Does cross-border commuting between EU-countries reduce inequality?

Arjen Edzes[*,#]

Jouke van Dijk[*]

Lourens Broersma[*]

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Abstract

Cross-border commuting might be a way to improve an efficient allocation of labour resources, improve the economic performance of border regions and reduce economic and territorial inequality. This study explores the impact of a set of socio-economic, infrastructural or cultural explanatory variables that drive cross-border commuting in the EU and Switzerland for all outgoing commuters from living countries and for all incoming commuters towards their working countries. We find that cross-border commuters respond in general in the theoretically expected way to wages, unemployment, accessibility, language similarity and distance. But besides these general findings we also find that, in the end, cross-border commuting is a result of push and pull factors that seem to work out differently for different groups of commuters. This may reduce the inequality at the region level both between countries and within countries, although the effects are most likely small given the relatively small number of commuters. However, the results by gender, age, education and sector show substantial differences indicating that at the level of individuals and specific groups the reduction in inequalities might be very limited and may even increase.

Keywords: cross-border commuting, gravity model, push and pull factors

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[*] University of Groningen, Faculty of Spatial Sciences, Department of Economic Geography, PO box 800, 9700 AP Groningen. a.j.e.edzes@rug.nl, jouke.van.dijk@rug.nl, l.broersma@rug.nl.

School of Law, Hanze University of Applied Sciences, Zernikeplein 7, 9747 AS Groningen.

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1. Introduction

According to European Union (EU) data, the EU border regions cover 40% of EU territory, account for 30% of the EU population, and produce 30% of the EU gross domestic product (GDP). In spite of their economic importance, border regions are often peripheral regions within their countries and have lower economic growth in terms of GDP and employment, and suffer from higher levels of unemployment (EC, 2017) and often also depopulation. Nijman and Wei (2020) argued that attention to urban spatial dimensions at various scales is critical to understanding current inequality trends, from intra-urban to regional and global scales. In this paper we focus on economic and territorial inequalities as key issues for border regions that face being in two types of peripheries: a geographical periphery as a border region and a social and economic periphery with limited opportunities for the inhabitants. The study of cross-border labour markets and cross-border commuting is becoming more and more important now increasing efforts are being undertaken by the European Commission (EC) and the Organisation for Economic Co-operation and Development (OECD) to boost economic growth, integration and cohesion in border regions (OECD, 2013; EC, 2017). Bagchi-Sen et al. (2020) found that workers from another country can play an important role in mediating spatial inequalities.

The almost 40 internal land borders of the EU and its immediate neighbours are crucial to the processes of integration and transforming mainly peripheral areas into areas of growth and opportunities (EC, 2017; Nerb et al., 2009). Two of the mechanisms through which these processes of integration and transformation could take place is by stimulating job creation in cross-border economies and the cross-border mobility of workers in the form of daily commuting (Möller et al., 2018; Lundquist & Tripple, 2013).

A high degree of cross-border labour mobility is desirable to help employment adjust favourably to changing demand conditions, to boost innovation and economic growth, and to stimulate regional integration to benefit from agglomeration economies (Jacob et al., 2019; Haas & Osland, 2014; OECD, 2013). When labour is not allocated

efficiently, this may have negative effects on the long-term level and growth rate of output in cross-border regions. So, a free and hence efficient movement of labour between border regions still constitutes one of the core principles of the EU and is an important component in fulfilling the single market (Chilla & Heugel, 2019).

In many cases, cross-border regions face the problem of depopulation. This can lead to even less economic activity, resulting in increasing unemployment. The opposite trend is also possible when depopulation leads to unfilled vacancies and incoming commuters are needed to fill the jobs. In both cases, efficient labour market dynamics would solve issues on both sides of the border. In other words, according to labour economic theory and the spatial mismatch hypothesis, an inefficient allocation of labour may lead to unemployment and a shortage of job opportunities on one side of the border and unfilled vacancies on the other side, and hence increase territorial inequality. This can certainly occur in border regions where geographical friction, in terms of physical accesibility or institutional barriers related to differences in language, fiscal regime, or recognition of diplomas, hinders efficient labour market outcomes.

However, despite efforts to enhance competitiveness and foster job creation, the EU concluded that, both in geographical and labour market terms, the current cross-border mobility rates of workers in the EU remain relatively low (EC, 2017; Nerb et al., 2009). Moreover, some studies have concluded that cross-border *immobility* is more common than mobility (Buch et al., 2009; Nerb et al., 2009, Bouwens, 2004; Van Houtum et al., 2004). Others concluded that in fact very little is known about cross-border commuting, simply because there is still no solid, harmonized knowledge database on cross-border commuting (Chilla & Heugel, 2019).

In this study we add to the literature of understanding cross-border commuting by analysing a unique dataset to and describe the development of cross-border commuting between EU countries and Switzerland during the period 1998-2016. Secondly, we construct a gravity model in which we explain cross-border commuting flows using common socio-economic, infrastructural and cultural factors. Although the

dataset has its limitations, it allowed us to test whether cross-border commuting flows can be explained by economic factors, like wages and unemployment, or whether other factors are more dominant. Our main hypothesis is that competitive regions – with higher wages and lower unemployment – show lower cross-border out-commuting rates than less competitive regions – with lower wages and higher unemployment. The hypothesis also takes other explanatory variables into account, reflecting obstacles like language differences, accessibility and differences in institutions. We estimated this model for all commuters, for specific groups of commuters by gender, education and age, and for those commuters working in specific industrial sectors.

This paper is organized as follows: Section 2 describes the empirical model of cross-border commuting; Section 3 reports the data we have for describing and analysing cross-border commuting; and Section 4 describes the data available on cross-border commuting for EU-countries. We focused on cross-border commuting based on data from the countries of residence, hereafter called *home country*, and from the countries of work, hereafter called *work country*. The estimation results are presented and discussed in Section 5. Finally, in Section 6 we present our conclusions and reflect on their impact on territorial inequality and the implications for policy decisions and future research.

2. A gravity model of cross-border commuting

Cross-border labour mobility is defined here in terms of cross-border commuting between EU member states, where cross-border commuters live in one country, but work in a neighbouring country. They move between their home and work countries mostly on a daily basis, but they return home at least once a week. Longer periods, in which someone stays in either their home or work country, are not considered as cross-border commuting. In this paper we follow an eclectic approach by constructing a gravity model in which we explain cross-border commuting with a diverse set of infrastructural and cultural factors.

When it comes to the functioning of cross-border labour markets and the determinants of cross-border commuting, we can distinguish different theoretical frameworks. (Edzes et al., 2018; Van Houtum et al., 2004). In the simple neo-classical approaches, cross-border commuting is driven by differences in economic factors, like differences in wages and job opportunities on either side of the border. More sophisticated theories take into account the multidimensional nature of borders, which lead to alternative explanations, ranging from economic geographical models of uneven development between regions, and the consequent development of push and pull factors in the labour market, to post-structural observations of "mental thresholds" (Knotter, 2014b). Push and pull factors refer to ones that drive people away or pull them into a region, because other regions may offer opportunities that do not exist in the home region. These models can include both rational and emotional explanatory frameworks (homo economicus versus homo socialis) (Jacob et al., 2019; Chilla & Heugel, 2019; Huber & Nowotny, 2013; Spierings & Van der Velde 2013, 2008; Van Houten et al., 2004). The homo economicus is driven by opportunities to maximize productivity and wages, as postulated in rational choice approaches and Human Capital Theory (Van Houten & Van der Velde, 2004; Becker, 1964). Spierings and Van der Velde (2013, 2008) introduced the concept of "bandwidth of unfamiliarity" to help understand the lack of mobility. Unlike rational choice approaches, barriers are considered endogenous: job seekers and entrepreneurs raise the obstacles themselves. Instead of focusing on wages and opportunities for jobs, people might just focus on communities where they feel at home and that have common value patterns (see also Klatt, 2014).

