Modelling Migration and Regional Labour Markets: An Application of the New Economic Geography Model RHOMOLO☆

Andries Brandsma[a], d'Artis Kancs[a], Damiaan Persyn[a,*]

[a]European Commission DG Joint Research Centre, IPTS, E-41092 Seville, Spain

Abstract

The present paper describes the modelling of regional labour markets in the newly developed dynamic spatial general equilibrium model RHOMOLO, where the labour market equilibrium is determined by firms' labour demand, a wage-curve determining unemployment, and inter-regional labour migration. The RHOMOLO model is parameterised by estimating the key structural parameters econometrically. In order to illustrate the potential of the proposed dynamic spatial general equilibrium approach for analysing regionally integrated labour markets, we carry out simulations showing the effects of a reduction in transportation cost, and assess the impact on regional labour markets. Our results confirm that wages and unemployment are by far the most important channels of adjustment to macro-economic and policy shocks in the EU. In contrast, labour migration plays a secondary role in labour market adjustments in the EU. Our results also suggest that the relationship between market access, labour demand and labour supply is non-linear and spatially inter-dependent, which underlines the importance of the proposed dynamic spatial general equilibrium approach.

Keywords: Dynamic spatial general equilibrium model, labour, migration, unemployment, wage, new economic geography.
JEL code: C68, D58, F22, J20, J61, J64, O15.

☆The authors acknowledge helpful comments from two anonymous reviewers and valuable contributions from Stefan Boeters, Steven Brakman, Johannes Broecker, Francesco Di Comite, Hans Lofgren, Philippe Monfort, Mark Thissen, Charles van Marrewijk, Renger Herman van Nieuwkoop, participants of the European Economic Association and Econometric Society conferences in Glasgow, Oslo, Malaga and Gothenburg, as well as participants of seminars and workshops at the European Commission. The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

*Corresponding author
Email address: damiaan.persyn@ec.europa.eu (Damiaan Persyn)

1. Introduction

Labour markets serve as an important channel of adjustment to macro-economic shocks, such as regional integration and economic crisis (Blanchflower and Oswald, 1995). The theory (see for example Agenor, 1996) suggests that labour markets can adjust in response to macro-economic and policy shocks through several channels: changes in unemployment; changes in labour force participation; changes in worker remuneration; labour migration; and others.

Consider, for example, the current economic crisis, which in most regions are associated with a negative labour demand shock, likely imply a reduction in employment opportunities in the affected regions. Depending on the characteristics of regions and preferences of people, firms and workers may respond differently through different channels of adjustment in different regions. One possibility is that unemployment would increase. Individuals may decide that the region no longer provides them with the opportunities they desire and leave the region in search for better opportunities. However, it is unlikely that all the people, who decide to leave the region, are those who directly lost their jobs as a result of the economic crisis. People who were unemployed prior to the shock may leave as well, if they see the likelihood of finding employment is decreasing due to the economic crisis. Even people with jobs may leave, if regional wages are depressed, or if they fear that the region is in decline and they may be next in line for loosing their job. Another possible adjustment of regional labour markets is through labour force participation, which may decrease. Some of those people, who lose their jobs, may decide to take early retirement, pursue goals outside of the labour market, or decide that the best thing for their future prospects is to undertake further training. Similarly, some who have lost their jobs and those who were already unemployed may become discouraged and no longer actively seek employment. A further mechanism of adjustment is through changes to the price of labour. A decrease in labour demand may have a negative impact on wages. A decrease in wages may help to mitigate the effect of the initial reduction in demand for labour by attracting new firms into the region, hence creating new jobs to offset the initial shock, or discouraging existing firms from cutting jobs.

According to Blanchard and Katz (1992); Decressin and Fatás (1995), regional labour markets are fundamentally different from national labour markets, and region-specific shocks trigger different adjustment mechanisms compared to national shocks. For example, in the EU there is more inter-regional migration in response to region-specific shocks than international migration in response to country-level shocks (European Commission, 2013). A second reason to consider labour markets at the regional level is the pattern and degree of specialisation in the production of goods and services, which is higher at the regional level when compared to the national level, such that analysing the national labour market response to shocks would give a very partial picture. Third, regions may differ in their response to macro-economic shocks also due to regional differences in labour supply characteristics. Finally, looking at inter-regional dynamics is likely to provide more policy relevant results, as many of them may average out at the national level.

In regionally integrated economies, such as EU regions, the channels of labour market adjustments may mutually accelerate each other or neutralise themselves over time. From the policy perspective, it is important that the particular channels, through which the adjustments occur, may have important policy implications (Boeters and Savard, 2012). For example, in the regional development policy, there is a debate surrounding the appropriateness of people-based policies versus place-based strategies (Barca *et al.*, 2012). One of the key issues in this debate is that attempts to improve the prospects of people in particular regions via place-based strategies may be confounded, if the in-migration response is large. In other words, regional policy could end up benefiting new entrants to the region rather than the initial target population or community. In order to capture the inter-regional dynamics and assess the relative strength of the particular channels of adjustment, a dynamic spatial general equilibrium approach is an important analytical tool for policy impact assessment.

The present paper describes the modelling approach of regional labour markets taken in the newly developed dynamic spatial general equilibrium model RHOMOLO, where the labour market equilibrium is determined by firms' labour demand, a wage-curve with unemployment, and inter-regional labour migration. The key parameters of the RHOMOLO model are estimated econometrically. As an example, in Section 3 we describe the estimation of the elasticities determining inter-regional labour migration. Although crucial for policy simulations, these parameters are not available in the literature for labour migration across all NUTS2 regions in the EU-27.

In order to illustrate the potential of the proposed dynamic spatial general equilibrium approach to regionally integrated labour markets, we carry out simulations showing the effects of a reduction in transportation costs in three different regional integration scenarios, and assess the impact on regional labour markets. In the first scenario, transportation costs are reduced symmetrically to and from a single region. This scenario allows us to trace the dynamics of the labour market response to an isolated shock. In the second scenario, transportation costs are reduced symmetrically between a small group of regions. This scenario sheds light on the effects which may be expected from the transport infrastructure projects increasing the accessability between several regions. In the third scenario, transportation costs between all EU regions are reduced asymmetrically and simultaneously, based on the approved Trans-European Transport Network (TEN-T) priority projects until 2020.

Our results confirm that wages and unemployment are by far the most important channels of adjustment to macro-economic and policy shocks in the EU. Improving regions' accessibility by around 3% would increase the real wage by around 0.3% and reduce unemployment by around 0.3%, suggesting a multiplier effect of market access on real wages and unemployment of around 0.1. In contrast, labour migration plays a secondary role in regional labour market adjustments in the EU. The multiplier effect of improved region's accessibility on net labour migration is around 0.01 (compared to 0.1 for wages and unemployment). These results are new and have not been reported in the literature before. Our results also suggest that the relationship between market access, wage rate, labour demand and supply is non-linear, and spatially inter-dependent, which underlines the importance of the chosen dynamic spatial general equilibrium approach.

2. Conceptual framework

2.1. Overview of the RHOMOLO model

RHOMOLO is a dynamic spatial general equilibrium model, which recently has been developed by the European Commission (see Brandsma *et al.*, 2013, for a formal description of the model). In order to assess spatially and temporally specific impacts of public policies, the model incorporates two important features: (i) the endogenous choice of location of workers and firms between all EU regions, regional linkages through trade flows, factor mobility and knowledge spillovers; and (ii) inter-temporal investment decisions by firms to increase their productivity, and by workers to increase their skills (human capital).

RHOMOLO is constructed in the framework of a spatial computable general equilibrium, incorporating the key aspects of new economic geography models (Krugman, 1991). The global economy consists of regional economies in the EU and one aggregate economy capturing the rest of the world. Each economy is disaggregated into six sectors. RHOMOLO v.2 is based on data at NUTS2 level, covering 267 regions of the EU, and follows the NACE v.2 classification of 6 sectors of economic activities.[1] The temporal coverage reaches from the base year (2007) up to the long-run steady state growth path, which can be extended when integrating with other long-run macro-economic models, such as QUEST.

[1]Both dimensions can be expanded to any level of geographical and sectoral disaggregation, at which sufficient socio-economic data are available.

Each region is endowed with two types of production factors: labour and capital. Labour supply is further disaggregated according to the education levels of workers: low, medium and high-skill. The regional supply of labour is determined by labour endowment in the previous period plus population growth and net migration (workers are mobile both between regions and between sectors). Sector-specific capital stocks evolve according to the last period's capital stock minus depreciation plus new investments into capital.

There are three types of economic agents in the model: households, governments and firms (industries). Most of the household income is spent on consumption of goods and services, the rest is saved. The RHOMOLO model includes the representation of two types of governments: national and regional. Governments receive income mainly from taxes. Both regional and national governments demand goods and services, make various transfers, and save part of their income.

Each region hosts two types of sectors: a perfectly competitive and an imperfectly competitive. Firms in the perfectly competitive sector produce a homogenous good (public services) under constant returns to scale. Monopolistically competitive sectors exhibit increasing returns to scale and consist of inter-regionally mobile firms, which produce horizontally differentiated goods. Following Krugman (1991), we assume the Chamberlinean monopolistic competition with free entry and exit of firms. Hence, output prices are equal to marginal costs plus a mark-up, which depends on the elasticity of substitution between varieties of differentiated goods. Both types of goods are traded between all regions subject to positive trade costs.

