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1 INTRODUCTION

The development of free movement areas like the European Union (EU) and the European Free Trade Association (EFTA)[1] has contributed to increased labour mobility in Europe, in particular, cross-border mobility. Indeed, the number of cross-border workers, defined by the European Parliament as "individuals who live in one EU or EFTA country and work in another (political criterion) to which they return as a rule daily or at least once a week (time criterion)", increased by about 138% between 2002 and 2017 in the EU-28/EFTA and reached about 2.1 million workers (Eurostat, 2018). Although these cross-border workers made up only 0.9% of the EU-28/EFTA labour force in 2017, this rate is much higher at the local level. For example, in France, the European country with the most cross-border workers, these workers sometimes represent up to 40% of the working population in a given region (Garnier and Toutin, 2017). The large increase in cross-border labour mobility and strong heterogeneity at the local level call for better understanding of the determinants of cross-border mobility decisions.

The literature has only recently taken up this question, highlighting four main factors that can explain these decisions: a) individual attributes such as gender, age, risk aversion (Nowotny, 2014), and family characteristics like children or other cross-border workers in the household (Gottholmseder and Theurl, 2007; Huber and Nowotny, 2013); b) location factors, specifically distance to the border and accessibility and quality of public transport services (Schiebel et al., 2015; Medeiros, 2019); c) cultural and informational factors, such as language differences and social ties (Van Houtum and Van Der Velde, 2004; Verwiebe et al., 2017); and d) differences in local labor markets acting as push and pull factors (Mathä and Wintr, 2009; Pigeron-Piroth et al., 2018; Chilla and Heugel, 2019). This last difference is in line with the seminal work of Lewis (1954) and Harris and Todaro (1970). Indeed, it is initially the existence of segmented markets with wage differences that explains the decision to migrate from a rural and agricultural sector to an urban and industrial sector. Thus, higher wages in urban areas attract employees from rural areas who have the required skills. However, this theoretical framework assumes pure and perfect competition and therefore that adjustments to the urban labor market are made based solely on wages. In reality, in the cross-border context, there are unemployment rate differences between border regions due to the differentials in job opportunities between countries. As in job search models (Mortensen, 1986), individuals in a region can thus decide

[1] EFTA is an intergovernmental organisation that aims to promote free trade and economic integration for the benefit of its four member states (Iceland, Liechtenstein, Norway and Switzerland.)

to extend their prospecting area in order to seize these opportunities and maximize their job-offer rate.

Beyond differences between labour markets, some recent articles go further and focus on labour complementarities based on two sources: internal and external heterogeneity of the firm (Osang and Weber, 2017). While internal heterogeneity describes the diversity of talent, external labour complementarities represent the diversity made up of the native population and migrant workers. This heterogeneity comes from different degrees of labour complementarity between countries' native populations and foreign workers. Therefore, the notion of complementarity can be defined through the complementarity of jobs, which, depending on the region, can diverge in terms of monetary (wage differential) or non-monetary (job satisfaction, job turnover, unemployment rate) characteristics. In addition, job opportunities may depend on labour shortages, which can differ by border country. Similarly, the skills required by border countries could be satisfied by the supply of labor in the border regions so that cross-border mobility decisions can contribute to the efficiency of matching in each local labour market. As pointed out by Moretti (2010), labour complementarities may be stronger when local labour markets are studied. This suggests that motivations for cross-border mobility can be explained by differences in labour complementarities.

Recently, Pires and Nunes (2018) uses Portuguese data to highlight the existence of fragmented labour markets according to company needs in the destination country. The study finds that the Norte de Portugal supplies less-qualified, low-paid workers, whereas Galicia offers qualified and well-paid workers. These facts therefore show the need for localized analyses making it possible to take into account the differences in local labour markets. However, although the existing literature has studied differences in local labour markets, they are assumed to be homogeneous whatever the border area studied. Thus, the notion of complementarity can help to explain that the profile of cross-border workers varies widely across the geographical areas studied (Garnier and Toutin, 2017). The analysis of labour market complementarities is all the more important in Europe as strong institutional differences can influence mobility. In particular, mobility between the Schengen area countries is perfectly free, while mobility between the Schengen area countries and other countries like Switzerland are governed by bilateral agreements laying down specific arrangements that may favour certain commuters.