Our model of cross-border commuting is straightforward and based on the gravity model. While the gravity equation has its origins elsewhere, it has been related to trade theory in the literature, as in Deardorff (1984) and McCallum (1985). McCallum (1985) argued that this gravity model could also be useful as the basis for tests of other propositions. It is in this spirit that we use the gravity model here to test cross-border commuting in the EU.

In its simplest version the gravity model applied to trade relations looks like:

$$\log x_{ij} = a + b \log y_i + c \log y_j + d \log(dist_{ij}) + e\, DUMMY_{ij} + u_{ij} \qquad (1)$$

where x_{ij} is the shipment or flow of goods from region/country i to region/country j, y_i and y_j is the stock of GDP in region/country i and j, $dist_{ij}$ is the distance from i to j, $DUMMY_{ij}$ is a dummy for inter-regional trade and u_{ij} is an error term.

Equation (1) is the basis for our cross-border commuting model. The dependent variable now becomes the flow of cross-border commuting, as a proportion of the total employed labour force in either the home or work country. We used the standard definition of employed labour force as used by OECD and Eurostat.

In our empirical models, we focused on home or work *countries*, instead of home or work *regions*. The main reason for this is that data on cross-border commuting by region are simply not available over a longer period in most EU-countries. However, this is not a major problem because several studies, like Mathä and Wintr (2009), Cavallaro and Dianin (2019) and Broersma et al. (2020) have shown that regional cross-border commuting is, in fact, close to the nationwide cross-border commuting. Broersma et al. (2020) show that over 80% of cross-border mobility is between NUTS-2 border regions for commuting flows between the Netherlands, Germany and Belgium. The use of country level data also affects the explanatory variables, because wage and unemployment level in the border region may differ from the national level, for example. Because border regions are located on the periphery of a country, the wage rate might well be lower than the national average and the unemployment rate might be higher. However, since the border region's economic and institutional relations with the national economy are usually stronger than with neighbouring regions or countries, we are confident that the national wage and unemployment rates can serve as proxies for these rates in the country's border regions. We therefore consider that, despite the

use of country level data, our analysis sheds light on the issues of the inequality of border regions as parts of European countries.

We used different denominators for scaling cross-border commuting, which depend on the type of commuting being analysed. When it concerns the individual commuter, characteristics such as gender, education or age are scaled by the employed labour force in the home country using the same characteristics for both the local and the cross-border workers who live there. On the other hand, when the analysis is of the jobs these commuters fill, using characteristics like sector or profession, they are scaled by the employed labour force in the work country, using the same characteristics for both the local and the cross-border workers who work in that country.

The explanatory (stock) variables *y* in (1) are taken from both home and work countries. In our setting, we have three different explanatory variables related to either home or work country. These variables illustrate the theoretical socio-economic, infrastructural or cultural phenomena used to explain cross-border commuting. These are (i) the real hourly wages, (ii) the unemployment rate, (iii) the share of the counties' surface being occupies by highways. According to neoclassical models, wage and unemployment differentials between home and work countries are the driving forces for labour mobility across borders (Jacob et al., 2019; Niebuhr & Stiller, 2004; Van Houten et al., 2004). However, note that these explanatory variables do have their limitations. Despite the efforts of Eurostat to standardize the variables, hourly wages may not fully reflect differences in taxes or social security systems between different EU-countries. In addition, unemployment rates may not be fully harmonized between these countries. Finally, highways at a national level can easily hide the importance that highways may have at a regional level, particularly in border regions.

We should, however, also note that inequalities in access to job opportunities are related to socio-economic deprivation, low accessibility to employment, as well as a low mobility and poor quality of transport supply (Pucci et al., 2019). For an appropriate analysis we needed to include these types of variables in our model, and after exploring

other potential data sources extensively, we concluded that the Eurostat dataset is the best available for the countries and time period we wanted to cover. We also constructed a distance measure between bordering EU-countries, based on the central point of each country. Finally, we constructed a dummy variable to refer to countries with a common language (D_{lij}=1) or not (D_{lij}=0).

Our model of cross-border commuting is a special case of model (1). In operational form, our cross-border commuting models using personal characteristics *k* are shown in equation (2):

$$\begin{aligned}\log(Y_{i,j,k,t} / E_{i,k,t-1}) = \rho &+ \alpha_1 \log(w_{i,t-1} / h_{i,t-1}) + \alpha_2 \log(w_{j,t-1} / h_{j,t-1}) + \\ &\beta_1 \log(u_{i,t-1} / lf_{i,t-1}) + \beta_2 \log(u_{j,t-1} / lf_{j,t-1}) + \\ &\gamma_i \log(road_{i,t-1} / land_{i,t-1}) + \gamma_2 \log(road_{j,t-1} / land_{j,t-1}) + \\ &\delta \log(dist_{i,j}) + \Sigma_l \theta_l D_{l,i,j} + \varepsilon_{i,j,k,t}. \qquad (2)\end{aligned}$$

As dependent variable we used $Y_{i,j,k,t}$, which is the flow of cross-border commuters with personal characteristics *k*, like gender, education or age, living in country *i* and working in neighbouring country *j* during year *t*. This $Y_{i,j,k,t}$ is taken as a share of the stock of the employed labour force by each personal characteristic *k* in the home country *i* at the start of year *t*, which is the end of *t*-1, $E_{i,k,t-1}$.

The explanatory variables in our model are: (i) the lagged real hourly wage rate in both home and work country, i.e. ($w_{i,t-1}/h_{i,t-1}$) and ($w_{j,t-1}/h_{j,t-1}$); (ii) lagged unemployment as share of the lagged labour force in the home country ($u_{i,t-1}/lf_{i,t-1}$) and work country ($u_{j,t-1}/lf_{j,t-1}$); (iii) the surface of highways (i.e. length times width, in km^2), where the latter includes unused stretches of land on both sides of the road, giving a total, fixed, width of 1 kilometre. This highway surface is taken as a share of the country's total land surface: for the home country ($road_{i,t-1}/land_{i,t-1}$) and work country ($road_{j,t-1}/land_{j,t-1}$). Next, the distance between the centre points of the countries *i* and *j* is denoted by $dist_{ij}$.

Finally, our model comprised a number of dummy variables to refer to neighbouring countries having a common language, and with ε as the error term.

In the model above we distinguish commuters by personal characteristics like gender, education and age. In addition, we estimated a model in which we could distinguish commuting flows for different industrial sectors. This allowed us to include the sector-specific wage rate for these sectors in both the home and work country as an explanatory variable. Because the sector information is only available for the period 2011-2016, we restricted our analysis to this shorter five-year period. In this model we focused on the sector to which the job belongs in the work country. Thus, the commuting flows were now scaled with the employed labour force in the *work country* in contrast to model (2), in which the commuter flows were scaled by the employed labour force in the *home country*. Note that the other explanatory variables are the same as in model (2).