RHOMOLO is solved in a recursively dynamic framework. Because of the detailed regional and sectoral dimensions, computationally, it would be impossible to implement full inter-temporally consistent dynamics in RHOMOLO, as it would prohibitively increase the number of non-linear equations which need to be solved simultaneously (the number of equations in the static model times the number of time periods). The recursive dynamic (sequential dynamic) framework contains a series of static equilibria that are linked between periods by exogenous and endogenous variable updating procedures, and are solved sequentially one period after other. Three types of factors (physical capital, human capital and knowledge capital) are accumulated endogenously between periods, according to the respective laws of motion.[2] As in all recursive dynamic models with myopic expectations, RHOMOLO assumes that the behaviour of inter-temporally optimising agents depends only on the current and

[2]Conceptually, it is possible to add updating mechanisms for other variables, such as public expenditure, transfers, technological change or debt accumulation.

past states of the economy, but is not the result of inter-temporal optimisation.

2.2. Labour market

The labour market in RHOMOLO accounts for unemployment by means of a wage curve, which links changes in regional unemployment rates to changes in regional real wages. In RHOMOLO the wage curve describes the negative relationship between the levels of unemployment and wages that arises, when these variables are considered on the regional level. According to Blanchflower and Oswald (1995), the wage curve summarises the fact that "A worker who is employed in a region of high unemployment earns less than an identical individual who works in a region with low joblessness". More generally, any change in fundamental characteristics of the labour market translates into shifts of the wage curve. Hence, the wage curve can be seen as the reduced form outcome of a more complete model of an imperfect labour market. Among others, micro-funded models of search and matching, bargaining models, and efficiency wage models (see Boeters and Savard, 2012) result in a wage-curve type relationship. Examples of practical applications are changes in the matching efficiency between which workers and employers, changes in the unemployment benefit scheme, or in the degree in which employees can be motivated by higher wages.

Figure 1 illustrates the effect of a positive shock to regional labour demand in a stylised neo-classical labour market model for a small regional economy, in the presence of a wage curve. Using the wage curve, *W(L)*, keeping all variables outside the regional labour market fixed, a positive regional labour market shock will in the short-run lead to higher regional wages and a decrease in the unemployment rate (A→B). Over time, in-migration causes both wages and unemployment rates to return to their pre-shock level (B→C). In reality, however, and in general equilibrium models such as RHOMOLO with many simultaneous channels of adjustment, everything else is *not* fixed. Firms will be exiting or entering the region which additionally shifts labour demand, there will be effects in other regions via trade-linkages, factor movements and knowledge spillovers, with feedback to the region under consideration, and so on. While Figure 1 is illustrative of the static effects which can be expected from a single regional shock in a simple labour market model, a dynamic spatial general equilibrium framework is necessary for assessing the spatial and temporal dynamics of the impacts of public policies.

The version of RHOMOLO used in this paper abstracts from individuals's labour market participation decisions. In reality, however, participation decisions play an important role as a channel of labour market adjustment to macro-economic shocks. This is especially the case of the EU (see for example Decressin and Fatás, 1995; Obstfeld and Peri, 2000; Bentivogli and

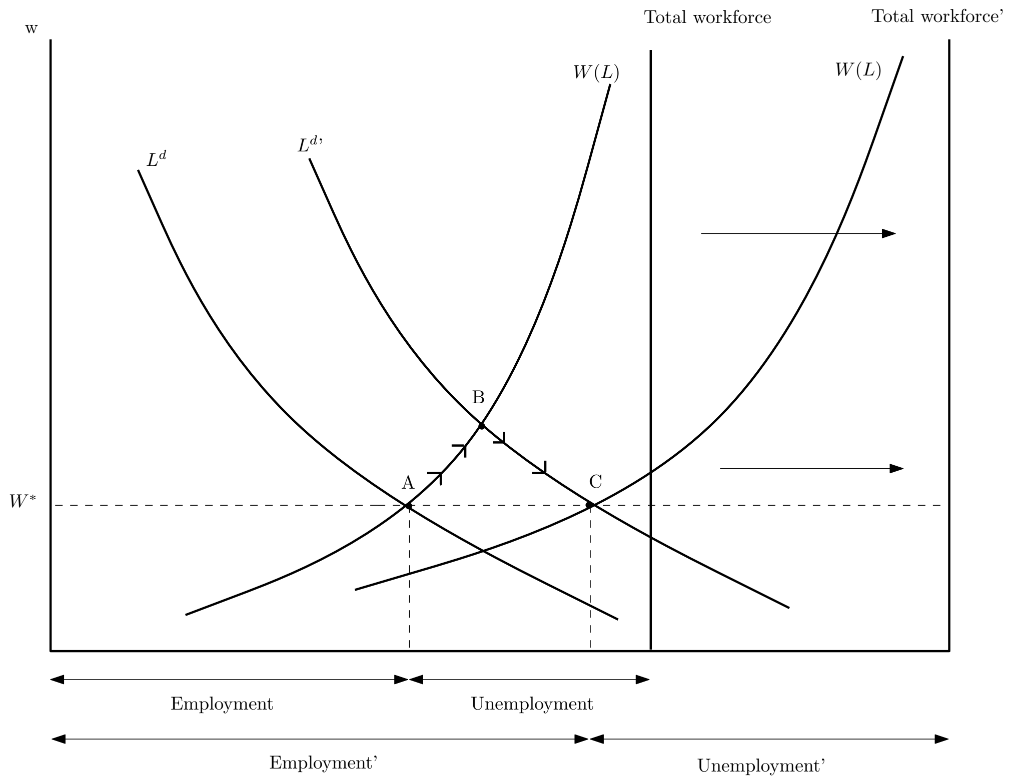


Figure 1: An illustration of the *partial equilibrium* effect of a single shift in labour demand (A→B), and subsequent in-migration (B→C) , on regional wages, employment and unemployment. The shift has a temporary effect on wages and the unemployment rate, and a permanent effect on the size of the local labour force.

Pagano, 2003). Therefore, a special labour-market module of RHOMOLO, which considers labour market participation decisions starting from individuals' optimal labour-leisure choice has been developed (see for example Brandsma *et al.*, 2013; Persyn *et al.*, 2014).

2.3. Data and empirical implementation

RHOMOLO covers 267 NUTS2 regions in EU27, which are disaggregated into 6 NACE Rev. 1.1 sectors (see Table 1 and Figure 2, respectively). The detailed regional and sectoral disaggregation imposes significant data requirements. In particular, the empirical implementation of the RHOMOLO model requires data for all exogenous and endogenous variables at regional (and sectoral) level for the base year (2010), and numerical values for behavioural parameters.

The base year (2010) data are compiled in form of an inter-regional Social Accounting Matrix (SAM) (see Potters *et al.*, 2013; Thissen *et al.*, 2014, for details). For the construction of all EU27 countries' SAMs, data of the World Input Output Database (WIOD) and

Table 1: Sectoral disaggregation of the RHOMOLO model

Code	Sector description
AB	Agriculture, hunting and forestry
CDE	Mining and quarrying, manufacturing, electricity and gas
F	Construction
GHI	Wholesale and retail trade, repair of motor vehicles, motorcycles, personal and household goods, hotels and restaurants, transport and communications
JK	Financial intermediation, real estate and business services
LMNOP	Non-market services

Source: Authors' aggregation based on the EUROSTAT (2003) NACE Rev. 1.1 classification.

the Global Trade Analysis Project (GTAP) have been used. The WIOD database provides International Input-Output tables, International and National Supply and Use tables, National Input-Output tables, and Socio-Economic and Environmental Accounts covering all EU27 countries and 13 other major regions in the world for the period from 1995 to 2009. An important advantage of the WIOD data is that re-exports are subtracted from the direct exports to calculate the final value of exports. Generally, the WIOD data are available for 59 NACE Rev. 1.1 sectors, which for the purpose of the present study are aggregated into six macro-sectors (see Table 1). First, the SAMs are constructed at the national level, and then regionalised by taking into account all available regional and sectoral data constraints, such as, regional data on value added, employment and other regional and sectoral information from EUROSTAT (see Potters *et al.*, 2013; Thissen *et al.*, 2014, for details).

Inter-regional trade flows are estimated using inter-regional traffic counts data from Thissen *et al.* (2013). This data is harmonised with the available macro-constraints from RHOMOLO's SAMs: the distribution of production and consumption over the EU regions to ensure consistency with the country level trade flows data from the COMEXT international trade statistics, and the rest of RHOMOLO's data. Inter-regional trade costs come from the TRANSTOOLS database.

