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Assessing the Social and Macroeconomic Impacts of Labour Market Integration: A Holistic Approach

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Contents

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Abstract

In the age of globalisation and the knowledge economy, skill mobility is perceived as one of the key factors for fully unlocking the labour market potential. Assessing the social and macroeconomic impacts of increased skill mobility is an important though also challenging task, which requires a holistic approach. This study presents the dynamic spatial general equilibrium approach taken in the Regional Holistic Model (RHOMOLO) to better understand the relationship between education, skills, migration and economic growth. Two key channels of labour market adjustment – *upward skill mobility* and *spatial skill mobility* – are presented and explained in particular detail. By performing numerical simulations and conceptual analysis of labour market integration, we aim to facilitate understanding of the advantages and limitations of the approach taken in RHOMOLO, and its potential for education, skills and employment policy impact assessment. The results from our analysis suggest that a holistic approach is indeed crucial for capturing all the direct and indirect, short- and long-run effects, and it has a wide potential for assessing region-, sector- and skill-specific macroeconomic and social effects of policies aiming at integration e.g. of marginalised communities, such as Roma or refugees, into the EU labour markets.

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☆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.

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1. Education, skills and migration in the RHOMOLO model

In the age of globalisation and the knowledge economy, skill mobility is perceived as one of the key factors for fully unlocking the labour market potential. Two types of skill mobility are of particular importance: *upward skill mobility* and *spatial skill mobility*. In addition to skill mobility, there are also other channels through which labour markets adjust to macroeconomic or policy shocks, such as regional economic integration or economic crisis (Blanchflower and Oswald, 1995). Generally, the economic theory (see for example Agenor, 1996) suggests that labour markets can adjust in response to macroeconomic and policy shocks through several channels: adjustments in employment/unemployment, investment in education, adjustments in labour force participation/nonparticipation, labour migration, adjustments in worker remuneration, and others.

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, 2015). 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 macroeconomic or policy shocks would give only a partial picture. Third, regions differ in their response to policy or macroeconomic shocks also due to regional differences in labour supply characteristics. Finally, 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 mechanisms, through which the labour market adjustments occur are identified at the regional level, as they may have important policy implications (Boeters and Savard, 2012). For example, in the regional development policy, there is an ongoing 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 immigration 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. Therefore, looking at inter-regional dynamics from a holistic perspective is likely to provide more policy relevant results, as

many of them may average out at the national level. In order to capture the inter-regional dynamics and assess the relative strength of each labour market channel of adjustment, a dynamic spatial general equilibrium approach is a particularly helpful tool for policy impact assessment.

This study presents the dynamic spatial general equilibrium approach taken in the Regional Holistic Model (RHOMOLO) to better understand the relationship between education, skills, migration and growth. RHOMOLO is developed by the Directorate-General Joint Research Centre of the European Commission for policy impact assessment and provides sector-, region- and time-specific support to EU policy makers on structural reforms, growth, infrastructure and human capital policies.[1] In the past, the RHOMOLO model has been used together with the Directorate-General for Regional and Urban Policy for impact assessment of Cohesion Policy, and with the European Investment Bank for impact assessment of EU investment support policies. The current version of RHOMOLO covers all NUTS2 regions of the EU, and each regional economy is disaggregated into six economic sectors. Spatial interactions between regions are captured through trade of goods and services (which is subject to trade costs), factor mobility and knowledge spillovers, making RHOMOLO particularly well suited for simulating human capital, R&D and innovation policies. RHOMOLO simulation results allow for providing a scientific model-based support to EU policy makers, and deriving skill-specific policy recommendations related to the accumulation, employment and remuneration of human capital on the one hand, and macroeconomic impacts on regional economies, such as growth, income, consumption, investment, savings, etc., on the other hand.

An important advantage of the RHOMOLO model is that it is able to capture all induced direct and indirect, short- and long-run general equilibrium effects of labour market policy interventions, such as changes in the relative wage for low-, medium- and high-skill labour, according to which both labour supply and labour demand would adjust in RHOMOLO. As a thought experiment, think about a policy measure leading to deeper a high-skill labour market integration between EU Member States. As regards labour supply, in RHOMOLO reduced migration costs and the triggered emigration of high-skill workers from low-wage regions would exert an upward pressure on high-skill wages, which in turn would create incentives for low- and medium-skill workers to invest into education and acquire medium and high skills, respectively, in the low-wage sending regions. Hence both, migration-induced wage-adjustments in sending and

[1] See Brandsma *et al.* (2015) for a formal description of the key mechanisms in the RHOMOLO model.

receiving regions, and wage-driven adjustments in skill accumulation and composition of workforce in each region are captured in RHOMOLO. As regards labour demand, in RHOMOLO there would be two types of induced effects. On the input side, changes in the relative low-, medium- and high-skill wages would trigger adjustments in factor demand for production of goods, because low-, medium- and high-skill labour and capital are mutually substitutable. On the output side, companies would adjust their specialisation patterns according to changes in the relative skill-abundance in the region where the company is located. In addition, firms may find it profitable to relocate to another region, which also would change labour demand on regional labour markets. Hence, both skill demand and skill supply channels are modelled endogenously and simultaneously in RHOMOLO.

In order to facilitate the understanding of social and macroeconomic impacts related to education and migration decisions of people in RHOMOLO, the present study explains two key mechanisms through which policy shocks are absorbed in regional labour markets – *upward skill mobility* and *spatial skill mobility* – in two different ways: performing numerical simulations with the RHOMOLO model, and undertaking conceptual analysis in a diagrammatic framework. The two approaches are complementary and are presented in a non-formal way to intuitively explain the potential impacts of a hypothetical policy scenario related to labour market integration, which is simulated as migration cost reduction, e.g. through a full EU-wide recognition of qualifications for high-skill workers. In this hypothetical example, high-skill workers become fully mobile across EU regions, and have perfect information about skill demand and supply in every EU region. The social and macroeconomic impacts of the high-skill labour market integration are assessed against the segmented labour market baseline.