In operational form, our cross-border commuting models by job and wage characteristics k are seen in equation (3):

$$\begin{aligned}\log(Y_{i,j,k,t} / E_{j,k,t-1}) = \rho &+ \alpha_1 \log(w_{i,k,t-1} / h_{i,k,t-1}) + \alpha_2 \log(w_{j,k,t-1} / h_{j,k,t-1}) + \\ &\beta_1 \log(u_{i,t-1} / lf_{i,t-1}) + \beta_2 \log(u_{j,t-1} / lf_{j,t-1}) + \\ &\gamma_i \log(road_{i,t-1} / land_{i,t-1}) + \gamma_2 \log(road_{j,t-1} / land_{j,t-1}) + \\ &\delta \log(dist_{i,j}) + \Sigma_l \theta_l D_{l,i,j} + \varepsilon_{i,j,k,t}. \qquad (3)\end{aligned}$$

In this case, the dependent variable, $Y_{i,j,k,t}$, is the flow of cross-border commuters moving from home country i towards the neighbouring work country j, where they work on a job in sector k during period t. This $Y_{i,j,k,t}$ is taken as the share of the stock of the employed labour force in work country j by each sector k at the start of year t, which is the end of t-1, $E_{j,k,t-1}$.

Our stocks of explanatory variables also had to be scaled. The cross-border commuting rate from home country i into work country j on a job in sector k is determined by the real hourly wage rate in that sector in both the home and work country, i.e.

($w_{i,k,t-1}/h_{i,k,t-1}$) and ($w_{j,k,t-1}/h_{j,k,t-1}$). The other explanatory variables are the same as those in model (2).

3. Data description

The dependent variable in our model is the cross-border commuting flow of workers living in one country (home country), but working in a neighbouring country (work country). We used aggregated data from the EU Labour Force Survey (LFS) for all EU-countries and Switzerland. Switzerland was added because it is surrounded by the EU and is host to many international organizations, which may well attract workers from EU countries. We restricted our analysis to commuting flows between bordering countries. Using the commuting flows for the full matrix of all countries would most likely lead to a matrix with many, very small close-to-zero or zero observations, because, for example, daily commuting from countries like Italy and Spain to the UK or Finland would be very unlikely. In this way we also prevented biases related to including many structural zeros, which were mentioned in the empirical trade literature dating back to the paper on "The Log of Gravity" by Santos Silva and Tenreyro (2006). The flow data for the countries included in the empirical analysis were scaled by the appropriate stock data drawn from aggregate Eurostat data, as described in the model specification (see previous section).

Our explanatory variables were all drawn from aggregate Eurostat databases. Hourly wages could be identified for several specific sectors, however Eurostat did not report sectoral hourly wages for Switzerland, so these were drawn from International Labour Organization (ILO) databases. We assume that cross-border commuting by sector can be explained by wage rates in that sector, instead of by the overall wage rate. Unemployment rates were available for all EU countries and Switzerland from Eurostat. The total length of highways in each EU country was also drawn from Eurostat; missing

data were filled in by information found on the Internet.[1] We used all these data to explain cross-border commuting between neighbouring EU-countries.

Finally, we constructed a dummy variable to refer to countries with a common language in at least the areas on each side of the border. These regions include eight groups of countries: (i) the southern Netherlands and northern Belgium (Dutch language), (ii) southern Belgium, Luxemburg and France (French), (iii) Luxemburg and Germany (German), (iv) northern and eastern Switzerland, Germany and Austria (German), (v) western Switzerland and France (French), (vi) southern Switzerland and Italy (Italian), (vii) Finland and Estonia (same Uralic language group of Finno-Ugric), and (viii) Ireland and Northern Ireland (English). The model contains 8 dummies for each group of bordering countries having the same (or a very similar) language.

In Table A1, for 2016 we show the cross-border commuting per EU-country and Switzerland as a percentage of the lagged employed labour force in the commuters' *home country*. The type of data used in model (2) are the commuting flows based on personal characteristics. In Table A2 we show the same as in A1, but now as a percentage of the employed labour force in the *work country*. The data used in model (3) are the commuting flows based on sector characteristics. Table A1 shows, for example, that 4% of the working people who live in Slovakia hold a job in a neighbouring country, mainly in the Czech Republic or Austria. Table A2 shows, for example, that, of the Luxemburg employed labour force, i.e., those holding a job in Luxemburg, approximately 37% live in France.

4. Cross-border commuting by type of worker /sector

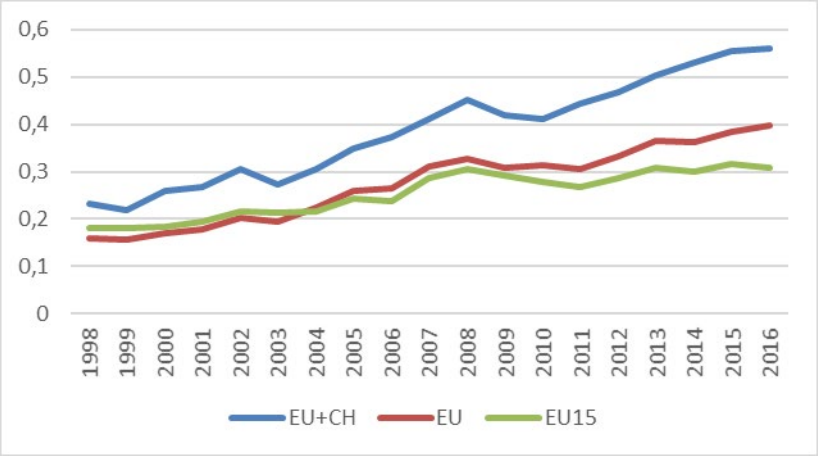
In absolute terms, the 2016 data revealed some 900,000 workers in the EU who qualified as a cross-border commuter between neighbouring countries. This is only

[1] See https://en.wikipedia.org/wiki/List_of_countries_by_road_network_size. This database was last accessed in the summer of 2020.

0.4% of the EU-wide employed labour force, so mobility between bordering EU member states is still in fact a small-scale phenomenon.

However, if we include Switzerland, cross-border commuting becomes more important, with some 1.3 million commuters in 2016 in absolute terms in this extended 'EU+' . But this is still only 0.6% of the total EU+ labour force. This number is in line with the numbers published by the EC (2017). Figure 1 shows cross-border commuting as a share of the lagged employed labour force in the home country, for various compositions of the EU, between 1998 and 2016. From the figure we see first that the level of cross-border commuting is small but it has been increasing in the past twenty years (up to 0.4% in 2016). Second, the rate of cross-border commuting for the EU+ is much higher than when Switzerland was excluded. The cross-border commuting rate in the old EU-15 countries was even below that of the current EU.

Fig. 1. EU cross-border commuting as percentage of the lagged employed labour force of the home countries for various compositions of the EU between 1998 and 2016.