Knowledge capital enters RHOMOLO through region-specific R&D intensities (innovation expenditures), which are available at the regional level from the EUROSTAT's Science and Technology Indicators database. Whereas R&D data by sector are available at the national level, comparable data are not available at the regional level for most of the countries. In order to regionalise the national R&D data by sector, we use the EUROSTAT's database, which distinguishes four sectors of performance – namely governments, higher education

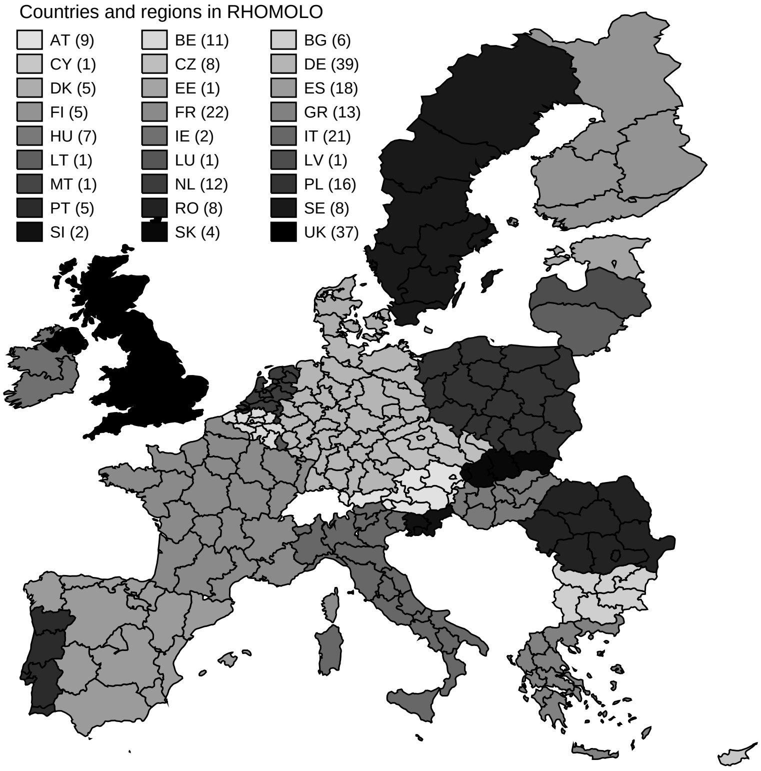


Figure 2: Spatial disaggregation of the RHOMOLO model. Notes: The number of NUTS2 regions in each country are in parentheses.

institutions, business sector and private non-profit organisations. Most of RHOMOLO sectors fall under the broader business sector. In a second step, we correct for the sectoral disaggregation by using the regional gross fixed capital formation by NACE sector. In this way we are able to construct the best available proxy for NACE sector R&D spending at the regional level – given the current availability of data.[3]

The regional stock of human capital is proxied by 3 levels of education: low skill (isced0_2), medium-skill (isced3_4), and high skill (isced5_6). Wages are differentiated on the basis of education levels, in order to allow for internalisation of investment decisions of households on the amount of education to be invested in each period. Data for this come from the LFS and the EU KLEMS database.

The regional stock of physical capital is constructed according to the Perpetual Inventory

[3]Currently undergoing extension of the innovation module in RHOMOLO with additional features beyond R&D includes two elements. First, European Commission-based regional patent statistics and citations offer valuable information on technological proximity across regions in Europe. Second, the inclusion of the micro-estimated data from the Community Innovation Survey is used to identify a broader set of regional innovation features – closely related to the policy domains identified in the current taxonomy of cohesion policy investments.

Method (PIM), because comparable data for all EU27 countries on capital stock at the regional/sectoral level of disaggregation are not available from any statistical data source. This approach takes the initial stock by country and industry (regionalised by GVA share) in the year 1995 and calculates the final capital stock by region and industry in 2010 by adding the yearly capital investments and depreciating the existing stock every year. We used the following data: gross fixed capital formation on NUTS 2 level and by sector in current prices for the years 1995-2010; price deflators for converting into constant prices; initial stocks for calculating the net capital stocks for each year applying the PIM from the EU KLEMS database. These data are available at the national level, but regionalised by the GVA share; depreciation rates (calculated by weighing the average service life of each of the six types of assets, using the EAS95 classification).

In order to parameterise the RHOMOLO model, all key structural parameters are estimated econometrically. Second, all parameters related to the elasticities of substitution both on consumer and producer sides are estimated based on micro-data. In the current version of RHOMOLO, the implemented elasticities of substitution are uniform for all sectors and regions. However, in future versions of RHOMOLO, they will be estimated by sector and region based on region- and sector-specific micro-data. The missing behavioural parameters are drawn from the literature (Okagawa and Ban, 2008).

Finally, as usual in computable general equilibrium models, all shift and share parameters are calibrated to reproduce the base year (2010) data in the SAMs. In order to determine the sensitivity of simulation results with respect to the implemented parameters in RHOMOLO, we perform extensive sensitivity analysis and robustness checks. Among others, the sensitivity analysis allows us to establish confidence intervals (in addition to the simulated point estimates) for RHOMOLO's simulation results.

3. Econometric estimation of migration elasticities

3.1. Specification of estimable migration equation

In order to derive an estimable migration equation relating the aggregate inter-regional migration flows to behavioural parameters in the theoretical model, we follow Sorensen *et al.* (2007) and Grogger and Hanson (2011), and start from the individual migration decision. Consider a worker k from origin region o, maximising indirect utility, V_{kor}, across all possible destinations r. Destination d will be chosen if

$$V_{kod} > V_{kor} \quad \forall\, r.$$
$$V_{kod} = Z_{od}\beta + \xi_{od} + e_{kod}.$$

The indirect utility V_{kod} of worker k migrating from origin region o to destination region d is determined by characteristics, Z_{od}, of region d (which may vary with respect to origin region o, such as bilateral distance). The term $Z_{od}\beta$ represents the utility the worker receives from these characteristics, where β is a vector of marginal utilities. The error term, ξ_{od}, represents unobserved location characteristics. $Z_{od}\beta$ and ξ_{od} assign the same utility level to all workers considering migration from o and to d. The idiosyncratic error term e_{kod} which varies across both workers and regions accounts for the fact that not all workers from the same region to choose the same destination. The probability that location d is chosen by a resident of region o then equals

$$\Pr\left(V_{kod} > V_{kor}\right) \quad \forall\, d \neq r$$
$$\Pr\left(e_{kod} - e_{kor} > Z_{or}\beta - Z_{od}\beta + \xi_{or} - \xi_{od}\right) \quad \forall\, d \neq r.$$

Now assume that the idiosyncratic error term e_{kod} follows an iid extreme value distribution. McFadden (1973) shows this yields the following probability for a worker k to migrate from o to d:

$$\Pr\left(M_{kod} = 1\right) = \frac{\exp\left(Z_{od}\beta + \xi_{od}\right)}{\sum_{d=1}^{R} \exp\left(Z_{od}\beta + \xi_{od}\right)}. \tag{1}$$

Berry (1994) in turn shows that probability (1) of migrating from o to d can be interpreted as the share of workers from o migrating to d. Following Sorensen *et al.* (2007), we therefore write the share of migrants from o to d as:

$$s_{od} = \Pr\left(M_{kod} = 1\right) = \frac{\exp\left(Z_{od}\beta + \xi_{od}\right)}{\sum_{d=1}^{R} \exp\left(Z_{od}\beta + \xi_{od}\right)} \tag{2}$$

and the share of stayers in region o as:

$$s_{oo} = \Pr\left(M_{koo} = 1\right) = \frac{\exp\left(Z_{oo}\beta + \xi_{oo}\right)}{\sum_{d=1}^{R} \exp\left(Z_{od}\beta + \xi_{od}\right)}. \tag{3}$$

Dividing equation (2) by (3) and applying a logarithmic transformation yields a simple estimable migration equation:

$$\ln\left(\frac{s_{od}}{s_{oo}}\right) = \ln\left(\frac{\exp\left(Z_{od}\beta + \xi_{od}\right)}{\exp\left(Z_{oo}\beta + \xi_{oo}\right)}\right) = Z_{od}\beta - Z_{oo}\beta + \xi_{od} - \xi_{oo} \tag{4}$$

Relaxing the iid assumption. The iid assumption on the idiosyncratic part of the error-term implies that there exists no correlation between individuals' tastes for locations. This is highly unlikely in our application on interregional migration within the EU, where cultural and language differences imply that individuals which have a taste for a certain region within a country are likely to have a taste for other regions within the same country (see Persyn and Torfs, 2012, for example). We therefore allow e_{kod} to be correlated within countries, while maintaining the iid assumption between countries.[4]

Index countries (nests) by c, denote country of destination by c_d, and assume that the indirect utility is given by:

$$V_{kod} = Z_{od}\beta + \xi_{od} + \sigma\zeta_{oc_d} + (1-\sigma)e_{kod}$$

with σ a measure of within-country correlation in taste.

The probability that an individual k will choose to migrate from region o to region d then is given by the product of the conditional probability that the individual will choose any region in the country c_d, times the probability that the individual chooses the particular region d within the country, or

$$\Pr\left(M_{kod} = 1\right) = \frac{\exp\left(\frac{Z_{od}\beta+\xi_{od}}{1-\sigma}\right)}{\sum_{d\in c_d}\exp\left(\frac{Z_{od}\beta+\xi_{od}}{1-\sigma}\right)} \cdot \frac{\sum_{d\in c_d}\exp\left(\frac{Z_{od}\beta+\xi_{od}}{1-\sigma}\right)^{(1-\sigma)}}{\sum_{c\in C}\left[\sum_{d\in c_d}\exp\left(\frac{Z_{od}\beta+\xi_{od}}{1-\sigma}\right)\right]^{(1-\sigma)}}$$

Following Sorensen *et al.* (2007), this probability can in turn be used to derive an estimable migration equation, which relates the observable aggregate migration shares to the underlying model's structural parameters

$$\ln\left(\frac{s_{od}}{s_{oo}}\right) = \left(Z_{od} - Z_{oo}\right)\beta + \sigma\ln(s_{od|c_d}) + (\xi_{od} - \xi_{oo}) \tag{5}$$

[4]Using countries as nests ignores the fact that some countries have important internal boundaries which would require constructing nests within countries; or the fact that tastes might be correlated between different countries, for example between countries that share a common language or joint history. We leave these issues to future work.

3.2. Data sources and variable construction

Dependent variable: inter-regional labour migration. The estimation of migration equation (5) requires a complete matrix of gross bilateral migration flows between all NUTS2 regions in EU. However, such data are currently not available. In order to address this data issue, we merge two available datasets: Eurostat's data on within-country interregional migration flows and OECD's data on international migration. This will allow us to construct an imputed data matrix of bilateral migration flows, which will be subsequently used in the empirical estimations.