The results from our analysis suggest that a holistic approach is indeed crucial for capturing all the direct and indirect, short- and long-run effects. The presented approach taken in RHOMOLO has a wide potential to assess holistically the macroeconomic and social effects of policies aiming at integration e.g. of marginalised communities, such as Roma or refugees, into the EU labour markets, as it allows to assess region- and sector specific social and macroeconomic effects in the short-, medium- and long-run.

2. The RHOMOLO model[2]

2.1. Overview

In the tradition of Computable General Equilibrium (CGE) models, RHOMOLO relies on an equilibrium framework à la Arrow-Debreu where supply and demand depend on the system of prices. Policies are introduced as shocks to the existing equilibrium of prices, which drive the system towards a new equilibrium by clearing all the markets after policy shocks. Therefore, CGE models have the advantage of providing a rigorous view of interactions between all the markets in an economy.

Given the territorial focus of RHOMOLO, a particular attention is devoted to the explicit modelling of spatial linkages, interactions and spillovers between regional units of analysis. For this reason, models such as RHOMOLO are referred to as Spatial Computable General Equilibrium (SCGE) models. A richer market structure has been adopted to describe pricing behaviour, as RHOMOLO deviates from the standard large-group monopolistic competition à la Chamberlin (1890). Given the potential presence of large firms in small regional markets, the assumption of atomistic firms of negligible size has been relaxed in favour of a more general small-group monopolistic competition framework (Baldwin *et al.*, 2003).

Each region is inhabited by households, whose preferences are captured by a representative consumer, who consumes with a love for variety (Dixit and Stiglitz, 1977). Households derive income from labour (in the form of wages), capital (profits and rents) and transfers (from national and regional governments). The income of households is split between savings, consumption and taxes. Households own factors of production (labour and capital), which they supply them to firms and receive remuneration in return.

Firms in each region produce goods that are consumed by households, government or firms (in the same sector or in others) as an input in their production process. Transport costs for trade between and within regions are assumed to be of the iceberg type and are sector- and region-pair-specific. This implies a 5 x 267 x 267 asymmetric trade cost matrix derived from the European Commission's transport model TRANSTOOLS.[3]

The economic sectors in each region differ with respect to the scope for product differentiation between varieties. The public sector operates under the constant-returns-to-scale sectors produce undifferentiated commodities and price at marginal costs. Firms in

[2]See Brandsma *et al.* (2015) for a formal description of the key mechanisms in the RHOMOLO model and Brandsma and Kancs (2015) for policy applications.

[3]`http://energy.jrc.ec.europa.eu/transtools/`

the differentiated good sector produce one particular variety of a good, under increasing returns to scale. These firms can price-discriminate their export markets and, given the small-group monopolistic competition structure, can set different levels of mark-ups in the different destination markets. The number of firms in each sector-region is empirically estimated through the national Herfindahl indices, assuming that all the firms within one region share the same technology. Given their higher weight in the price index, firms with higher market shares are able to extract higher mark-ups from consumers than their competitors, and, since market shares vary by destination market, also mark-ups vary by destination market.

2.2. Labour market

The labour market in RHOMOLO captures all key interactions between labour demand and labour supply. On the labour supply side, each region is populated by workers, who are differently skilled. The RHOMOLO model distinguishes between three skill levels of workers: low-skill, medium-skill and high-skill, which correspond to three levels of education: primary and lower-secondary education (ISCED 0-2), upper-secondary and post-secondary education (ISCED 3-4), and tertiary education (ISCED 5-6).[4] As it will be explained in Section 2.4, using the Labour Force Survey (LFS) qualification data allows us to calculate the educational attainment rates for each EU region and education level in the base year, which are required for calibration of the RHOMOLO model. On the labour demand side, the relative price of labour together with the demand for final goods and services determine labour demand. Companies (and public sector) rent labour services from households, for what they receive wage income. In line with the empirical evidence, in RHOMOLO wages differ between different skill levels: high-skill workers earn higher wage than medium-skill workers, which in turn is higher than wage of low-skill workers.

There are two ways how workers from a particular region can increase the remuneration per unit of their labour supply in RHOMOLO. First, workers can upgrade their skills through investment into education (*upward skill mobility*), which however is costly for workers. Moreover, while in education, workers do not receive any wage income. Upgrading skills from low to medium or from medium to high would increase worker wage, if employed. Second, workers can migrate to another EU region with a higher wage rate and offer their skills there (*spatial skill mobility*). In RHOMOLO, labour migration between EU regions is costly for workers. Migration costs capture not only the physical

[4] International Standard Classification of Education (ISCED), see Annex 1 for details.

relocation costs, but also social, cultural, linguistic costs, information imperfections, people's preferences for a particular region, climate, etc. Moving to a high-wage region would increase worker's wage for the same skill level, if employed. These two channels of labour adjustment – *upward skill mobility* and *spatial skill mobility* – are the main focus of the present note.

In addition, in RHOMOLO labour supply decisions are also modelled through labour market participation choices of people and employment decisions of companies (see Brandsma *et al.* (2014); Persyn *et al.* (2014)). In the same time, also worker remuneration may change, which in turn may affect labour supply decisions of workers and labour demand decisions of firms. As noted by Boeters and Savard (2012), it is crucial to account for all four adjustment channels of regional labour markets in policy impact assessment, as there exist important interactions between them. Failing to model them simultaneously may result in suboptimal policy recommendations.