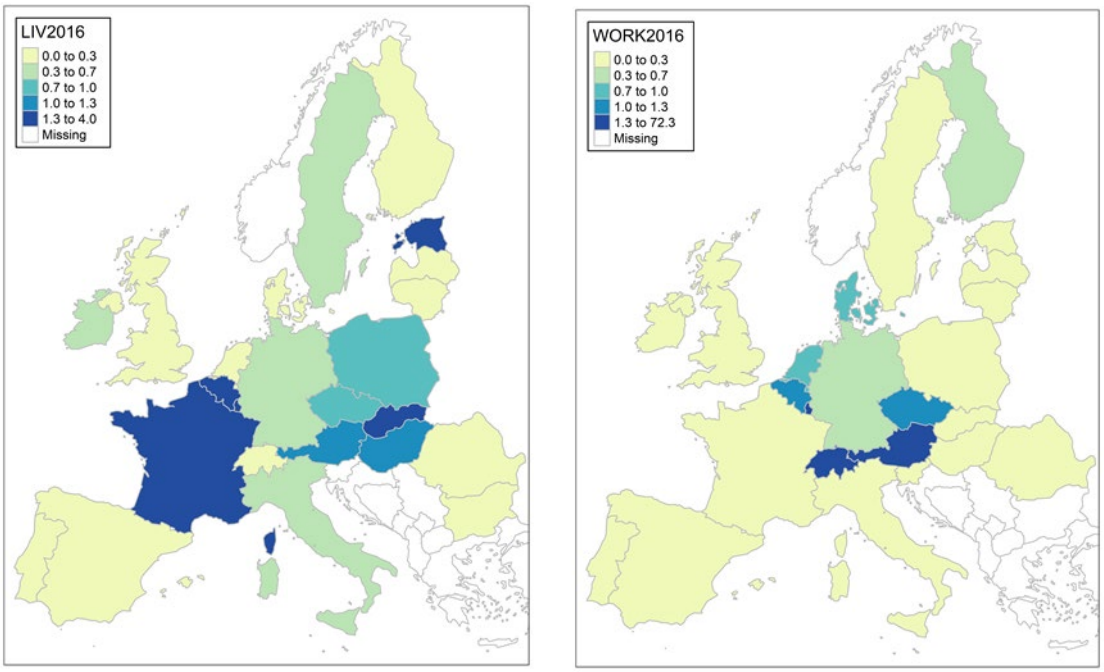


Source: Eurostat

Figure 2 shows the rates of out-commuting and in-commuting in 2016 for all the relevant EU-countries and Switzerland. Out-commuting shows the home countries in

which cross-border commuters are resident; in-commuting shows the countries where they work. Home countries with a relatively large share of cross-border commuters are France, Belgium, Slovakia, and Estonia. Countries in which a high share of cross-border commuters work are Luxemburg, Switzerland, Austria, and the Czech Republic, but also Belgium, the Netherlands, and Denmark. Note that Belgium has both high out- and in-commuting.

Fig. 2. Commuting out of (left panel) or into (right panel) EU-countries and Switzerland from neighbouring countries in 2016, as a share of the lagged employed labour force of the home or work countries, respectively.

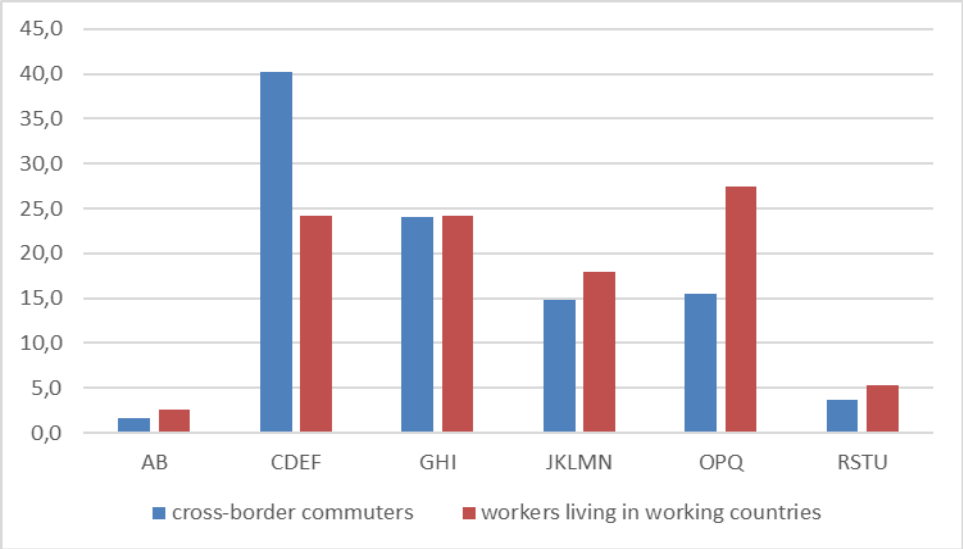


Source: Eurostat

Next, Figure 3 shows the distribution of jobs by sector, for all EU-countries plus Switzerland, which were filled in 2016 by cross-border commuters and by local workers. Local workers are those worker that live in work countries. Cross-border commuters typically work in sectors like manufacturing and construction and are particularly

underrepresented in government services. Since these first two sectors are more cyclical than others, this means cross-border commuting itself is also more cyclical. Table A4 lists the individual industries.

Fig. 3. Distribution of jobs by industrial sector in the total EU plus Switzerland, filled by cross-border commuters and local workers in 2016.



AB= agriculture and mining; CDEF= manufacturing and construction; GHI= 'old' commercial services; JKLMN= 'new' commercial services; OPQ= government services; RSTU= other services. See for more details Table A4 in the Appendix.

Source: Eurostat

5. Results

Here we present the estimation results for our models of cross-border commuting. Table 1 shows the ordinary least squares (OLS) estimation results for the commuting flows in the 18-year period 1998-2016 based on model (2), in which we analysed commuting flows of all workers and commuting flows based on personal characteristics of gender, education, and age, scaled by the lagged employed labour force in the *home country* with the same characteristics. Table 2 shows the OLS estimation results for

commuting flows in the five-year period 2011-2016 based on model (3), in which we analysed commuting flows of all workers and commuting flows based on sectoral characteristics scaled by the total and sectoral lagged employed labour force in the *work country*.

5.1 Results for commuting flows by gender, education, and age as share of the lagged employed labour force by these items in the *home country*

The estimation results for the model of overall cross-border commuting, as a share of the overall employed labour force in the home country, are shown in the first column of Table 1. We found that the log of the lagged hourly wages in the home and work countries are both highly significant in explaining this overall commuting rate. A rise of 1%-point in the home country's wage rate will make cross-border commuting from that home country fall by -0.61%-points. A 1%-point rise in the work country's wage rate will increase cross-border commuting into the work country by 0.89%-points. This is, of course, what we would expect. Higher wages in the home country will make locals more reluctant to look for work abroad, while higher wages in the work country will ensure that more locals choose to go there to work.

Second, we expect higher unemployment in the home country to increase the incentive to look for work abroad, and that is indeed what we found. A 1%-point rise in the unemployment rate in the home country will increase cross-border commuting by 0.33%-points, while the same unemployment rise in the work country decreases cross-border commuting by -0.22%-point. This makes sense as more unemployed workers in the home country will make it more difficult to find a job locally and they may start looking for work across the border. On the other hand, a rise in unemployment in the work country will raise competition for the jobs available for cross-border commuters. So higher unemployment in the home country will act as a push factor, while high unemployment in the work country may act as a kind of pull factor.

Third, with respect to distance or accessibility, as measured by the share of highways in both home and work countries we expect to see a similar difference. More highways in the home country make work sites within that country easier to reach, so there are fewer incentives to look for work across the border. More highways in the work country make it easier to look for work over there. The first column of Table 1 does show a negative but insignificant effect on cross-border commuting from the home country. A 1%-point rise in the share of highways in the work country will raise the rate of cross-border commuting by 0.16%-points. Hence, highways in the work country do act as pull factor, because they 'pull in' cross-border commuters from a neighbouring country.