Data on migration between NUTS2 regions *within* countries is available from Eurostat for most of the EU member states.[5] The first step in constructing an approximate dataset of gross bilateral migration flows between NUTS2 regions consists of calculating migration probabilities between every pair of regions within each country, for each country separately. Secondly, international migration flows without any regional dimension were obtained from the OECD. These international migration flows were subsequently 'regionalised', assuming that international migrants distribute themselves between the regions of the country of destination according to the same pattern as within-country migrants do. Similarly, the international migrants are assumed to originate from specific regions of origin in the source country in the same proportions as the within-country migrants originate from different regions in the source country.

More formally, use f_{od} to denote the migration flow of workers between origin region o in country c_o and region d in destination country c_d, which is to be imputed. Use $F_{c_o c_d}$ to denote the aggregate international migration flow between countries, C. Write $m_{o(c_o)}$ for the share of within-country migrants originating from region o, and similarly $m_{(c_d)d}$ for the share of people which migrate to region d, originating within country c_d . We then assume that migration flow between regions o and d can be approximated by

$$f_{od} = F_{c_o c_d} \cdot m_{o(c_o)} \cdot m_{(c_d)d} \tag{6}$$

This approach is an approximation, and will introduce errors, if the true distribution of international migrants differs significantly from the observed distribution of within-country migrants. One can imagine, for example, that Austrian migrants would have a stronger tendency to migrate towards northern Italy when compared to the average Italian inter-

[5]The countries for which internal regional migration data are available are Austria, Belgium, Bulgaria, the Czech Republic, Spain, Finland, Hungary, Italy, the Netherlands, Poland, Romania, Sweden, Slovenia and Slovakia.

regional migrant, given the geographic proximity of Austria to northern Italy. Whereas we believe that this effect exists and will affect the estimated migration flows, its impact on the estimated parameters of the migration equation, which are our key interest, will likely be limited.

Explanatory variables. In line with the underlying conceptual framework, we measure the indirect utility for living in region d for an individual from region o, $V_{kod} = Z_{od}\beta + \xi_{od} + e_{kod}$ by the expected real income in destination region d, net of migration costs for migrating between o and d. We approximate the real expected income in region r by $income_r = W(r) \cdot (1 - u(r))/P(r)$, with $W(r)$ the average local wage, $u(r)$ the unemployment rate, and $P(r)$ the local consumer price index. The migration costs are approximated by a log-linear function of the great circle distance between the geographic centre of the origin and destination NUTS-2 region. A dummy variable $\mathrm{I}(intl_{od})$ for international migration equals 1 in case region o and d are located in different countries. The empirical specification of the estimation equation then becomes

$$\begin{aligned}\ln\left(\frac{s_{od}}{s_{oo}}\right) &= \beta_1 \ln(income_o) + \beta_2 \ln(income_d) + \beta_3 \ln(distance_{od}) \\ &\quad + \beta_4 \mathrm{I}(intl_{od}) + \beta_5 \ln(s_{od|c_d}) + (\xi_{od} - \xi_{oo})\,.\end{aligned} \tag{7}$$

The data on wages, the unemployment rate and consumer price index (CPI) were taken from the Eurostat regional databases. The year 2004 was chosen to perform the analysis, as this year has the best data coverage.[6] Although, according to the underlying conceptual framework, coefficients β_1 and β_2 should be of opposite sign and of equal size, we follow Kancs (2011) and do not impose this restriction in our empirical application. We report the empirical results for specifications including a log-linear distance term to estimate the elasticity of migration with respect to distance. In the simulations using RHOMOLO which will be discussed in Section 4, a fifth-order polynomial in distance will be used to obtain results which are as realistic as possible.

3.3. Empirical results

Using the imputed interregional migration flows obtained from (6), equations (4) and (5) were subsequently estimated. The estimation of equation (5) requires an instrumental variable approach due to the endogeneity of the conditional probability (share). Following the common approach in the literature on discrete choice in the context of product demand

[6]Choosing a different year does not materially affect the results.

estimation, we chose the number of regions in country as an instrument for the probability of choosing a specific region as the destination of choice, conditional on the destination country choice. The share of people choosing a particular region in a country will on average be inversely related to the number of regions in the country. The number of regions in a country is exogenous to the migration decision in itself, as the size of countries and the number of NUTS-2 regions contained in them are clearly unrelated to contemporary migration patterns. Column (I) of Table 2 shows the results of estimating equation (7) using the OLS

Dependent variable: $\log(s_{od}/s_{oo})$		
	(I)	(II)
$\ln(income_o)$	-0.506^{***}	-0.514^{***}
	(0.0197)	(0.0243)
$\ln(income_d)$	0.820^{***}	0.773^{***}
	(0.0236)	(0.0275)
$\ln(distance_{od})$	-0.455^{***}	-0.650^{***}
	(0.0202)	(0.0330)
$\mathrm{I}(intl_{od})$	-4.482^{***}	-4.06^{***}
	(0.048)	(0.067)
$\ln(condshare_d)$		-1.221^{***}
		(0.0423)
_cons	-4.163^{***}	-5.563^{***}
	(0.292)	(0.426)
N	14485	14485

OLS estimates of equation (7). Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Estimation results

estimator. Column (II) reports the instrumental variables estimation described above. The estimated effect of income in the destination region decreases and the elasticity of distance increases when taking into account the endogeneity of the conditional probability, but overall the results of OLS and IV are rather similar. The size of the effect of the international migration dummy $\mathrm{I}(intl_{od})$ is remarkable, emphasising the importance of international borders (often corresponding to important cultural and language barriers) on labour mobility. One important point is that the coefficient on the conditional share implies an estimate of σ, the measure of within-country correlation in taste has the opposite sign and is outside of the theoretically consistence range between 0 and 1. In this light, and because the difference between the OLS and IV estimates are quite close, we opted to use the OLS estimates in the simulation analysis.

Being rooted in the discrete choice theory, the estimated migration model allows us to infer the structural parameters governing individual behaviour from observable aggregate migration flows. An important advantage of this approach is that when assessing the effects of policy simulations –to which we turn in the next section– the predicted migration flows will obey key macro-accounting rules. In particular, the predicted increase in migration inflow resulting from an increasing attractiveness of regions must imply an equal increase in outgoing migration from other regions, such that the total EU population is unaffected by migration internal to the EU. Such properties do not hold when modelling migration flows in an ad-hoc way, or as a Poisson process (for a discussion, see Schmidheiny and Brülhart, 2011).

4. Policy simulations: three illustrative scenarios of economic integration

4.1. Simulation setup

In this section we use the example of a trade cost reduction to simulate the impact of economic integration on regional labour markets. We carry out simulations showing the effects of a reduction in transportation costs in three different economic integration scenarios, and assess the impact on regional labour markets. In the first scenario, transportation costs are reduced symmetrically to and from a single region. This scenario allows us to trace the dynamics of the labour market response to an isolated shock. In the second scenario, transportation costs are reduced symmetrically between a small group of regions. This scenario sheds light on the effects which may be expected from transport infrastructure projects increasing the accessability between several regions. In the third scenario, transportation costs between all EU regions are reduced asymmetrically and simultaneously, based on the approved TEN-T priority projects until 2020.

Traditionally, labour migration has been studied in reduced form models, where the key explanatory variables, such as wages or unemployment, are determined a priori and fixed exogenously. However, according to the underlying theoretical and empirical framework, workers' decisions about migration and location depend on inter-regional differences in indirect utility, which in turn depend on the wage rate, the unemployment rate, the consumer price index and the distances between all regions. Given that the wage rate of workers and regional price index depend on the size of region labour force, all these variables affect each other, and hence are endogenous, which explains our choice of the dynamic spatial general equilibrium framework - RHOMOLO.

Migration. In RHOMOLO the simulated population change in region r with labour force L_r due to migration is difference between the incoming and outgoing migration, or

$$\sum_o L_o \cdot s_{or} - \sum_d L_r \cdot s_{rd} \tag{8}$$

where shares, s_{od}, are given by equations (2) and (3), using the corresponding estimates from Table 2 for the coefficient vector, β. The effect of a change on a covariate in vector, Z_{od}, is calculated by comparing the model-predicted migration flows using the observed covariates Z_{od}, with the model-predicted flows when using a counterfactual dataset where the original covariates have been replaced.

Employment. As participation decisions are not considered in the current version of RHOMOLO, the workers taking up the newly created jobs are either formerly unemployed, or new migrants into the region (see Pissarides and Wadsworth, 1989). Writing $'$ for the growth rate of a variable, the underlying labour market accounting rule implies that

$$\begin{aligned} \text{employment} &= \left(\frac{\text{employment}}{\text{labour force}}\right) \cdot (\text{labour force}) \\ \text{employment}' &= \left(\frac{\text{employment}}{\text{labour force}}\right)' + (\text{labour force})' \end{aligned} \tag{9}$$

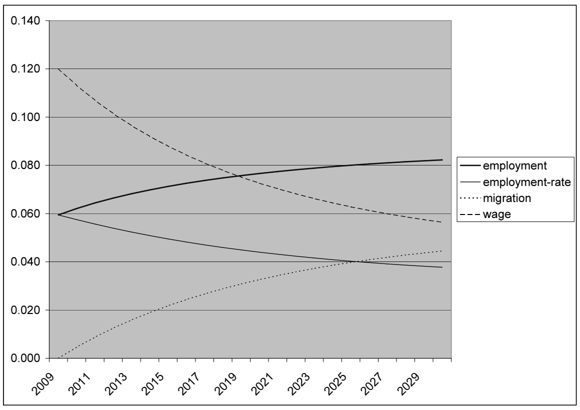
such that the growth of employment must equal the sum of the growth of the employment rate and the growth of the labour force (which in our model only occurs by migration).