In addition to those labour market mechanisms, which are modelled explicitly in RHOMOLO, many more peculiarities of regional labour markets are captured implicitly. For example, differences in skill and hence productivity levels among people with the same level of education are captured by calibrating RHOMOLO to the base year regional labour market data. Productivity differences between workers living in different regions together with migration costs between regions account for sizeable inter-regional wage differences for people with the same education level.

2.3. Spatial dimension

The structure of the RHOMOLO model engenders different endogenous agglomeration and dispersion patterns of firms by making the number of firms in each region endogenous (see Di Comite and Kancs (2014)). Three effects drive the mechanics of endogenous agglomeration and dispersion of economic agents: the market access effect, the price index effect and the market crowding effect. The market access effect captures the fact that firms in central regions are closer to a large number of consumers (in the sense of lower transportation costs) than firms in peripheral regions. The price index effect captures the impact of having the possibility of sourcing cheaper intermediate inputs because of the proximity of suppliers and the resulting price moderation because of competition. Finally, the market crowding effect captures the idea that, because of higher competition on input and output markets, firms can extract smaller mark-ups from their customers in central regions. Whereas the first two forces drive the system of regional economies towards agglomeration by increasing the number of firms in core

regions and decreasing in the periphery, the third force causes dispersion by reducing the margins of profitability in the core regions.

RHOMOLO contains three endogenous location mechanisms that bring the agglomeration and dispersion of firms and workers about: the mobility of capital, the mobility of labour, and vertical linkages. Following the mobile capital framework of Martin and Rogers (1995), we assume that capital is mobile between regions in the form of new investments, and that the mobile capital repatriates all of its earnings to the households in its region of origin. Following the mobile labour framework of Krugman (1991), we assume that workers are spatially mobile; workers not only produce in the region where they settle (as the mobile capital does), but they also spend their income there (which is not the case with capital owners); workers' migration is governed by differences in the expected income, and differences in the cost of living between regions (the mobility of capital is driven solely by the equalisation of the nominal rates of return).[5] Following the vertical linkage framework of Venables (1996), we assume that, in addition to the primary factors, firms use intermediate inputs in the production process; similarly to final goods consumers, firms value the variety of intermediate inputs. Furthermore, the trade of intermediate inputs is costly.

In addition to these effects, which are common to theoretical New Economic Geography models with symmetric varieties, the specific characteristics of spatial CGE models, such as RHOMOLO, implicitly add important stability mechanisms in location patterns by calibrating consumer preferences over the different varieties in the base year. Through calibration, the regional patterns of intermediate and final consumption observed in the base year data are translated into variety-specific preference parameters, which ensure a given level of demand for varieties produced in each region, including peripheral ones. Therefore, it would be impossible to obtain extreme spatial configurations in terms of agglomeration or dispersion because firms in the regions with very low number of firms would enjoy very high operating profits due to the high level of consumer marginal provided by their relative scarce variety and thus would attract more firms in the region.

2.4. Data and empirical implementation

The RHOMOLO model covers 267 NUTS2 regions in the EU27, which are disaggregated into six NACE Rev. 1.1 sectors plus an R&D sector (see Table 1 and Figure 1,

[5] As noted above, in RHOMOLO also the regional unemployment rates enter the migration problem of workers.

respectively).[6] The regional and sectoral disaggregation implies considerable data needs. In particular, for the empirical implementation of the RHOMOLO model, data for all exogenous and endogenous variables at regional (and sectoral) level for the base year (2010), as well as numerical values for all behavioural parameters are required.

Table 1: Sectoral disaggregation of the RHOMOLO model

NACE code	Sector description
AB	Agriculture, hunting and forestry
CDEF	Mining and quarrying, manufacturing, electricity and gas and 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, excluding R&D
R&D	Research and development activities (R&D)
LMNOP	Non-market services

Source: Authors' aggregation based on the EUROSTAT (2003) NACE Rev. 1.1 classification. R&D sector is separated out from the standard NACE group JK.

The base year (2010) data are compiled in form of regional Social Accounting Matrices (SAMs) (see Thissen *et al.*, 2014, for details). For the construction of national SAMs, data are taken from the World Input Output Database (WIOD) project and the Global Trade Analysis Project (GTAP). The WIOD database consists of 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 the rest of the world for the period from 1995 to 2009. In the context of the RHOMOLO model, an attractive feature of the WIOD data is that an attempt is made to identify and correct for the re-exports before calculating the total value of exports by country.

Inter-regional labour migration patterns are captured in RHOMOLO by data on net changes in the regional labour force (see Brandsma *et al.*, 2014, for details). Using these data, the relocation of workers between any pair of regions is modelled as a function of expected income and migration costs. For the estimation of migration elasticities data are required on labour migration, consumer price index (CPI), regional

[6]The simulations presented in this paper were performed with the RHOMOLO model, which was calibrated to 2010 base year data. In the next updates of the base year RHOMOLO will be updated to 2013/2014 and extended to include mode regions. See `https://ec.europa.eu/jrc/rhomolo` for the latest version of the RHOMOLO model and base year data.