Table 1. Estimation and test results of overall commuting and commuting by gender, education level and age-group, as share of the lagged employed labour force by the same types in the home country, 1998-2016

	t-statistics in brackets							
	General model	Model by gender		Model by level of education			Model by age (yrs)	
Explanatory Variables		Male	Female	Low	Medium	High	15-44	45+
Constant	**1.62** (2.37)	**2.19** (3.20)	**2.49** (3.57)	**5.69** (3.27)	**2.22** (3.17)	**2.55** (4.06)	**2.32** (3.37)	**2.07** (2.94)
Log of lagged hourly wages in home country	**-0.61** (-8.61)	**-0.68** (-9.38)	**-0.52** (-7.13)	**-0.56** (-6.46)	**-0.71** (-9.85)	**-0.47** (-6.39)	**-0.69** (-9.44)	**-0.64** (-8.59)
Log of lagged hourly wages in work country	**0.89** (12.32)	**0.85** (11.47)	**0.76** (9.75)	**0.52** (5.46)	**0.83** (11.22)	**0.50** (6.96)	**0.85** (11.32)	**0.80** (10.44)
Log of lagged rate of unemployment in home country	**0.33** (2.99)	**0.29** (2.60)	**0.29** (2.59)	**0.67** (5.30)	**0.46** (4.09)	-0.02 (-0.16)	**0.38** (3.39)	0.13 (1.11)
Log of lagged rate of unemployment in work country	**-0.22** (-2.04)	**-0.25** (-2.32)	-0.14 (-1.21)	-0.03 (-0.27)	**-0.40** (-3.62)	-0.06 (-0.57)	**-0.30** (-2.77)	0.02 (0.21)
Log of lagged share of highways in home country surface	-0.05 (-0.63)	0.01 (0.18)	-0.06 (-0.77)	**-0.14** (-1.69)	-0.06 (-0.75)	0.04 (0.54)	0.00 (0.03)	0.01 (0.15)

Log of lagged share of highways in work country surface	**0.16** (2.40)	**0.14** (2.13)	0.07 (1.04)	**0.26** (3.07)	**0.20** (2.96)	0.09 (1.48)	0.10 (1.48)	**0.13** (1.79)
Log of distance between centres of gravity of home and work countries	**-0.61** (-4.93)	**-0.60** (-4.75)	**-0.77** (-6.03)	**-0.79** (-5.35)	**-0.63** (-4.91)	**-0.53** (-4.58)	**-0.65** (-5.19)	**-0.64** (-5.02)
Common language dummy								
$D_{Belgium\text{-}Netherlands}$	**1.28** (4.70)	**1.23** (4.52)	**1.17** (4.35)	**1.04** (3.57)	**1.29** (4.72)	**1.26** (5.11)	**1.20** (4.41)	**1.29** (4.73)
$D_{Belgium\text{-}France\text{-}Luxemburg}$	**1.95** (11.93)	**1.58** (9.65)	**1.61** (9.99)	**1.18** (6.54)	**1.48** (9.03)	**1.72** (11.58)	**1.72** (10.50)	**1.46** (8.89)
$D_{Germany\text{-}Luxemburg}$	**1.11** (4.46)	**0.97** (3.93)	**1.11** (4.59)	0.24 (0.86)	**1.01** (3.99)	**1.20** (5.25)	**1.12** (4.53)	**0.96** (3.85)
$D_{Austria\text{-}Germany\text{-}Switzerland}$	**0.95** (5.62)	**0.89** (5.29)	**0.87** (5.23)	**0.51** (2.75)	**0.95** (5.60)	**1.07** (7.05)	**0.94** (5.61)	**0.90** (5.30)
$D_{France\text{-}Switzerland}$	**1.45** (5.40)	**1.41** (5.25)	**1.44** (5.53)	**1.03** (3.65)	**1.36** (5.10)	**1.58** (6.65)	**1.46** (5.47)	**1.50** (5.60)
$D_{Italy\text{-}Switzerland}$	**0.96** (3.46)	**0.95** (3.45)	**0.81** (3.03)	**0.86** (3.06)	**0.84** (3.08)	**0.64** (2.64)	**0.90** (3.26)	**1.03** (3.75)
$D_{Estonia\text{-}Finland}$	**1.31** (4.34)	**1.77** (5.60)	**0.76** (2.25)	**2.37** (6.05)	**1.69** (5.52)	**1.15** (3.51)	**1.57** (4.86)	**1.55** (4.49)
$D_{Ireland\text{-}N.\ Ireland}$	0.40 (1.42)	**0.49** (1.76)	0.13 (0.45)	0.33 (1.10)	0.35 (1.26)	0.34 (1.38)	0.45 (1.58)	0.29 (1.04)
Adj R^2	0.43	0.40	0.36	0.32	0.42	0.37	0.41	0.36
Number of observations	1125	1103	1011	826	1049	997	1088	1036

Between brackets are the *t*-values and bold values are significantly different from zero at 90% significance or more. Adj R^2 indicates the R^2 adjusted for the number of explanatory variables.

Fourth, the larger two neighbouring countries are, the larger our distance measure between home and work country will be, and hence the more negative the effect will be on cross-border commuting. Likewise, the shorter the distance measure is between two neighbouring countries, or the smaller these countries are, the less negative the effect on cross-border commuting will be. In other words, the rate of cross-border

commuting between two smaller countries will be less negative than between two larger countries.

Fifth and finally, we considered the effect of cross-border commuting in neighbouring countries that share a language. We already saw that in the EU and Switzerland there are eight groups of countries with a similar language. Table 1 shows that having a common language clearly has a positive effect on cross-border commuting in nearly all situations, except for Ireland and Northern Ireland, as part of the UK, where the language effect is insignificant. This might be due to the specific political and geographical circumstances here.

Commuting by gender

The models for cross-border commuting by gender are given in the next two columns of Table 1. We find that the log of the lagged wage rate in both the home and work country are again highly significant in explaining the male commuting rate. A 1%-point rise of the overall wage rate in the home country, will make male commuting from that home country fall by -0.68%-points. Higher wages in the home country obviously make it less attractive for male workers to go abroad for a job. At the same time, a 1%-point rise in the wage rate of the work country will make male commuting into that country rise by 0.85%-points. These wage effects are slightly less for female commuters, but they do have the same signs and are also significant. A 1%-point rise in the home country's wage rate, will lower female commuting from that country by -0.52%-points and a 1%-point rise in the work country's wage rate raises female commuting into that country by 0.76%-points.

Table 1 also shows the following effects of unemployment on cross-border commuting by gender. A 1%-point rise of the unemployment rate in the home country will raise both male and female commuting by 0.29%-points. On the other hand, a 1%-point rise of the unemployment rate in the work country only has a significant, downward, effect of -0.25%-points on male commuting. So, more unemployment in the home country

will stimulate both male and female workers to look for a job across the border, while more unemployment in the work country particularly affects how attractive it is for male commuters to work there. More unemployment means more job competition. There is, on the other hand, no significant effect on female commuters.

The effect of highways on cross-border commuting by gender only holds for male commuters and only holds for highways in the work country. A 1%-point rise in the share of highways in the total land surface of the work country will raise male commuting into this country by 0.14%-points. There is no effect seen for females, nor from the roads in the home country, i.e., more highways in the work country will only pull in male commuters.