Thus, the goal of this paper is to measure whether differentials in wage and unemployment

rate are indeed determinants of cross-border mobility, but above all whether the differential effect varies according to the characteristics of the border regions. The rest of the article is structured as follows. Section 2 presents the empirical context and the data. Section 3 presents the method and discusses the results. Finally, section 4 concludes.

2 EMPIRICAL CONTEXT AND DATA

To test the impact of complementaries in local labour markets, we decided to focus on Luxembourg and Switzerland, the two main destinations of cross-border workers. More precisely, we focus on mobility from two French *departements*: Moselle and Haute-Savoie. Indeed, a full three-quarters of the cross-border workers to Luxembourg and Switzerland come from these two *departements* respectively. In addition, labour mobility to Luxembourg and Switzlerland has very different institutional contexts, and the local labour markets on each side of the border have quite different complementarities (Table 1).

2.1 Institutional contexts and complementarities in local labour markets

The first focus of our two-case study is the very different institutional contexts. As a member state of the European Union (EU), Luxembourg has a common migration policy with the other EU member states. There are thus no restrictions on migration between France and Luxembourg. As a consequence, the profile of cross-border workers is very close to those who remain in France (Garnier and Toutin, 2017). Contrary to Luxembourg, mobility to Switzerland is governed by a bilateral agreement, the Agreement on the Free Movement of Persons (AFMP), adopted in June 2002. This agreement grants citizens of the EU-15 the right to work in Switzerland, subject to obtaining an official work permit. This permit is issued on request from Swiss companies seeking foreign employees (including cross-border workers) with the required skills. As the Swiss economy suffers from a shortage of skilled workers (Kägi and Lobsiger, 2014; Indergand and Beerli, 2015), employers' requests mainly concern this type of worker. Finally, cross-border workers to Switzerland are higher-skilled workers, such as managers, professionals, and technicians (ISCO 1-3) (Garnier and Toutin, 2017). In addition to the institutional differences, a strong economic heterogeneity can be seen between the regions on either side of the border (Table 1).

Table 1: Unemployment rates and wages in the two case studies

	France	Haute-Savoie	Switzerland	Moselle	Luxembourg
Unemployment rate	9.9	7.5	4.5	10.5	5.1
Unemployment rate for skilled workers (ISCO 1-3)	3.7	3.5	3.1	4.0	4.6
Annual gross wages	35,386€	37,949€	86,756€	34,572€	61,538€
Annual gross wages for skilled workers (ISCO 1-3)	61,607€	70,453€	153,132€	63,761€	110,535€

Source: Unemployment rates (ILO definition - 2012): INSEE, ILO, SECO, and Statec; Wages (in euros, full-time equivalent, 2014): DADS, Eurostat, OFS, and Statec

Even though the two French *departements* in this study have higher unemployment rates than the two neighboring countries, the difference is much higher in Moselle, particularly for qualified workers (ISCO 1-3). For skilled workers, the unemployment rate is very low in Haute-Savoie, close to the Swiss rate. This rate is probably very close to the French frictional unemployment rate, suggesting that there is almost full employment in this area for managers, professionals, and technicians. On the other hand, the differences in salary are more marked in the case of Haute-Savoie vs. Switzerland, where wages are 2.3 times higher in Switzerland, compared to 1.7 times in the case of Moselle vs. Luxembourg. These wage differences are even greater for skilled workers. Finally, these localized statistics seem to show two very different cases: In Haute-Savoie, incentives for cross-border mobility could be more related to higher salary opportunities in Switzerland, while in Moselle, these incentives could depend on both better wages and more employment opportunities.

2.2 Data

To analyse the impact of complementarities in local labour markets on cross-border labour mobility decisions, we use the 2012 *French Population Census* survey from the French National Institute of Statistics and Economic Studies (INSEE). This individual-level survey is representative of the French population and is particularly well-suited to analyse cross-border labour mobility. It indeed clearly identifies all the cross-border workers. The survey also provides information on some factors that could influence the cross-border commuting decision (individual characteristics, place of residence, and workplace). However, to capture the other expected determinants such as distance, wages, unemployment, and home prices, some complementary data are used. First, to take account of commuting time, we use the information about individual places of residence and workplaces in the *Population Census*. We use a Transport Route Planner (Mappy ®) to calculate the fastest itinerary in minutes for each individual to

go to work[2]. Second, to capture the effect of housing market conditions, we introduce into the database the price of real estate for Moselle, Haute-Savoie (Notaries real estate barometer, 2016), Luxembourg (STATEC, 2016) and Switzerland (Swiss Real Estate, 2016)[3]. Third, to control for the impact of wages on cross-border labour mobility, we impute in the dataset the hourly observed wage by sector (construction, industry, and service) in euros for each country: France, Luxembourg, and Switzerland[4] (OCDE, 2010). All the explanatory variables are expressed in relative terms. Dependent and explanatory variables are presented in the Appendix (Table 3); for some summary statistics, see Table 4 in the Appendix.