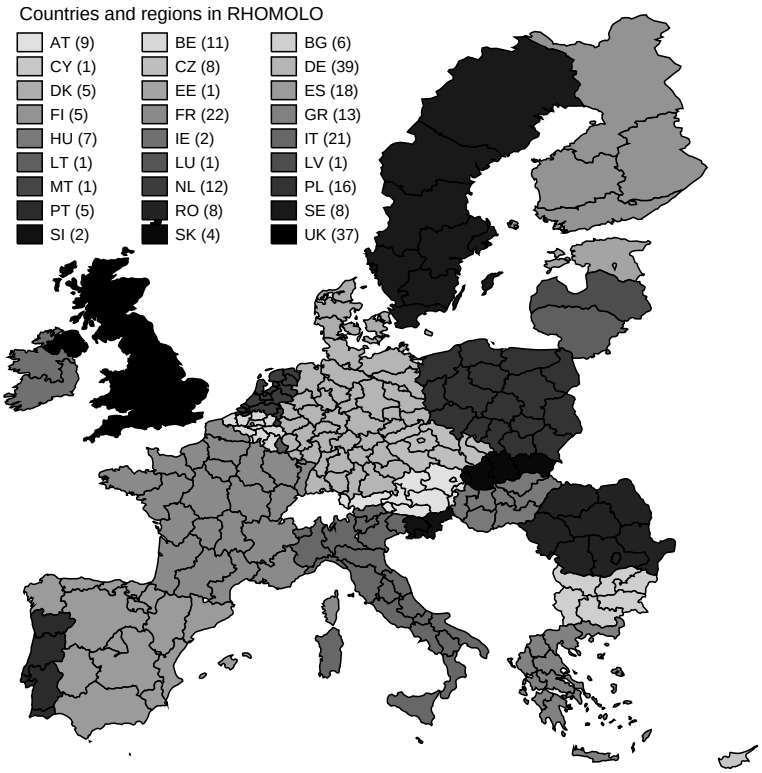

Figure 1: Spatial disaggregation of the RHOMOLO model. Notes: The number of NUTS2 regions in each country are in parentheses (in total these numbers sum up to 267).

GDP and unemployment. The EUROSTAT's Regional Migration Statistics provides data on migration within Member States. In order to complete the regional migration matrix, national totals are brought in line with the OECD data on migration flows between countries. The Household Income and Active Population data, which are extracted from EUROSTAT, together with data on unemployment and wages, which are computed from the Labour Force Survey (LFS), provide the necessary input to the estimation, calibration and modelling of regional labour markets and interactions between them in RHOMOLO.

Inter-regional trade flows are estimated using detailed inter-regional transport and freight data from Thissen *et al.* (2013, 2014). These data are aligned with the available regional accounts: the distribution of production and consumption over EU regions and national SAMs to ensure consistency with the rest of RHOMOLO data. Asymmetric region-pair-specific trade costs are extracted from the TRANSTOOLS model, which add up to country level trade and transportation margins calculated from WIOD.

Knowledge capital enters RHOMOLO through the R&D sector, whose data are also retrieved from the World Input Output Database. In RHOMOLO the stock of capital

builds up over time by accounting for the annual national R&D services supplied to the market (which is a flow variable).

The regional stock of human capital is proxied in RHOMOLO by 3 different levels of education: primary and lower-secondary education (ISCED 0-2), upper-secondary and post-secondary education (ISCED 3-4), and tertiary education (ISCED 5-6). Wages are differentiated on the basis of the corresponding categories of education levels to account for the decision of households to spend their time on education. Data for this are available in the LFS and EU KLEMS databases.

Data on the regional stock of physical capital are constructed using the Perpetual Inventory Method (PIM). This approach starts with an estimate of the initial stock by country and industry, regionalised by the share in gross value added (GVA) in 1995 and calculates the final capital stock by region and by industry in 2010 by adding the yearly capital investments and making assumptions on depreciation. The following data can be estimated: gross fixed capital formation by sector at the NUTS2 level in current prices for the years 1995-2010; price deflators for conversion 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, which are regionalised by the GVA share. Depreciation rates are calculated by weighing the average service life of each of the six types of assets for each country.

The structural parameters of RHOMOLO are estimated econometrically or, where econometric estimations are not possible due to data limitations, borrowed from the literature (Okagawa and Ban, 2008). The parameters related to inter-regional labour migration are estimated in a panel data setting for each country separately. Similarly, the parameters related to the elasticities of substitution both on the consumer and on the producer side are estimated econometrically.

Finally, as usual in spatial 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. Simulations of labour market integration with RHOMOLO

3.1. Simulation setup

Generally, there are many different ways how to model policy interventions in RHOMOLO. For example, in RHOMOLO labour market policy interventions can be modelled as a reduction of geographical relocation/migration costs, which facilitates the *spatial skill mobility*. The European Qualifications Framework (EQF), as one of such policy initiatives, aims to improve the recognition of skills and qualifications across different countries and systems in the EU. In RHOMOLO, an EU-wide recognition of skills and qualifications increases the mobility of workers across EU regions and improves the match between skill demand and skill supply in every EU region.[7]

Assessing the impacts of labour market policy interventions in RHOMOLO consists of two main steps. The first step consists of econometric estimations of behavioural parameters. In the above example, the link between EU policies deepening the labour market integration and regional human capital stock needs to be estimated econometrically using historical data. The econometric analysis has to provide answers to questions such as: how many people would migrate from low-income to high-income regions given certain net income differences between regions? How many additional people would migrate when migration costs would decrease? Estimating the link between the EU labour market policy interventions and human capital growth in each region is one of the main empirical challenges, which have to be addressed when assessing the labour market policy interventions and deriving skill-specific and policy-relevant conclusions.

In the second step, the estimated skill-specific policy impact on the regional human capital growth is used as policy scenario input into the RHOMOLO model to simulate the labour market policy impact on regional macroeconomic outcomes, such as growth, income, consumption, employment, savings, investments, trade, inequality, etc. An important advantage of the RHOMOLO model is that it is able to capture all the induced direct and indirect general equilibrium effects of labour market policy interventions, such as changes in the relative wage for low-, medium- and high-skill labour, according to which both labour supply and labour demand would adjust in RHOMOLO.

In addition, also the government budgetary effects of policy interventions are fully captured in RHOMOLO. On the government expenditure side, any type of policy intervention needs to be financed through taxes, which is captured explicitly in RHOMOLO.