4.2. Symmetric single region integration scenario

In the symmetric single region integration scenario all bilateral transportation costs between the *single* region BE24 and *all* other EU regions were reduced proportionally by 10 percent.[7] Limiting the integration scenario to one region in this simulation exercise allows us to better isolate the effects on regional labour markets, and may serve as a reference.

The results of a symmetric decrease of transport costs to and from a single region on both the region itself and its neighbouring regions are reported in Figures 3-7. Figure 3 focusses on the dynamic labour market response over time. The Figure shows the effect of

[7] For illustration purposes, we select this region in Belgium, because this region is affected by a TEN-T priority project: TEN-T 2: High-speed railway axis Paris-Bruxelles/Brussel-Köln-Amsterdam-London.



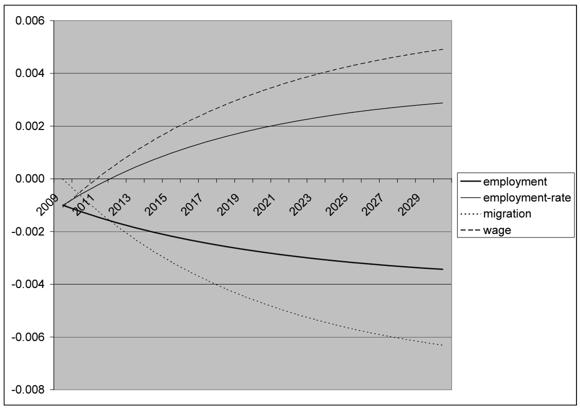


Figure 3: Impulse-response results of a symmetric single region integration shock on the region itself (BE24, Vlaams Brabant, left figure), and a neighbouring region (BE22, Limburg, right figure). The lines show the growth rates of the different variables in the years following the shock.

the symmetric 10 percent decrease in transportation costs to and from the Belgian region BE24 (Vlaams Brabant) on the region itself (left figure), and the neighbouring region BE22 (Limburg, right figure). The effects on other nearby regions are comparable. The labour market impact is somewhat similar to the stylised positive shock to the labour market which was illustrated in Figure 1. The total employment increases by about 0.06 percent in the first year and continues to increase at a moderate pace in the years following the shock. As explained in Section 4.1, the workers taking up the newly created jobs are either formerly unemployed, or new migrants into the region. Indeed, in Figure 3 we see that in the first year the increase in employment of 0.06 percent is accompanied by an equal increase in the employment rate.[8] The simultaneous increase in the local regional wage triggers in-migration in the years following the initial shock, with the contribution of migration increasing, and wages and the employment rate slowly subsiding. These results are in line with other studies employing the general equilibrium framework for studying labour migration at the regional level (Kancs, 2011).

Neighbouring regions experience a decrease in transportation costs towards the integrating region, BE24, but simultaneously face an increase in the relative transportation costs towards all other regions. Whether the total employment in other regions will increase or decrease depends on their geographic location and market size, but also, for example, on the regional specialisation patterns. The labour market dynamics for the neighbouring region BE22, which are illustrated in the right figure of Figure 3, therefore can not be generalised but

[8]The employment rate E/(E+U) is equal to 1 minus the unemployment rate E/(E+U).

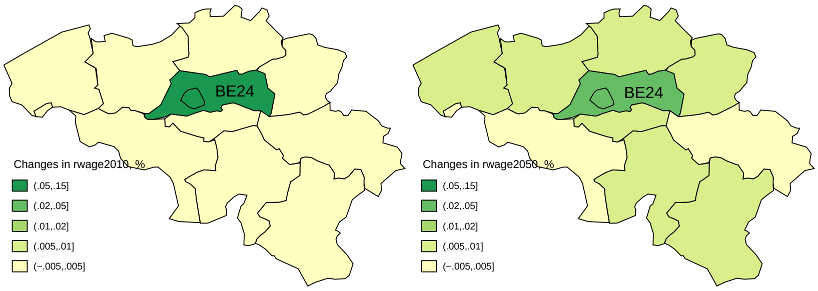


Figure 4: Simulation results of a symmetric single region (BE24) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of 10 % improvement in region's accessibility on **real wages**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Belgian regions (the impact on other EU regions is of lower order of magnitude).

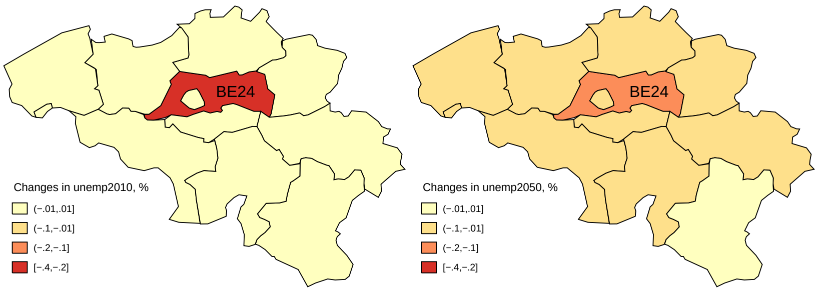


Figure 5: Simulation results of a symmetric single region (BE24) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of 10 % improvement in region's accessibility on **unemployment**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Belgian regions (the impact on other EU regions is of lower order of magnitude).

rather serve as an example. Nevertheless, it is interesting to see that the effects are about an order of magnitude smaller, when compared to the integrating region, BE24, experiencing the symmetric decline in transportation costs. Different from the integrating region, there is an initial and widening negative effect on the total regional employment in the neighbouring regions, with simultaneous out-migration. This is not surprising, given the incentives for migration, and the predicted increase in real wages and the employment rate in the region facing the shock to transportation costs. Also different from the integrating region, the initial effect on real wages and the employment rate in the neighbouring region is negative, although the effects on these variables become positive around two to three years after the initial shock. The effects in this neighbouring region remain relatively small, however.

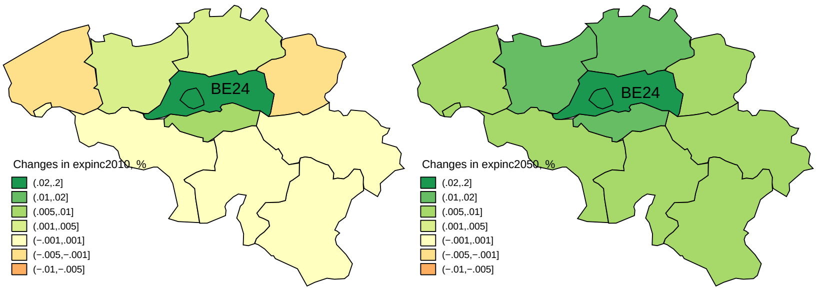


Figure 6: Simulation results of a symmetric single region (BE24) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of 10 % improvement in region's accessibility on **expected income**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Belgian regions (the impact on other EU regions is of lower order of magnitude).

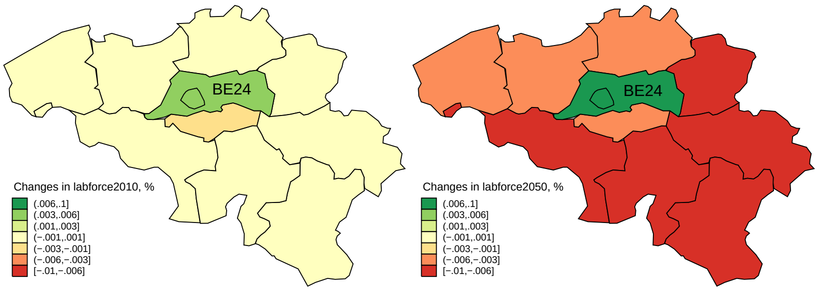


Figure 7: Simulation results of a symmetric single region (BE24) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of 10 % improvement in region's accessibility on **labour force**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Belgian regions (the impact on other EU regions is of lower order of magnitude).

To further illustrate the temporal and spatial patterns of the regional labour market response to a shock in market integration, Figures 4 to 7 show the effects in the short-run (2010) and long-run (2050), for all regions in Belgium, the country to which the region BE24 belongs.

These figures highlight that, in the short-run, the labour market effects are largely concentrated in the integrating region (BE24). In the long-run, however, the effects spill over also to the neighbouring regions. The effects of wages and the unemployment rate become weaker over time in the region under consideration, while simultaneously spreading spatially and increasing in magnitude in the neighbouring regions. The effects on income and the size of the labour force in the local labour market, in contrast, grow stronger over time, while simultaneously spreading spatially. In the short-run, the labour market effect in several neighbouring regions is negative. According to Figure 6, the expected real income would decrease slightly in the north west (West-Vlaanderen) and north east (Limburg) in the short-run. In the long-run, however, the labour market effect is positive for all regions in the country, with increasing real wages and income, and reducing unemployment rates.

4.3. Symmetric multi-region integration scenario

In this scenario, transportation costs are reduced symmetrically exclusively between five Polish regions (PL11, PL12, PL22, PL61 and PL63).[9] The simulation is thought to reflect the effect of a single transport infrastructure project improving the connectivity between them. The results of this symmetric multi-region integration shock on regional labour markets in Poland are reported in Figures 8-11, which show the long-run (2050) impacts on real wages, unemployment, expected income and labour force, respectively. The impacts in this scenario are more complex than in the previous section because, due to shifts in the relative attractiveness of regions, inequalities may arise also between the integrating regions.