The distance measure shows that when the travel distances are greater i.e., in large neighbouring countries in our setting, it will be particularly females who cross the border less. They do not appear to like travelling long distances, while this is less of a problem for males. As summarized by Broersma et al. (2020), a general finding in the literature is that women commute less and over a shorter distance than men (Jacob et al., 2019). There are several possible explanations: women are still the primary care givers for children and are often the secondary income earner in a household. However, psychological explanations also seem to be relevant: for instance, commuting has an important detrimental effect on the psychological health of women, but not on men (Roberts et al., 2011). It looks as though women's greater sensitivity to a longer commuting time seems to be a result of their greater responsibility for day-to-day family tasks, including childcare and housework. Women’s range of work is further limited because they are more likely to use public transport and non-motorized transport, particularly walking (Miralles-Guasch, 2016; Crane, 2007). Therefore, women’s willingness or ability to trade longer commuting times against other job characteristics like higher wages seems to be more restricted (Jacob et al., 2019). In addition, local labour systems for men and women greatly differ, as Cristaldi (2005) concluded from her detailed study of gender commuting patterns in Italy. Women are

not only ‘‘constrained’’ within given physical spaces (smaller than men), but also obliged to make the best of the limited work opportunities available in that limited space. Since it is a reasonable assumption that the average commuting distance for cross-border commuting is larger than for domestic commuting, the explanatory power of the economic variables will be much larger for males than for females (Broersma et al., 2020).

Finally, the common-language effect holds for both males and females, with little difference in the effect: having a common language on both sides of a border has a positive effect on cross-border commuting for both males and females. The only exception is seen in the closely related (Finno-Ugric) languages of Finland and Estonia. Here, the male-effect, of 1.77%-points, is clearly larger than the female-effect, which is 0.76%-points. More males than females go from Estonia to work in Finland. This might be related to the geographical situation; commuting travel is mainly by ferry which might imply relative long commuting distances or times, which affect males less than females.

Commuting by education level

We expect that more highly educated workers will show higher cross border commuting rates, because higher education makes workers more flexible and they can deal with institutional and language barriers more easily. A higher salary also means the costs of commuting take up a smaller share of the salary. This is in line with the fact that highly educated workers, in general, commute over larger distances within countries.

The models for the cross-border commuting rate by level of education are given in columns four, five and six of Table 1. Table 1 shows the effects that lagged explanatory variables have on low, intermediate, and highly educated cross-border commuters, as shares of the lagged employed labour force with the same education levels in the home country.

A 1%-point rise in the home country’s wage rate makes commuting abroad by lower educated workers fall by -0.56%-points, while a similar change in the wage rate for the

work country will raise commuting of lower educated workers into that country by almost the same %-points. So, for the lower educated, the push and pull effects of wages on commuting are about the same (with opposite signs). For the intermediate level commuters, we found a push-effect of -0.71%-points, against a pull-effect of 0.83%-points. For highly educated commuters, the push- and pull-effects are -0.47%-points and 0.50%-points, respectively. So, for each level of education, these effects are almost similar and opposite.

Next, we move to the effects of unemployment on cross-border commuting by education. For the lower educated, a 1%-point rise in the unemployment rate of the home country will raise cross-border commuting by 0.67%-points, while there is no effect from unemployment in the work country. For the intermediate level we did find an effect from unemployment in both the home and work countries. A 1%-point rise in home unemployment raises cross-border commuting of intermediate level workers by 0.46%-points, while a similar unemployment rise in the work country reduces their commuting by -0.40%-points. So, for intermediate level workers, we find a similar and significant push- and pull-effect on commuting, while there are no effects on the highly educated.

A 1%-point rise in the share of highways in the home country reduces commuting of the lower educated by 0.14%-points, although only at 90% significance. A 1%-point rise in the share of highways in the work country, on the other hand, increases cross-border commuting by lower educated workers by 0.26%-points. So, more highways in the work country stimulate the lower educated to look for work there, while more highways in the home country make them look for a job locally. For intermediate level workers there is only a significant pull-effect of 0.20%-points from highways in the work country. For highly educated commuters there is neither a significant push- nor pull-effect from a greater share of highways.

The distance measure shows that when the travel distance is greater (in large neighbouring countries), there will be less cross-border commuting. However, this

negative effect is largest for the lower educated, less for the intermediate level, and least for highly educated workers.

Finally, the common language-effect is, in most cases, the least important for lower educated commuters, slightly more for the intermediate level, and most for the highly educated, because communication is more important for them than for those in manual jobs. However, for the border between Finland and Estonia, we found a reverse effect. There, most commuters were lower educated; relatively many lower educated Estonians work in Finland. Cross-border commuting between the English-speaking countries of Ireland and Northern Ireland revealed no differences in education levels.

Commuting by age group

What is the effect of age on cross-border commuting? We distinguished two groups: young (15-44 years) versus older (>45 years) commuters. We expected young workers to show higher cross-border commuting rates, because they are more flexible than older workers. However, Schwanen et al. (2001) showed that the relationship between age and distance travelled is weak. Levinson (1998) found that middle-aged commuters have longer travel times than younger or older ones. The final two columns of Table 1 show the effects of the explanatory variables in the models of cross-border commuting by age group, as a share of the lagged employed labour force by that age group in the home country.

A 1%-point rise in the home country's wage rate reduces commuting away by young workers by -0.69%-points, while for older workers the reduction is only slightly less at -0.64%-points. On the other hand, a 1%-point rise in the work country's wage rate increases commuting in by 0.85%-points for young workers and 0.80%-points for older ones. The differences are small, but the effects are slightly less for older commuters.

On the contrary, however, the effect of the unemployment rate on commuting by age group shows remarkable differences. For the younger group, the home- and work

country unemployment rates have significant and opposite effects. A 1%-point rise in the home country's unemployment rate raises cross-border commuting by younger workers by 0.38%-points; a 1%-point rise in the work country's unemployment rate reduces cross-border commuting in this young group by -0.30%-points. For the older group we found no significant effect from unemployment rates in either the home- or work country.

A 1%-point rise in the share of highways in the total land surface had only a very small –and hardly significant– effect in the work country, on both young and older commuters. Neither did the distance measure between countries really show any difference between the age groups. A 1%-point rise in our distance measure between country centres reduced commuting of both young and older workers by about -0.65%-points. Finally, there were no large differences between the age groups for all eight common-language country groups.

5.2 Results for commuting flows by sector as a share of the lagged employed labour force by that sector in the *work country*

Table 2 presents the OLS estimations for the relevant types of cross-border commuting by sector in the *work country*, as a share of the lagged employed labour force in that same sector. Our analysis was restricted to the period 2011-2016 because sector information was not available earlier. One advantage of this recent data is that we can now distinguish wage rates by sector instead of using overall wage rates, so cross-border commuting can now be explained by sector using the real hourly wages in each sector.

The estimations in the first column of Table 2 show that the log of the lagged real wage rate in the home country has no significant effect on cross-border commuting, while the log of the lagged real wage rate in the work country has a significant positive effect. In some regions there may be a tradition of working on the other side of the border because the work locations are close to the border and/or the highway infrastructure

makes it easy to commute across the border. Workers may also be used to relatively long commuting distances, e.g., because they work in the construction industry and do not have a fixed work location. A 1%-point rise in the work country's real wage rate increases cross-border commuting inwards by 0.4%-points. So, higher wages in the work country pull in cross-border workers from neighbouring countries.

The direction of the effects of unemployment are in line with expectations in Table 2, but the magnitude is much larger than seen in the unemployment effects in Table 1. A 1%-point rise in the unemployment rate of the home country increases cross-border commuting by 1.13%-points, while the same rise in the work country's unemployment reduces cross-border commuting by about the same percentage. Thus, more unemployment in the home country leads to workers looking for a job across the border, while a rise in unemployment in the work country raises competition for the available jobs, so cross-border commuting drops. High unemployment in the home country acts as a push factor, i.e., pushing workers over the border, while low unemployment in the work country is a pull factor.