[7] http://ec.europa.eu/education/policy/strategic-framework/skills-qualifications_en.htm

On the government income side, potential policy benefits include higher contributions to income taxes, welfare (e.g. pension) system, as well as resolving the labour market shortages in specific sectors and regions, leading to higher value added tax revenue. Also they are accounted for in RHOMOLO.

3.2. Step 1: Econometric estimations of skill mobility

As noted above, first the elasticity of skill mobility needs to be estimated econometrically. The main challenge of econometric estimations is to derive an estimable migration equation which is able to relate the aggregate inter-regional migration flows to labour mobility parameters of RHOMOLO. We follow Brandsma *et al.* (2014), who have derived such an estimable migration equation starting from the individual migration decision of Sorensen *et al.* (2007); Grogger and Hanson (2011). The dependent variable in the estimable equation is inter-regional labour migration, whereas the explanatory variables are related to expected work income.

Dependent variable: inter-regional labour migration. The estimation of migration equation requires a complete matrix of gross bilateral migration flows between all NUTS2 regions in the EU. However, such data are currently not available. In order to address this issue of data paucity, we merge two available data sets: EUROSTAT's data on within-country interregional migration flows and OECD's data on international migration. This allows us to construct an imputed matrix of bilateral migration flows, which can be used in empirical estimations. Data on migration between NUTS2 regions *within* countries are available from EUROSTAT for most of the EU Member States.[8] 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 extracted from the OECD data base. These international migration flows were subsequently 'regionalised', assuming that international migrants distribute themselves between the regions of the country of destination following the same pattern as within-country migrants do. Analogously, 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

[8]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.

country.[9]

Explanatory variables. In line with the underlying conceptual framework of RHOMOLO, we measure the indirect utility for living in region d for an individual from origin region o, 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 regional wage, $u(r)$ the unemployment rate, and $P(r)$ the regional consumer price index. 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. In the estimable equation we include a log-linear distance term that captures the elasticity of migration with respect to distance. In order to obtain results, which are as realistic as possible, a fifth-order polynomial in distance is used. A dummy variable, $I(intl_{od})$, 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

$$\begin{aligned} \ln\left(\frac{s_{od}}{s_{oo}}\right) &= \beta_1 \ln(income_o) + \beta_2 \ln(income_d) + \beta_3 \ln(distance_{od}) \\ &\quad + \beta_4 I(intl_{od}) + \beta_5 \ln(s_{od|c_d}) + (\xi_{od} - \xi_{oo}) \,. \end{aligned} \tag{1}$$

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 the econometric estimations.

The estimation of equation (1) requires an instrumental variable approach, because of the endogeneity of the conditional probability (share). Following the common approach in the literature on discrete choice in the context of product demand 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

[9]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-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.

of NUTS-2 regions contained in them are clearly unrelated to contemporary migration patterns.

Table 2: Estimation results

Dependent variable: $\log(s_{od}/s_{oo})$		
	OLS	IV
$\ln(income_o)$	-0.520^{***}	-0.509^{***}
	(0.0185)	(0.0221)
$\ln(income_d)$	0.824^{***}	0.787^{***}
	(0.0242)	(0.0273)
$\ln(distance_{od})$	-0.453^{***}	-0.656^{***}
	(0.0219)	(0.0326)
$\mathrm{I}(intl_{od})$	-4.478^{***}	-4.119^{***}
	(0.041)	(0.062)
$\ln(condshare_d)$		-1.227^{***}
		(0.0461)
_cons	-4.168^{***}	-5.566^{***}
	(0.284)	(0.433)
N	14485	14485

Source: Authors' estimations. Notes: estimates of equation (1). Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2 reports the estimation results. Column OLS of Table 2 shows the results of estimating equation (1) using the ordinary least squares (OLS) estimator. Column IV reports the instrumental variables (IV) 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, though overall the results of OLS and IV estimators 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 opt 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 of RHOMOLO governing skill mobility from the observable aggregate labour 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 all the key macro-accounting rules. In particular, the simulated 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 Brandsma *et al.*, 2014).

3.3. Step 2: Simulations using the RHOMOLO model

This section illustrates the impact of a policy intervention that targets labour market integration through an improved *spatial skill mobility*. Note that, even though in this example we simulate labour market policy intervention through improved *spatial skill mobility*, both adjustments in the *upward skill mobility* and adjustments in the *spatial skill mobility* take place simultaneously in RHOMOLO. That is, workers respond to an increase (decrease) in the remuneration of skills in regional labour markets both through investment into education (*upward skill mobility*), and through immigration (emigration) from (to) other regions, where the high-skill wage rate is lower (higher) (*spatial skill mobility*). In order to better identify the skill mobility effects, in these simulations two other important labour market adjustment channels – participation/nonparticipation and employment/unemployment – are shut down.

3.3.1. Social and labour market effects

In order to assess the social impacts of labour market integration, first a segmented labour market baseline scenario, against which we will assess the impact of the high-skill labour market integration, needs to be simulated. In the base year data, we observe significant high-skill wage differences across EU regions, because the *spatial skill mobility* channel is partially inactive (due to high migration costs, non-recognition of skills acquired in other Member States, etc.), only the *upward skill mobility* channel is fully active. However, the education channel alone is not strong enough to evade completely or to reduce significantly the inter-regional wage differences. Depending on the sectoral structure, in each region there is a lower or higher demand for low- and medium-skill workers. If all workers in a region would attain higher education and become highly

skilled then, because of lower supply, wages for low- and medium-skill workers would go up, reducing in such a way the skill premium. The skill premium must by large enough to cover the education costs, as no worker would invest into education, if the skill premium would not cover her education costs.