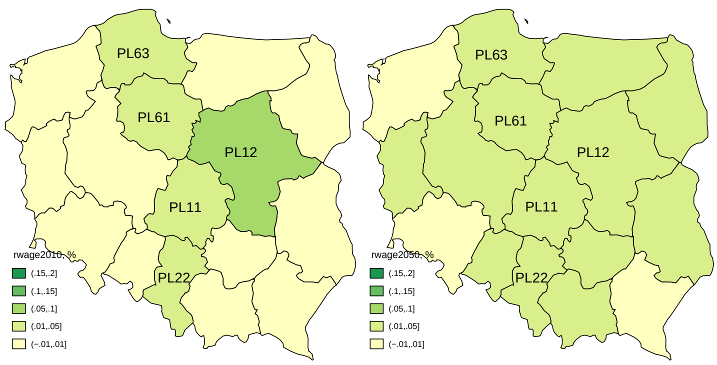


Figure 8: Simulation results of a symmetric multi-region (PL11, PL12, PL22, PL61 and PL63) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of improvement in regions' accessibility on **real wages**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Polish regions (the impact on other EU regions is of lower order of magnitude).

According to Figure 8, improved regions' accessibility would have a positive impact on real wages in all regions, though at a differentiated rate. In the short-run (left figure), workers

[9]For illustration purposes, we select these five regions in Poland, because these regions are affected by two TEN-T priority projects: TEN-T 23: Railway axis Gdansk-Warszawa-Brno-Bratislava-Wien, and TEN-T 25: Motorway axis Gdansk-Brno-Bratislava-Wien.

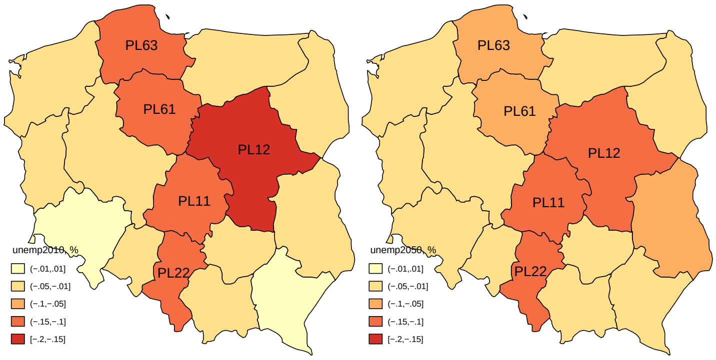


Figure 9: Simulation results of a symmetric multi-region (PL11, PL12, PL22, PL61 and PL63) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of improvement in regions' accessibility on **unemployment**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Polish regions (the impact on other EU regions is of lower order of magnitude).

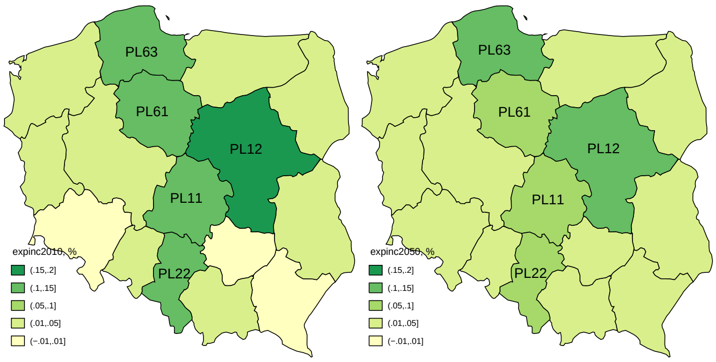


Figure 10: Simulation results of a symmetric multi-region (PL11, PL12, PL22, PL61 and PL63) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of improvement in regions' accessibility on **expected income**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Polish regions (the impact on other EU regions is of lower order of magnitude).

in the capital city region, PL12, would benefit the most in terms of real wage (+0.2%). Two effects may help to explain these results: market access effect and market size effect. Given that the capital city region, PL12, is located in the centre of the five integrating regions, it has the best market access vis-à-vis the other four integrating regions. Second, region PL12 has the largest internal market from the five regions, implying that the 'home-market effect' might be the strongest there. In the long-run (right figure), however, the relatively

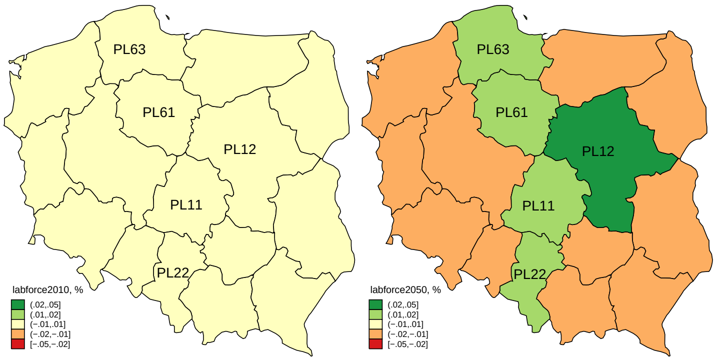


Figure 11: Simulation results of a symmetric multi-region (PL11, PL12, PL22, PL61 and PL63) integration shock. Short-run (2010, left figure) and long-run (2050, right figure) impacts of improvement in regions' accessibility on **labour force**, changes in percent. Simulations are performed using the RHOMOLO v.2 model with all NUTS2 regions in EU-27, reported are only the Polish regions (the impact on other EU regions is of lower order of magnitude).

larger impact on wages in the capital city region, PL12, decreases vis-à-vis the other four integrating regions.

The impact on regional unemployment rate is negative for all regions (Figure 9). Similar to the impact on wages, in the short-run (left figure), workers in the capital city region, PL12, would benefit the most also in terms of unemployment (-0.2%). The inter-regional differences in the impact of unemployment appear somewhat more persistent over time (right figure). These results are in line with empirical evidence for EU regions, which confirms significant and persistent differences in unemployment levels across the EU regions (Elhorst, 2003).

Figure 10 confirms findings of the previous two Figures: an improvement in market access favours the integrating regions vis-à-vis other regions, particularly the capital city region, PL12, which is located in the centre of the five integrating regions, and has the largest internal market from the five regions. These findings seem to confirm those of Puga (2002), who warns that improving transport infrastructure connecting core regions to more peripheral regions may help the core region more in relative terms. The positive impact on integrating regions is more pronounced in the short-run (left figure) than in the long-run (right figure) when, due to inter-regional linkages on goods and factor markets, also the non-integrating regions benefit from the TEN-T investments. These findings underline the importance of an inter-regional general equilibrium approach to policy questions, which have spatial impacts.

Finally, Figure 11 reports the impact on the size of the regional labour force through inter-regional migration. Our simulations suggest that the five integrating regions with improved market access would attract workers from other regions. In the short-run (left figure), the induced (additional) relocation of workforce is very low (0.0.1%). In the long-run (right figure) migration slightly increases (up to 0.05%) though, generally, the integration-induced labour migration is very low. These results are in line with the empirical evidence of low labour migration in the EU (European Commission, 2013).

4.4. Asymmetric multi-region integration scenario

After sketching the labour market effects of symmetric changes in transportation costs for selected regions, we now turn to simulating the impacts of an asymmetric multi-region integration shock in the whole EU. The simulation exercise is based on real Trans-European Transport Network (TEN-T) investments. Our approach consists of two steps: (i) simulating the impact of transport infrastructure investments on regions' accessibility; and (ii) simulating the impact of transportation cost reduction on regional income, migration, etc. In the first step, the improvements in the transport network due to transport infrastructure investments are simulated in a transport model, where the units of measurement are kilometres of new infrastructure, number of additional lanes, maximum speed, etc. In the second step, the changes (improvements) in the accessibility (market access) of regions are simulated in an economic model, where the units of measurement are relative prices, wages, employment, migration, etc.

We simulate the impact of the TEN-T investments on regions' accessibility by employing the TRANSTOOLS model of European Commission.[10] The TEN-T scenario includes all approved TEN-T priority axes and projects until 2020. The output of the TRANSTOOLS model are two generalised transportation cost matrices (one for the base year and one for the TEN-T scenario, which have three dimensions: origin region, o, destination region, d, and sector, i. The simulation results from the TRANSTOOLS model suggest that completing the TEN-T networks will significantly reduce transportation costs between regions. According to the TRANSTOOLS model's simulations, through a 14 % reduction in road congestion and improved rail performance, up to 11.2% time and 3.9% cost savings will be achieved when completing the 30 priority axes/projects, which form the 'backbone' of the TEN-T. In addition, the TRANSTOOLS simulation results suggest that the freight transport in the EU will increase by more than two thirds until 2020, and double in the new Member States.

[10] TRANS-TOOLS ("TOOLS for TRansport Forecasting ANd Scenario testing") is a European transport network model that has been developed in collaborative projects funded by the European Commission DG JRC and DG TREN. See http://energy.jrc.ec.europa.eu/transtools for a formal description of the TRANSTOOLS model.

