	0.11	0.11
P-value			0.00		
ITT					
Effect	0.39	0.12	6.87	1.77	0.49
Standard error	0.09	0.10	8.94	0.50	0.45
P-value	0.00	0.22	0.44	0.00	0.27
Number of observations			3,369		
Trimmed observations			1,193		

Note: Standard errors are estimated by cluster bootstrapping.
Only observations whose first lottery participation was after 2005 are included.

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