More highways in the home country have a negative effect on cross-border commuting, as more locations in the home country can then be reached and there is less need to cross the border for work. A 1%-point rise in the share of highways in the home country reduces cross-border commuting by -0.62%-points. However, more highways in the work country have a positive effect on cross-border commuting, as jobs can then be reached more easily. A 1%-point rise in the share of highways in the work country increases cross-border commuting by 0.89%-points. The effects of highways were now significant on both sides of the border, but much larger in size than those reported in Table 1. In the home country, highways are significant and act as a 'keep-effect': they keep workers in their home country. At the same time, highways in the work country act as a pull factor, because they help pull in cross-border commuters from the neighbouring country.

The effect of distance is, just as in Table 1, significantly negative, implying that larger distances lead to lower commuting rates and that there will be relatively more cross-border commuting between smaller countries (with smaller travel distances).

Finally, we considered the effect of cross-border commuting on neighbouring countries with the same language. We already saw that in the EU and Switzerland, there are eight groups of countries that have the same language. Table 2 shows that having a common language has a clear and significant positive effect on cross-border commuting.

Table 2. Estimations and test results of cross-border commuting by sector, as a share of the lagged employed labour force in the same sectors in the work country, explained by real hourly wages by sector, unemployment rate, highway share, and distance between countries in the period 2011-2016.

		Cross-border commuting by sector in work country			
Sector	All sectors (A thru U)	Manuf. constr. (CDEF)	Old services (GHI)	New services (JKLMN)	Govt. services (OPQ)
Explanatory variables					
Intercept	**3.55** (2.40)	**4.11** (2.27)	**3.25** (1.99)	**3.62** (2.04)	**4.73** (3.40)
Log of lagged hourly wages in home country	-0.02 (-0.10)				
Log of lagged hourly wages in work country	**0.39** (2.63)				
Log of lagged hourly wages in manufacturing and construction (CDEF) in home country		0.13 (0.65)			
Log of lagged hourly wages in manufacturing and construction (CDEF) in work country		-0.09 (-0.49)			
Log of lagged hourly wages in old services (GHI) in living c.			0.11 (0.57)		
Log of lagged hourly wages in old services (GHI) in working c.			0.15 (0.91)		
Log of lagged hourly wages in new services (JKLMN) in living c.				**0.73** (3.39)	
Log of lagged hourly wages in new services (JKLMN) in work country				-0.30 (-1.50)	
Log of lagged hourly wages in government services (OPQ) in home country					**-0.81** (-5.71)

Log of lagged hourly wages in government services (OPQ) in work country					**0.74** (6.14)
Log of lagged unemployment rate in home country	**1.13** (4.14)	**0.95** (2.84)	**0.65** (2.10)	**1.00** (3.04)	**-0.53** (-1.93)
Log of lagged unemployment rate in work country	**-1.13** (-4.52)	**-1.07** (-3.18)	**-0.86** (-2.86)	**-0.99** (-3.00)	0.07 (0.25)
Log of lagged share of highways in home country surface	**-0.62** (-4.06)	**-0.94** (-5.02)	**-0.82** (-5.00)	**-0.80** (-4.22)	-0.16 (-1.13)
Log of lagged share of highways in work country surface	**0.89** (5.98)	**1.05** (5.59)	**0.81** (5.02)	**0.67** (3.79)	**0.27** (1.88)
Log of distance between centres of gravity of home and work countries	**-0.89** (-3.39)	**-0.74** (-2.30)	**-0.66** (-2.27)	**-0.89** (-2.83)	**-0.77** (-3.26)
Common language dummy					
$D_{Belgium\text{-}Netherlands}$	0.66 (1.09)	**1.23** (1.76)	**1.18** (1.87)	0.84 (1.29)	**1.02** (2.02)
$D_{Belgium\text{-}France\text{-}Luxemburg}$	**1.57** (4.35)	**1.77** (4.15)	**1.59** (4.18)	**1.37** (3.47)	**1.43** (4.42)
$D_{Germany\text{-}Luxemburg}$	**0.93** (1.66)	**1.10** (1.73)	0.84 (1.47)	**1.38** (2.34)	**1.18** (2.47)
$D_{Austria\text{-}Germany\text{-}Switzerland}$	**0.62** (1.69)	**2.16** (4.50)	**1.53** (3.58)	**1.78** (3.98)	**1.66** (4.63)
$D_{France\text{-}Switzerland}$	0.81 (1.50)	**3.58** (4.17)	**3.13** (4.09)	**3.22** (4.08)	**3.81** (6.15)
$D_{Italy\text{-}Switzerland}$	0.70 (1.31)	**2.82** (3.30)	**2.05** (2.68)	**1.87** (2.38)	1.86 (3.00)
$D_{Estonia\text{-}Finland}$	**1.76** (3.14)	**2.84** (3.37)	**1.75** (2.50)	**1.43** (1.78)	-0.72 (-1.06)
$D_{Ireland\text{-}Northern\ Ireland}$	0.76 (1.35)	0.94 (1.46)	0.42 (0.71)	0.51 (0.82)	**0.91** (1.93)
Adj R^2	0.38	0.37	0.36	0.32	0.48
Number of observations	409	341	339	304	309

Between brackets are the *t*-values and bold values are significantly different from zero at 90% or more. The sector letters (A – U) are explained in Table A4 in the Appendix. Adj R^2 indicates the R^2 adjusted for the number of explanatory variables.

Sector cross-border commuting and sector wages

Table 2 further shows the estimations for four broad economic sectors, including the effects of sector-specific wage rates on cross-border commuting in each sector. Whereas only the wage rate in the work country is significant for all types of workers, for most sectors the specific wage rates were insignificant in both countries. For example, in the manufacturing and construction sector, which has the highest commuting rates (see Figure 3), wages were not a major driving force. Only in the

government services sector, with relatively low commuting rates, did we see the expected negative effect of wage rates in the home country on cross-border commuters. So, a higher wage rate for government services in the home country leads to less cross-border commuting. At the same time, Table 2 shows that a higher wage rate for government services in the work country leads to more cross-border commuting into the work country. Table 2 also shows that, in contrast to our expectations, higher wages in the new services sector in the home country does not restrict higher cross-border commuting out to another country. This was the only anomaly seen in the models of Table 2.

So, in general terms, wage rates by sector in either the home or work country had no effect on cross-border commuting by sector for the period 2011-2016. It would seem that other factors like unemployment, accessibility and a common language are the main driving forces for cross-border commuting in all the sectors except government services.

We find that sector cross-border commuting is reduced by highways in home countries, but encouraged by highways in work countries. Furthermore, more unemployment in the home country leads to more cross-border commuting, while more unemployment in the work country reduces cross-border commuting. The reader should note that the (negative) effect that unemployment in the home country has on cross-border commuters working in government services is not significant at 5%. The effect of the 'country-distance' in Table 2 is negative so, as we saw earlier, larger countries have relatively less cross-border commuting. All in all, sector wage rates had hardly any effect on cross-border commuting per sector. Compared to Table 1, the results for the other variables have, in general, the same sign, but their magnitude and significance is higher.