The labour market integration scenario reinforces the second channel of adjustment – *spatial skill mobility*. Figure 2 reports the impact of the high-skill labour market integration on the real (adjusted for price changes) high-skill wages in the EU regions as percentage differences between the baseline and the counterfactual equilibrium. The simulation results reported in Figure 2 suggest that in most regions the real wage of workers would increase (green colour), only in few regions the real wage would decrease (red and orange colours). High-skill wages would increase particularly strong in those regions, where they are below the EU-average, and where the largest emigration of high-skill workers would take place. High-skill wage would increase more than +2% in a number of less developed regions of Eastern Europe, Greece, and Portugal. In contrast, high-skill wage would decrease by more than -1% in several more developed regions in Benelux, Denmark, France and Ireland regions.

In RHOMOLO, high-skill workers from regions, where the demand and hence the relative wage for high-skill labour is low, would migrate to regions with higher wages for high-skill work. Arriving in high-wage regions and supplying their skills there would increase the supply of high-skill labour, which in turn would exert a downward pressure on high-skill wages. The opposite would happen in low-wage regions, where the wage rate for high-skill labour would increase because of a decrease in skill supply. In such a way the spatial skill mobility reduces high-skill wage differences across EU regions. Note, however, that wages are not fully equalised across EU regions, e.g. due to differences in labour productivity.

Wage adjustments trigger further general equilibrium effects in regional labour markets. As regards labour supply, emigration of high-skill workers from low-wage regions exerts an upward pressure on high-skill wages, which in turn creates incentives for low- and medium-skill workers to invest into education and become medium and highly skilled, respectively. As regards labour demand, there are two types of induced effects. On the input side, changes in the relative low-, medium- and high-skill wages trigger adjustments in factor demand for production of goods, because low-, medium- and high-skill labour and capital are mutually substitutable. On the output side, companies adjust their specialisation patterns according to changes in the relative skill-abundance

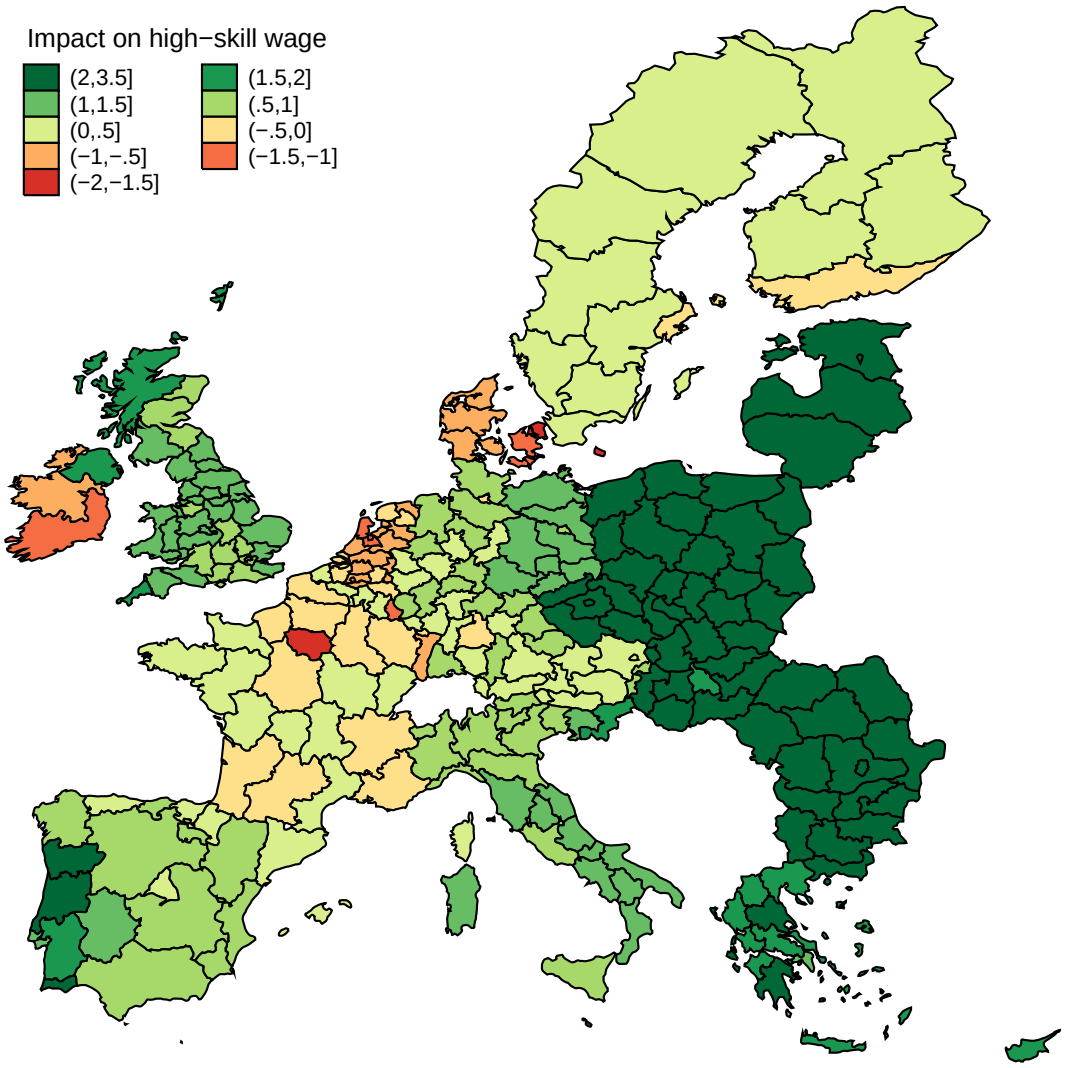

Figure 2: **Simulation results:** The impact of high-skill labour market integration on real high-skill wage in EU regions. Source: Authors' simulations with the RHOMOLO model.