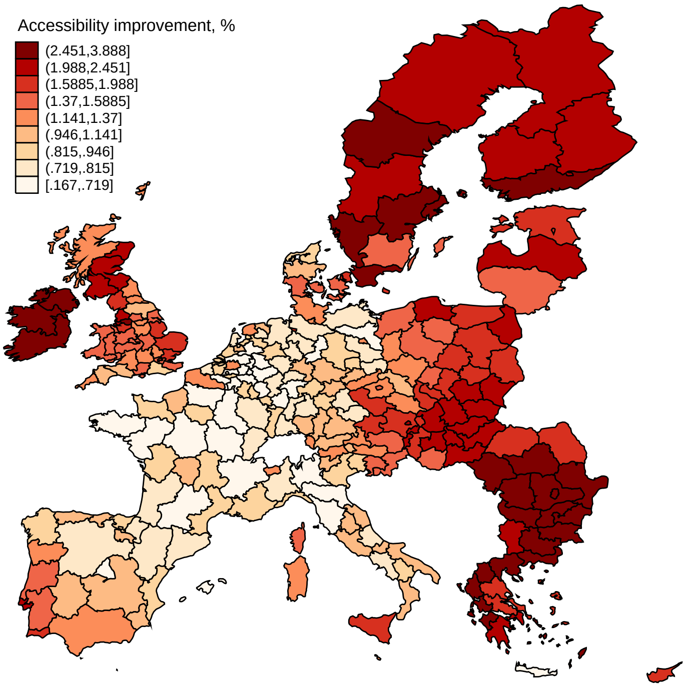


Figure 12: Asymmetric multi-region integration scenario: Improvements in regions' accessibility due to TEN-T investments, changes in percent from the baseline. Simulations are performed using the TRANSTOOLS v.2 model.

In order to illustrate the asymmetric multi-region integration scenario, we have calculated an accessibility indicator for each region, which measures the weighted average transportation costs from region, o, to all potential destination regions, d. The generalised transportation costs are weighted by the bilateral trade flows between the respective regions. Calculating the accessibility indicator for the baseline and for the TEN-T scenario, and expressing differences in percent yields changes in regions' accessibility due to the TEN-T. Figure 12 maps these changes in regions' accessibility due to the TEN-T investment for all NUTS2 regions in the EU.

According to Figure 12, on average, the accessibility of the EU 'peripheral regions' would improve relative to the 'core regions' as a result of the TEN-T investments. In terms of accessibility, the largest beneficiaries are the new EU Member States, Scandinavia, Greece, and Ireland. Also the Southern Italy, Portugal, the Southern Spain, Denmark and the UK would benefit substantially from the TEN-T investments. In contrast, the accessibility would increase less in centrally located regions of Luxembourg, Belgium, Netherlands, France and Germany.

In the second step, we employ the RHOMOLO model to simulate the impact of an asymmetric multi-region integration on regional labour markets. The results of the asymmetric multi-region integration shock on regional labour markets in the EU are reported in Figures 13-16, which show the long-run (2050) impacts on real wages, unemployment, expected income and labour force, respectively.

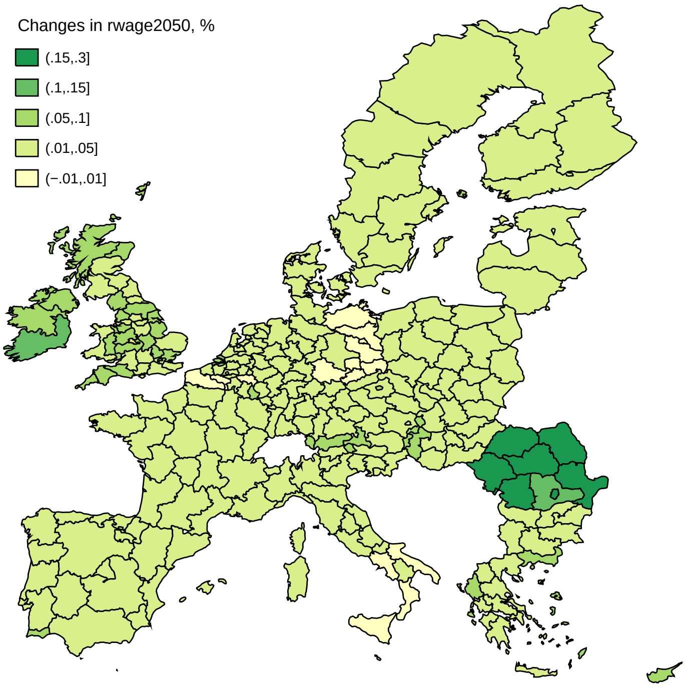


Figure 13: Simulation results of an asymmetric multi-region integration shock: Long-run (2050) impacts of improvement in regions' accessibility on **real wages**, changes in percent. Simulations are performed using the RHOMOLO v.2 model.

According to Figure 13, the TEN-T investments would increase real wages in all EU regions in the long-run. The impact on real wages would be the highest in the Romanian regions – up to 0.3% compared to the baseline. Similarly, Figure 14 suggests that the TEN-T investments would reduce unemployment in almost all EU regions in the long-run. Again, the Romanian regions would gain the most also in terms of employment creation – up to 0.5% compared to the baseline. These results can be best understood, when comparing them to the simulated scenario (Figure 12), according to which the Romanian regions would benefit extensively from the TEN-T investments. Improving regions' accessibility by around 3% would increase the real wage by around 0.3% and reduce unemployment by around 0.3%, suggesting a multiplier effect of market access on real wages and unemployment of around 0.1.

The results from Figures 13 and 14 are confirmed by the simulated impact on the expected

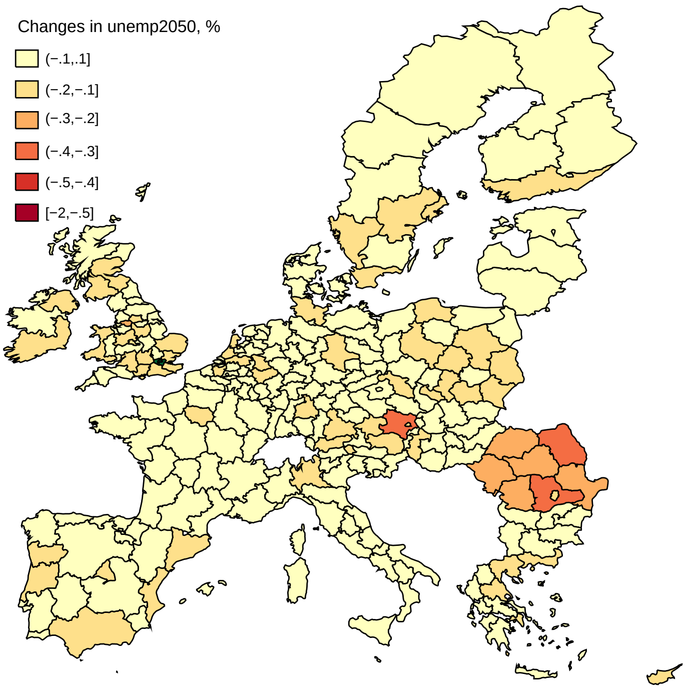


Figure 14: Simulation results of an asymmetric (TEN-T) multi-region integration shock: Long-run (2050) impacts of improvement in regions' accessibility on **unemployment**, changes in percent. Simulations are performed using the RHOMOLO v.2 model.

income (Figure 15). Due to the improved market access, the expected income would grow the fastest in the Romanian regions, north-east Poland and Ireland. In the long-run, the TEN-T investments would increase income also in all other EU regions. As above, the multiplier effect of improved region's accessibility on the expected income is around 0.1.

The impact of the asymmetric multi-region integration shock on changes in regional labour force is reported in Figure 16. According to Figure 16, in almost every EU Member State there are some regions, which would loose workforce, and some other regions, which would gain workforce. In most cases, the capital city regions would gain workforce. These results confirm the importance of national borders, and the observed low international labour mobility in the EU. The large differences in the TEN-T investment between countries do not translate into significant international migration flows, and the regional changes in the size of the labour force rather reflect within-country migration in response to relative changes in the attractiveness of regions within countries. These results confirm that there are important differences in the response to macro-economic shocks between the regional and national labour markets. Our results also suggest that labour migration, as a channel of labour market adjustment to macro-economic shocks, is less important than wages and unemployment. The

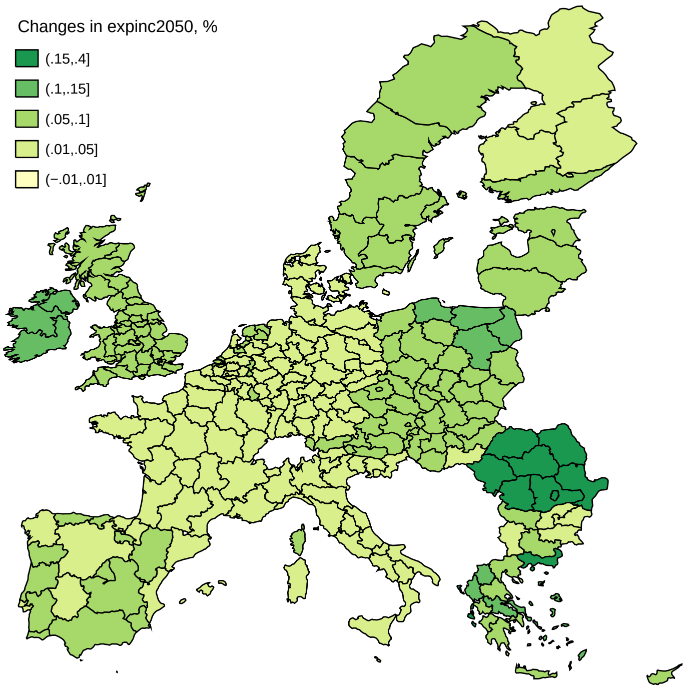


Figure 15: Simulation results of an asymmetric (TEN-T) multi-region integration shock: Long-run (2050) impacts of improvement in regions' accessibility on **expected income**, changes percent. Simulations are performed using the RHOMOLO v.2 model.

multiplier effect of improved region's accessibility on the net labour migration is around 0.01 (compared to 0.1 for wages and unemployment). These results are in line with the empirical evidence for the EU (European Commission, 2013).[11]

Similar to the results reported in Sections 4.2 and 4.3, the dynamics of the short-run and medium-run results (not reported) suggest important non-linearities in the relationship between market access, wage rate, labour demand and supply. The non-linearities (which were discussed in more detail in Sections 4.2 and 4.3) may be explained by the underlying theoretical framework, according to which changes in regions' accessibility increase market access, resulting in more output per firm, higher demand for labour, and hence higher wages. Higher wages, in turn, would attract workers from other regions. On the other hand, a decrease in the inter-regional transportation costs increases competition, reduces firm profits and wages. Lower wages may induce workers to leave the integrating regions. Given that the strengths of the particular forces depends on region's characteristics, such as economic geography and all other regions' characteristics, the total effect is non-linear in the level of

[11]Note that, according to the underlying conceptual framework, the gross labour migration may be larger (and empirically is larger) than the net labour migration.