6. Concluding remarks

This is the first study on cross-border commuting in the EU plus Switzerland (EU+) based on Eurostat data for the 18-year period 1998–2016: our study distinguishes between different groups of workers by gender, education level, and age. In addition, for the five-year period 2011–2016, we also analysed cross-border commuting by four sectors. In 2016 cross-border commuting encompassed almost 1.3 million persons, but it still represented less than 0.6% of the total employed labour force of this EU+,. In 1998 there were 450,000 cross-border commuters in the EU+. Thus, although EU cross-border commuting almost tripled in the 1998-2016 period, as a share of the total employed labour force, the level remained low.

An important question in this respect is how much an increase in cross-border commuting can reduce territorial inequalities. To gain more insight into this, we estimated models in which cross-border commuting from one EU-country to a neighbouring one is explained by differences between the two countries in (i) hourly (net) wages; (ii) unemployment rates; and (iii) share of highways. In addition, we included a distance measure because country size is also an important factor (the share of cross-border commuting is higher for smaller countries). We also took into account that a common language between neighbouring countries stimulates looking for a job across the border.

For the models of cross-border commuting estimated for the period 1998-2016, we found that higher real hourly wages in the home country lead to less cross-border commuting out. High real wages in the work country, on the other hand, lead to more cross-border commuting in. These wage effects can also be interpreted in terms of push- or pull-effects. Lower wages in the home country 'push workers out' to a work country. Likewise, higher wages in the home country encourage workers to take local jobs.

In addition, more unemployment in the home country increases the area for job searching and thus also across the border, leading to more cross-border commuting.

Higher unemployment in the work country makes it more difficult for cross-border commuters to find a job there: rising unemployment in a country raises competition for local jobs. More highways in the home country have no effect on cross-border commuting, while more highways in the work country lead to slightly higher cross-border commuting rates. The larger a country is, the lower cross-border commuting rates will be; the smaller a country is, the higher the share of cross-border commuting from (or into) that country is. Finally, a common language in both the home and work country makes it easier for workers to search for jobs across the border and hence has a positive effect on cross-border commuting.

The sector models, with sector-specific wage characteristics on which the cross-border commuter works, were estimated for the period 2011-2016. In the overall model for all sectors, the overall wage rate had far less effect than the effect it had in the commuter models with worker characteristics like gender, age, and education over the longer period of 1998-2016. In addition, we looked at specific sector wage effects on per sector commuting. In these cases the wage effects had largely vanished. We only found a significant sector wage effect for government services: higher government wages in the home country reduced cross-border commuting of government workers, while higher government wages in the work country increased their cross-border commuting. Given the country-specific nature of government jobs, it was an unexpected result to find that cross-border commuting in this sector is triggered by wage differentials. When we compared the estimations of the model with personal characteristics over the longer period 1998-2016 (Table 1) with the model estimated for jobs by sector (Table 2), the results for the explanatory variables unemployment, accessibility, distance, and common language in general have the same sign, but the magnitude and significance are higher in the model based on commuting by sector (Table 2).

These observations lead to some important policy implications. We found that cross-border commuters respond, in general, as theoretically expected to unemployment,

wages, accessibility, language similarity, and distance. This implies that cross-border commuting may indeed help to reduce economic and territorial inequalities between border regions and their economic periphery, because the commuting flows respond by the movement of workers from areas with lower wages and higher unemployment to areas with higher wages and lower unemployment. However, the effects are most likely small given the relatively small number of cross-border commuters in the total workforce.

However, besides these general findings, we also found that cross-border commuting is a result of push and pull factors that seem to work out differently for different groups. The results by gender, education, age, and sector show substantial differences, indicating that for specific groups the reduction in inequalities might be very limited and may even increase for some groups which are less mobile and/or less responsive to differences in wages, unemployment, and accessibility. Although cross-border commuters respond to differences in economic opportunities, policy measures aimed at lowering institutional, language, and accessibility barriers might help to further enhance worker mobility between border regions and hence reduce inequalities between border regions in different countries and between regions within countries. To gain further insight we need more sophisticated (detailed) data, preferably on individuals in a systematic data set covering all European countries. The study of cross-border labour markets and cross-border commuting is becoming increasingly important since the European Commission and the OECD are undertaking more efforts to boost economic growth, integration, and cohesion in border regions (OECD, 2013; EC, 2017).

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APPENDICES (4)

Table A1. Cross-border commuting between EU-countries and Switzerland in 2016 as percentage of the lagged employed labour force of the home country. (See Table A3 for country abbreviations)

Home country \ Work country	AT	BE	BG	CH	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK
AT				0.26	0.01	0.69							0.03		0.03									0.01	0.06	
BE						0.20						0.37					0.91		0.69							
BG																						0.00				
CH	0.01					0.16						0.02			0.07											
CZ	0.24					0.66														0.01					0.05	
DE	0.08	0.01		0.22	0.00		0.02					0.02					0.12		0.12	0.02						
DK						0.08																	0.08			
EE											2.27							0.05								
EL																										

	ES												0.04										0.04					
	FI								0.03																0.08			
	FR		0.11		0.77		0.13				0.02					0.00		0.36										
	HU	1.21																					0.01			0.06		
	IE																											0.47
	IT	0.01			0.29								0.04															
	LT																		0.01		0.01							
	LU		0.58				0.95						0.42															
	LV								0.05								0.05											
	NL		0.16				0.17																					
	PL					0.06	0.63										0.00									0.00		
	PT										0.15																	

RO													0.00													
SE							0.34				0.02															
SI																										
SK	2.09				1.62								0.27							0.03						
UK														0.02												

Table A2. Cross-border commuting between EU countries and Switzerland in 2016, as a percentage of the lagged employed labour force of the work country. (See Table A3 for country abbreviations)

Home country \ Work country	AT	BE	BG	CH	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK
AT				0.26	0.01	0.07							0.03		0.01									0.03	0.10	
BE						0.02						0.06					16.05		0.38							
BG									0.12																	
CH	0.01					0.02						0.00			0.01											
CZ	0.29					0.00														0.00					0.10	
DE	0.75	0.10		1.93	0.28		0.35					0.03					19.02		0.56	0.04						
DK						0.01																	0.04			
EE											0.60							0.04								
EL																										
ES												0.02									0.17					
FI								0.11															0.04			

	FR		0.61		4.53		0.08				0.03					0.00		37.22										
	HU	1.23																					0.00		0.02	0.11	
	IE																										0.03
	IT	0.05			1.45								0.03												0.04		
	LT																		0.01		0.00						
	LU		0.03				0.01						0.00														
	LV								0.07								0.03										
	NL		0.28				0.03																				
	PL					0.19	0.25										0.00									0.01	
	PT										0.04																
	RO			0.00										0.00													
	SE							0.59				0.04															
	SI																										
	SK	1.22				0.78								0.16							0.00						

	UK														0.33										

Table A3. Country abbreviations used in Tables A1 and A2

AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
FI	Finland
FR	France
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxemburg
LV	Latvia
NL	Netherlands
PL	Poland
PT	Portugal

RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
UK	United Kingdom

Table A4. The letters used to denote different sectors

A	Agriculture, forestry and fishery
B	Mining
C	Manufacturing industries
D	Energy supply
E	Water supply and waste management
F	Construction
G	Trade
H	Transport and storage
I	Hotels, restaurants, cafés
J	Information and communication
K	Financial services
L	Rent and trade of real estate
M	Specialist business services
N	Rent and other business services
O	Public administration and public services
P	Education
Q	Health care and welfare services
R	Culture, sports and recreation
S	Other services
T	Services by families
U	Extra-territorial activities