3 METHOD AND RESULTS

To test the impact of complementarities in local labour markets on cross-border mobility decisions, we estimate the individual choice to become a cross-border worker using our dataset. Let us define the probability of being a commuter (mover) as:

$$Prob(mover) = \begin{cases} 1 \text{ for mover state } (i{=}m) \\ 0 \text{ for stayer state } (i{=}s) \end{cases}$$

To analyse this probability, we use two types of models. First, simple probit models for mobility to each destination (j), Luxembourg or Switzerland, are estimated:

$$Prob(mover_{ij} = 1) = F(\beta_j x_{ij}\ , \delta_j T_{qij}\ , \lambda_j u_i\ , \gamma_j w_{ij}\ , \alpha_j p_{hij}\ , \epsilon_{ij})$$
$$\text{with } F(z) = 1 \text{ - exp } \{\text{- exp (z)}\}$$

where:

- x contains individual and household characteristics, to take into account observable individual heterogeneity;
- T_q represents dummies for commuting time to the border, divided into three terciles;
- u and w denotes labour market conditions;

[2]We also calculated the distance in kilometres, which does not change the results. We retained the distance in minutes because individuals can have the same commuting distance in kilometres and yet have very different travel times due to the area's topography, which will influence the type of road used (highway, mountain road, county road).

[3]We use 2016 house prices because 2012 house prices were not available for all three countries.

[4]Wages are given in PPP.

- p_h represents home prices;
- ϵ is an error term.

However, in these simple probit models, commuting time to the border (T_q) is suspected to be endogenous as it follows housing location choice. Indeed, this choice seems to clearly depend on three main factors: individual characteristics like family constraints (Quigley and Weinberg, 1977; Waddell, 2002), the trade-off between distance to work and real estate prices (Alonso, 1964; McFadden, 1978; Clark et al., 2003), and preferences for amenities (Tiebout, 1956; Brueckner et al., 1999; Oates, 1969; Bayoh et al., 2006; De Palma et al., 2007; Huu Phe and Wakely, 2000). Therefore, to take into account the endogeneity of the dummies for commuting time to the border and obtain robust estimates of its impact on cross-border mobility decisions, we estimate probit models with endogenous binary covariates (Arendt and Holm, 2006). Following the literature, the explanatory factors of commuting time to the border we use include individual characteristics, real estate prices, and housing amenities. For this last one, we added three proxies of housing amenities. Among the key factors explaining location choice, amenities are important, particularly access to public services such as schools and health care (Aissaoui et al., 2015; Frenkel et al., 2013). We have therefore included the number of amenities in municipalities and the availability of two types of amenity (elementary schools and cinemas)[5] as instruments. To evaluate the robustness of our instruments, we perform an Amemiya-Lee-Newey test, which tests the null hypothesis of the absence of overidentification. The results are presented in Table 2. Our estimates are made on both subsamples (Moselle and Haute-Savoie) in order to be able to study the potential difference in labour complementarities. Estimated marginal effects of covariates are given, and standard errors are corrected for heteroskedasticity (White, 1996).

[5]Data are obtained from the 2012 "Base permanente des équipements (BPE)" survey from the French National Institute of Statistics and Economic Studies (INSEE). Amenities are reported at the municipal level, and the database is updated on an annual basis.