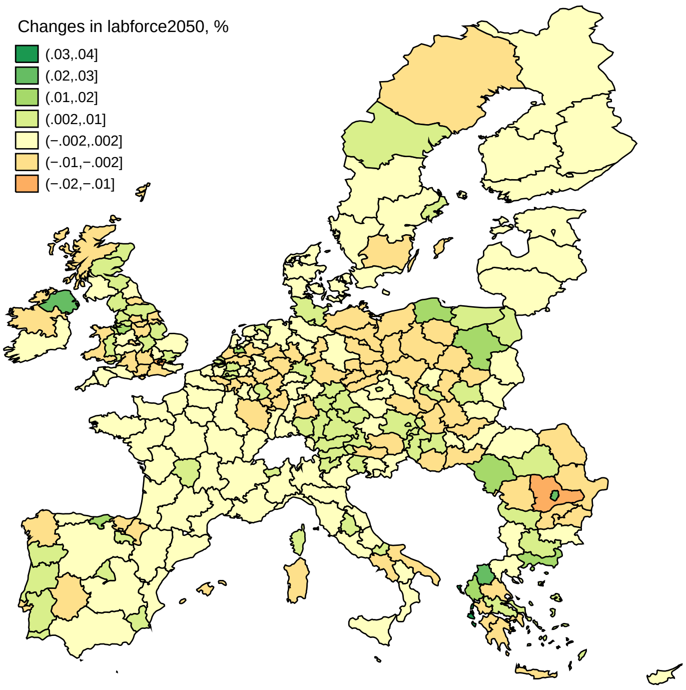


Figure 16: Simulation results of an asymmetric (TEN-T) multi-region integration shock: Long-run (2050) impacts of improvement in regions' accessibility on **labour force**, changes in percent. Simulations are performed using the RHOMOLO v.2 model.

economic integration and spatial location.[12] Our results clearly show the benefit of analysing such non-linear relationships between market access, wage rate, labour demand and supply, as well as spatial inter-dependencies in a dynamic spatial general equilibrium framework, where both labour migration and the explanatory variables of labour supply and demand are determined endogenously and solved inter-temporally.

5. Conclusions

The present paper describes the modelling approach of regional labour markets taken in the newly developed dynamic spatial general equilibrium model RHOMOLO, where the labour market equilibrium is determined by firms' labour demand, a wage-curve determining unemployment, and inter-regional labour migration. The RHOMOLO model is parameterised by estimating the key structural parameters econometrically. As an example, we describe the estimation of the elasticities of inter-regional labour migration.

[12]See Di Comite and Kancs (2013) for a detailed description of agglomeration and dispersion forces and mechanisms in RHOMOLO.

In order to illustrate the potential of the proposed dynamic spatial general equilibrium approach to regionally integrated labour markets, we carried out simulations showing the effects of a reduction in transportation costs in three different regional integration scenarios, and assessed the impact on regional labour markets. In the first scenario, transportation costs to and from a single region are reduced proportionally by 10 percent. This scenario allows us to trace the dynamics of an isolated shock through the regional labour markets over time. In the second scenario, transportation costs are reduced symmetrically between selected regions. The impacts in this scenario are more complex. In the third scenario, transportation costs between all EU regions are reduced asymmetrically and simultaneously. This scenario is based on the approved Trans-European Transport Network (TEN-T) priority projects until 2020.

Our results confirm that wages and unemployment are the most important channels of adjustment to macro-economic and policy shocks in the EU. Improving region's accessibility by around 3% would increase the real wage by around 0.3% and reduce unemployment by around 0.3%, suggesting a multiplier effect of market access on real wages and unemployment of around 0.1. In contrast, labour migration, and especially international migration, plays only a secondary role in regional labour market adjustments in the EU. The multiplier effect of improved region's accessibility on net labour migration is around 0.01 (compared to 0.1 for wages and unemployment). These results are new and have not been reported in the literature before. Our results also suggest that the relationship between market access, wage rate, labour demand and supply is non-linear, and spatially inter-dependent, which underlines the importance of the chosen dynamic spatial general equilibrium approach.

References

Agenor, P.-R. (1996). The labor market and economic adjustment. *IMF Staff Papers*, **43** (2), 261–335.

Barca, F., McCann, P. and Rodriguez-Pose, A. (2012). The case for regional development intervention: Place-based versus place-neutral approaches. *Journal of regional science*, **52** (1), 134–152.

Bentivogli, C. and Pagano, P. (2003). Regional disparities and labour mobility: The Euro-11 versus the USA. *Labour*, **13** (3), 737–760.

Berry, S. (1994). Estimating discrete-choice models of product differentiation. *The RAND Journal of Economics*, pp. 242–262.

Blanchard, O. J. and Katz, L. F. (1992). Regional evolutions. *Brookings Papers on Economic Activity*, **23** (1), 1–76.

Blanchflower, D. and Oswald, A. (1995). *The wage curve.* MIT press.

Boeters, S. and Savard, L. (2012). *The Labour Market in CGE Models.* CPB Discussion Paper 201, CPB Netherlands Bureau for Economic Policy Analysis.

BRANDSMA, A., KANCS, D., MONFORT, P. and RILLAERS, A. (2013). *RHOMOLO: A Dynamic Spatial General Equilibrium Model for Assessing the Impact of Cohesion Policy.* IPTS Working Papers JRC81133, European Commission, DG Joint Research Centre.

DECRESSIN, J. and FATÁS, A. (1995). Regional labor market dynamics in Europe. *European Economic Review*, **39** (9), 1627–1655.

DI COMITE, F. and KANCS, D. (2013). *Modelling of Agglomeration and Dispersion in RHOMOLO.* IPTS Working Papers JRC81349, European Commission, DG Joint Research Centre.

ELHORST, J. P. (2003). The mystery of regional unemployment differentials: Theoretical and empirical explanations. *Journal of Economic Surveys*, **17** (5), 709–748.

EUROPEAN COMMISSION (2013). *Labour Market Developments in Europe 2013.* European Economy 2013/05, DG for Economic and Financial Affairs.

GROGGER, J. and HANSON, G. (2011). Income maximization and the selection and sorting of international migrants. *Journal of Development Economics*, **95** (1), 42–57.

KANCS, D. (2011). Labour migration in the enlarged EU: A new economic geography approach. *Journal of Economic Policy Reform*, **14** (2), 171–188.

KRUGMAN, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, **99** (3), 483–499.

MCFADDEN, D. (1973). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (ed.), *Frontiers in Econometrics*, New York: Academic Press.

OBSTFELD, M. and PERI, G. (2000). Regional non adjustment and fiscal policy: lessons for EMU. *Intranational Macroeconomics*, p. 221.

OKAGAWA, A. and BAN, K. (2008). *Estimation of substitution elasticities for CGE models.* Discussion Papers in Economics and Business 2008/16, Osaka University, Graduate School of Economics and Osaka School of International Public Policy.

PERSYN, D. and TORFS, W. (2012). *A gravity equation for commuting.* VIVES Discussion Paper Series 33, Faculty of Economics and Business, University of Leuven.

—, — and KANCS, D. (2014). Modelling regional labour market dynamics: Participation, employment and migration decisions in a spatial CGE model for the EU. *Investigaciones Regionales*, **29**, 77–90.

PISSARIDES, C. and WADSWORTH, J. (1989). Unemployment and the inter-regional mobility of labour. *Economic Journal*, **99** (397), 739–55.

POTTERS, L., CONTE, A., KANCS, D. and THISSEN, M. (2013). *Data Needs for Regional Modelling.* IPTS Working Papers JRC80845, European Commission, DG Joint Research Centre.

PUGA, D. (2002). European regional policies in light of recent location theories. *Journal of Economic Geography*, **2** (4), 373–406.

SCHMIDHEINY, K. and BRÜLHART, M. (2011). On the equivalence of location choice models: Conditional logit, nested logit and poisson. *Journal of Urban Economics*, **69** (2), 214–222.

SORENSEN, T., FISHBACK, P., ALLEN, S. and KANTOR, S. (2007). *Migration Creation, Diversion, and Retention.* Nber working paper series, National Bureau of Economic Research.

THISSEN, M., DI COMITE, F., KANCS, D. and POTTERS, L. (2014). *Modelling Inter-Regional Trade Flows: Data and Methodological Issues in RHOMOLO.* IPTS Working Papers JRC91716, European Commission, DG Joint Research Centre.

—, DIODATO, D. and VAN OORT, F. G. (2013). *Integrated Regional Europe: European Regional Trade Flows in 2000.* The Hague, PBL Netherlands Environmental Assessment Agency.