in the region where the company is located. Firms located in the high-skill abundant regions would specialise in the production of skill-intensive goods, whereas firms located in the low-skill abundant regions would specialise in the production of skill-extensive goods. In addition, also companies may find it profitable to relocate between regions, if fierce competition on input and/or output markets drives profits to zero, whereas in other regions they are positive. These and other adjustments within and between regional economies take place until a new global equilibrium is established, in which no worker and no company can be better off by changing their education, location, employment, consumption, investment, production, trade, migration, etc. patterns. Hence,

the new (counterfactual) equilibrium describes the optimal response of utility maximising households and profit maximising firms to the labour market integration shock in terms of macroeconomic outcomes, such as growth, income, employment, consumption, production, savings, investment behaviour, etc. In order to identify the pure policy impact, in Figure 2 each of the counterfactual equilibrium variables is compared to the corresponding baseline variable. The difference between the two can be attributed to the net policy impact of labour market integration.

3.3.2. Macroeconomic effects

As for the macroeconomic impacts, Table 3 reports selected aggregated results of the high-skill labour market integration for the whole EU. An important result from the simulated hypothetical high-skill labour market integration scenario appears that at the aggregate level the total EU economy would gain in terms of GDP growth (+0.94%). As reported in Table 1, the impact would be differentiated between different skill levels at the aggregated EU level: high-skill workers would gain the most in terms of wage increase. A further interesting result is that also low- and medium-skill workers would gain from the high-skill labour market integration. Among others, a more efficient use of labour in the production process is an important driver for these gains.

One of the key mechanisms, which generates the aggregate gains for the EU economy, is a more efficient resource allocation, particularly of high-skill labour. Productivity gains are one of many induced general equilibrium effects in the RHOMOLO model, although they themselves are only indirectly linked to *spatial skill mobility*. On the input side, because of the high-skill labour market integration, high-skill workers are employed relatively more in those regions and sectors where the marginal product and hence the wage rate of high-skill labour is the highest. More efficient allocation of high-skill labour yields productivity gains at the aggregate level. On the output side, regional economies can better exploit their comparative advantages by deeper specialising in the production of skill intensive (skill extensive) goods, yielding additional productivity gains.

Note that in the simulated hypothetical labour market integration scenario we assumed that high-skill workers become fully mobile across EU regions and receive full information about skill demand and supply in every EU region. As a result, labour migration considerably reduces spatial wage disparities across EU regions. In reality, however, workers do not have perfect information, national labour markets are rather segmented in the EU, there are important quality differences between different education systems across the EU Member States, etc. Hence, in reality, the impact of a deeper

Table 3: Simulated policy impact on selected macroeconomic variables for the EU

Macroeconomic variable	Percentage change from the baseline
GDP	+0.94%
Wage: low-skill	+0.27%
Wage: medium-skill	+0.31%
Wage: high-skill	+0.88%
Output	+1.15%
Productivity (TFP)	+0.60%
Investment	+0.79%
Exports	+2.63%
Imports	+1.42%

high-skill labour market integration on the inter-regional wage differences may not be as pronounced as simulated in our hypothetical labour market integration scenario.

For the sake of expository simplicity, only few effects and results of the RHOMOLO model have been presented and discussed in this section. In RHOMOLO, however, there are many more channels of adjustment present and many more effects take place simultaneously. The simple simulation example presented above aims solely at providing intuition for a better understanding of the key mechanics of the RHOMOLO model and its potential for policy impact assessment. Analogously, in Table 1 only few selected output variables of RHOMOLO are reported and even they have been aggregated together for the whole EU. The RHOMOLO model, however, produces more than 50 different macroeconomic indicators, for each regional economy, each industrial sector, each skill level and each year.

4. Conceptual analysis of labour market integration

4.1. Setup: upward and spatial skill mobility

In this section we decompose and explain graphically two key channels – *upward skill mobility* and *spatial skill mobility* – through which regional labour markets adjust to the high-skill labour market integration. We also show how the interaction between the two channels affects labour market outcomes. We employ a diagrammatic framework, as it greatly facilitates the understanding of the numerical simulation results presented in the previous section, and helps highlighting the most important channels of adjustment without involving a formal mathematical analysis.

For the sake of graphical tractability of the diagrammatic analysis, we make several simplifying assumptions. First, we assume that there are only two regions (one Less Developed Region (LDR) and one More Developed Region (MDR)), and only two types of skills (low-skill and high-skill). Second, as in the simulations presented in Section 3.3, we consider only two channels of labour market adjustment (education and migration), whereas we abstract from two other important channels (participation and employment), which are present in RHOMOLO (see Brandsma *et al.* (2014); Persyn *et al.* (2014)). Third, we assume that the demand for low-skill labour is infinitely elastic. If the elasticity of low-skill labour demand would be lower, then an additional low-skill wage effect would arise, which would affect the ratio of high-skill/low-skill workers in LDR.[10] Finally, in the presented diagrammatic analysis we abstract from labour market demand effects, although in reality (and in RHOMOLO), an increase in population in a region would increase local consumption for goods, which in the presence of non-zero transportation costs would favour local producers, resulting in higher production and higher demand. These simplifications are required to keep the analytical exercise as simple as possible, while showing the main mechanics of skill adjustments.

Suppose that the less developed region, LDR, is endowed with L^{LDR} units of labour, which is shown on the horizontal axis in the left panel of Figure 3. High-skill labour, L_H^{LDR}, is measured from the left to right, whereas low-skill labour, L_L^{LDR}, from the right to the left, with $L^{LDR} = \lambda_H L_H^{LDR} + \lambda_L L_L^{LDR}$. Curves D_H^{LDR} and D_L^{LDR} represent firm demand for high-skill and low-skill labour, respectively, and S_H^{LDR} is worker supply of high-skill labour in LDR. λ_H and λ_L are efficiency parameters measuring the relative labour productivity of high-skill and low-skill workers, respectively.