Table 2: Determinants of cross-border mobility decisions: Marginal effects

VARIABLES	**to Switzerland** Model 1: Instrumented probit model	**to Luxembourg** Model 2: Instrumented probit model
Individual attributes:		
Men	0.051***	0.031***
	(0.002)	(0.001)
No. of individuals enrolled	-0.007***	0.002***
	(0.001)	(0.0002)
Education:		
No diploma	-0.095***	-0.037***
	(0.003)	(0.002)
Prof. secondary	-0.050***	-0.035***
	(0.003)	(0.001)
Secondary	-0.042***	-0.029***
	(0.004)	(0.002)
Tertiary ed.	*ref.*	*ref.*
Age:		
Under 30	0.049***	0.069***
	(0.004)	(0.003)
Age 30-39	0.088***	0.092***
	(0.004)	(0.003)
Age 40-49	0.059***	0.058***
	(0.004)	(0.002)
Over 50	*ref.*	*ref.*
Time to border:		
First group	*ref.*	*ref.*
Second group	-0.034***	-0.066***
	(0.002)	(0.001)
Third group	-0.002	-0.085***
	(0.002)	(0.001)
Wage and unemployment:		
Ratio wage (ln)	0.321***	0.026**
	(0.037)	(0.012)
Ratio unemployment (ln)	-0.106***	-0.016***
	(0.003)	(0.002)
Home prices:		
Home prices (ln)	0.021***	0.002***
	(0.001)	(0.0002)
Observations	97 258	113 861
Ratio of correct predictions	80.4%	87.6%
Wald test for exogeneity	167.048***	158.34***
Amemiya-Lee-Newey test	0.879 *(p-value: 0.7708)*	0.287 *(p-value: 0.5299)*

Instruments: no. amenities, elementary schools, cinemas
Robust *standard errors* are in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The rate of correct predictions is over 80% for all models. As Wald tests in instrumental probit models confirm the endogeneity of commuting time to the border (T_q), we prefer to examine the results from probit models with endogeneous binary covariates (models 1 and 2). Note that Amemiya-Lee-Newey tests confirm the validity of the instruments chosen.

As expected, our econometric estimates confirm the influence of traditional factors for cross-border mobility such as the influence of individual characteristics and commuting distance, even after controlling for the risk of endogeneity, or home prices. Above all, our results highlight the impact of complementarities in local labour markets on cross-border labour mobility decisions. Indeed, while financial opportunities increase the probability of being a commuter, and the unemployment rate decreases this probability, the magnitude of the impact is quite different according to the mobility studied and therefore according to local conditions.

First, the wage effect is much stronger for commuters to Switzerland, becoming the most important determinant in the "commuting options"[6]. Indeed, a rise of one unit in the wage ratio increases the probability of becoming a commuter by more than 32% for mobility to Switzerland, as opposed to only 2.6% for Luxembourg. This clearly suggests that the cross-border mobility decision depends more on wage differentials in the Haute-Savoie case. Second, the marginal impact of unemployment is six times lower in Haute-Savoie than in Moselle with regard to cross-border mobility decisions. Indeed, an increase of one unit in the unemployment rate ratio (that is, an increase of unemployment in the foreign country) decreases the probability of being a commuter to Switzerland by more than 10%, while it decreases the probability of being a commuter in Luxembourg by less than 2%. These results suggest that for Haute-Savoie, deteriorations in Swiss economic conditions discourage the commuting option. Expanding the search area to Switzerland would not more open up new job opportunities, even though potential wages are higher. On the contrary, for Moselle, the rise of unemployment will not change the initial situation: Moselle continues to suffer from a higher unemployment rate compared to Luxembourg.
To conclude, our results confirm that complementarities in local labour markets affect labour mobility. In Haute-Savoie, cross-border mobility decisions are more motivated by the desire to find better-paid employment. On the contrary, cross-border decisions in Moselle seem to depend both on job opportunities and the wage differential.

4 CONCLUSION

This article analyzed the effects of complementarities in the local labour market on cross-border labour mobility decisions. Our estimates, which compare French labour mobility to Luxembourg and to Switzerland, confirm the importance of carrying out analyses differentiated by

[6]Note that the comparison of marginal effects in nonlinear models should be conducted with caution (Kuha and Mills, 2020).

region since the complementarities of local labour markets on both sides of the border play a very important role in mobility decisions. Indeed, mobility to Switzerland is mainly driven by the wage differential as unemployment rates, notably for skilled workers, are relatively similar. On the contrary, cross-border mobility decisions in Moselle seem to be motivated by both wages and job opportunities, as Luxembourg offers a higher demand for labour as well as higher wages.

The main contribution of this article is to show that cross-border mobility decisions is strongly affected by the complementarities of local and foreign labor markets. This result allows us to link the literature on migration and the literature on job search. Indeed, while the impact of the institutional context had already been taken into account through the analysis of rural-urban migration, it had been neglected in the literature on job search and commuting. In addition, since mobility flows can achieve an efficient allocation of resources (Borjas, 1999), this article provides a better understanding of individual trade-offs by territory. This is useful both for firms, which can activate financial levers to retain employees, and for public authorities, which can adapt public policies to the territory. Indeed, the choice of cross-border mobility has important implications for transport policies and individual housing location choices.

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APPENDIX

Table 3: Definitions of variables

Variables	Definitions
Stayers	Dummy variable =1 if the individual works in France
Movers	Dummy variable =1 if the individual works in a foreign country
Men	Dummy variable = 1 if the individual is male
No. of individuals enrolled	Number of individuals enrolled by household
No diploma	Dummy variable = 1 if the individual has no diploma
Prof. secondary	Dummy variable = 1 if the individual has a professional certificate
Secondary	Dummy variable = 1 if the individual has a secondary school diploma
Tertiary ed.	Dummy variable = 1 if the individual's highest level of education is university graduate
Under 30	Dummy variable = 1 if the individual is under thirty years old
Age 30-39	Dummy variable = 1 if the individual is between thirty and thirty-nine years old
Age 40-49	Dummy variable = 1 if the individual is between forty and forty-nine years old
Over 50	Dummy variable = 1 if the individual is over fifty years old
Minutes	Time between place of residence and workplace for commuters, and nearest border for stayers
First groups	Dummy variable = 1 if time to border is less than 31 minutes for Haute-Savoie and 48 minutes for Moselle
Second groups	Dummy variable = 1 if time to border is between 31 and 41 minutes for Haute-Savoie and 48 and 67 minutes for Moselle
Third groups	Dummy variable = 1 if time to border is more than 41 minutes for Haute-Savoie and 67 minutes for Moselle
Hourly wage France	Average hourly wage in euros in France by business type
Hourly wage foreign	Average hourly wage in euros in foreign countries by business type
Ratio wage (ln)	Logarithm (hourly wage by business type in foreign country/hourly wage by business type in France)
Unemployment rate France	Unemployment rate for all the municipalities of Haute-Savoie and Moselle
Unemployment rate foreign	Unemployment rate for all the counties of Switzerland and Luxembourg
Ratio unemployment (ln)	Logarithm (unemployment in foreign country/unemployment in France)
Price France	Average home price in Haute-Savoie and Moselle
Price foreign	Average home price in Luxembourg and Switzerland

Table 4: Summary Statistics

	Haute-Savoie			Moselle		
VARIABLES	All	Stayers	Movers	All	Stayers	Movers
Dependent variables	1	0.80	0.20	1	0.87	0.13
Individual attributes:						
Men	0.52	0.51	0.58	0.52	0.51	0.59
No. of individuals enrolled	0.74	0.75	0.71	0.73	0.71	0.81
Education:						
No diploma	0.16	0.17	0.10	0.17	0.18	0.11
Prof. secondary	0.25	0.26	0.23	0.29	0.30	0.25
Secondary	0.20	0.20	0.19	0.20	0.20	0.18
Tertiary ed.	0.39	0.37	0.48	0.34	0.32	0.47
Age:						
Under 30	0.21	0.20	0.20	0.20	0.20	0.22
Age 30-39	0.27	0.26	0.33	0.26	0.24	0.37
Age 40-49	0.29	0.29	0.28	0.28	0.28	0.29
Over 50	0.24	0.25	0.18	0.26	0.27	0.13
Time to border:						
Minutes	37.8	37.21	40.55	60.51	63.63	39.24
First group	0.33	0.32	0.39	0.33	0.26	0.82
Second group	0.34	0.36	0.25	0.34	0.37	0.15
Third group	0.33	0.32	0.36	0.33	0.37	0.03
Wage and unemployment:						
Hourly wage France	16.21	16.21	16.22	16.23	16.24	16.17
Hourly wage foreign	27.55	27.54	27.61	22.23	22.23	22.20
Unemployment rate France	8.81	8.64	9.52	12.40	12.55	11.29
Unemployment rate foreign	6.80	6.80	6.82	7.10	7.10	7.13
Home prices:						
Price France	152 753	147 668	173 245	92 557	92 200	94 981
Price foreign	839 560	811 419	952 970	339 159	337 850	348 068
No. Observations	99259	79585	19674	114345	99721	14624

Data source: Population Census, 2012