In line with the simulation analysis presented in Section 3.3, we abstract from participation and employment decisions and focus on two decisions of workers: education and migration. First, we consider the education decision, where workers choose between offering low-skill labour versus investing into education and acquiring high skills in LDR. Given that education is costly, workers invest into education only when education would increase their net wage.[11] Net of schooling costs, workers must earn at least the low-skill wage, which is equal to w_L^{LDR*} in Figure 3. The vertical difference between the high-skill labour supply, S_H^{LDR}, and the low-skill wage rate, w_L^{LDR*}, represents the cost of acquiring education (Figure 3, left panel). The last low-skill worker, who enters education at L_H^{LDR*},

[10]Moreover, it can be easily verified that, as long as the condition $L_H^{LDR}/L_L^{LDR} \leq L_H^m/L_L^m$ holds, the results with low-skill labour migration would be qualitatively equal to those presented here.

[11]We implicitly assume that all workers, for whom it pays off to become skilled, invest in education.

is just able to compensate his education costs, though his skill premium is equal to zero. In equilibrium, the education cost of the marginal worker who enters education is equal to EC^*. Abstracting from participation and employment channels of adjustment, the rest of workers, $L^{LDR} - L_H^{LDR*}$, remain with low skills. The equilibrium wage of low-skill workers without migration, w_L^{LDR*}, is at the point where the demand for low-skill labour, D_L^{LDR}, intersects vertical line at L_H^{LDR*}. The equilibrium stock of high-skill labour is L_H^{LDR*} and the high-skill wage rate is w_H^{LDR*}.

The labour market equilibrium for receiving region, MDR, is analogous. In absence of migration, the equilibrium high-skill wage, low-skill wage and the stock of high-skill workers are w_H^{MDR*}, w_L^{MDR*}, and L_H^{MDR*}, respectively (Figure 3, right panel).

Next, consider the high-skill worker decisions where to offer their skills, locally or abroad. The trade-off, which high-skill workers face here, is given by the expected wage increase after migration versus migration costs, MC.[12] Differences in development and hence wage levels between the less developed and more developed regions trigger migration from LDR to MDR. Workers migrate if the expected wage income arising from relocation is higher than migration costs.[13] In presence of positive migration costs, $MC > 0$, the net wage which high-skill migrant workers earn in MDR is lower than the high-skill wage of incumbent worker, because the net wage of migrants is high-skill wage in destination region, w_H^{MDR}, minus migration costs, MC.

According to migration network theory and the estimated migration elasticities in Section 3.2, migration costs are not constant, they are decreasing in the number of migrants from LDR residing in MDR. In Figure 3 (middle panel) these network effects are captured by a decreasing distance between curves S_{MC}^m and S^m. Curve S^m is migrant work supply on the migrant labour market, which is derived by subtracting the high-skill labour supply, S_H^{LDR}, from the high-skill labour demand, D_H^{LDR}, in LDR. Curve S_{MC}^m is migrant supply adjusted for migration costs, MC.

In equilibrium, L_H^m high-skill workers emigrate from LDR incurring migration cost, MC^*, and receive net wage, $w_H^m \left(= w_{Ho}^{MDR*} - MC^*\right)$ in MDR. The equilibrium wage rate of high-skill labour, w_{Ho}^{MDR*}, is determined by the intersection of migration supply, S_{MC}^m,

[12]These costs include not only the direct transportation costs to the destination country, but also employment uncertainty (which is higher abroad than at home), social costs of leaving family and/or friends behind, cultural adjustment costs, language barriers etc. (Kancs, 2011).

[13]We recognise that in reality the migration decision of workers is driven not only by wage differences but also by non-economic considerations. However, in the present study we abstract from all other determinants of migration and consider cross-country wages differences as the only force driving labour migration.

and migration demand, D^m (Figure 3, middle panel). Migration demand, D^m, is derived by subtracting the high-skill labour demand, D_H^{MDR}, from the high-skill labour supply, S_H^{MDR} in MDR (right panel in Figure 3). In presence of migration, the high-skill wage in MDR is reduced from w_H^{MDR*} (high-skill equilibrium wage without migration) to w_{Ho}^{MDR*} (high-skill equilibrium wage with migration).

4.2. Impact of the high-skill labour market integration

The high-skill labour market integration affects the spatial labour market equilibrium by reducing migration costs and improving access to high-skill jobs in the more developed region, MDR, which in the short-run leads to a positive high-skill wage gap between MDR and LDR. Positive net of migration cost wage differences trigger migration of high-skill workers from LDR to MDR. In the long-run, in addition to these direct labour market effects, high-skill labour migration triggers further induced general equilibrium effects, the most important of which are explained in the following sections.

4.2.1. Social and labour market effects

As shown in Section 3.3.1, through reduced migration costs and improved access to high-skill jobs in MDR, in the short-run, the high-skill labour market integration increases the net of migration cost wage gap between MDR and LDR, and hence disturbs the spatial labour market equilibrium. The increased wage differences trigger skill migration – driven by higher expected earnings in MDR – high-skill workers migrate from LDR to MDR. In the long-run, in addition to this direct short-run effect on high-skill labour force distribution between LDR and MDR, migration itself affects factors which drive migration, e.g. inter-regional wage differences and migration costs. Both the high-skill worker outflow (direct effect) in LDR, and the induced second-round migration effects – triggered by changes in the relative wages in LDR and MDR and changes in migration costs – are examined in this section.

The most direct and visible effect induced by the high-skill labour market integration is transfer of human capital embodied in migrant skills from LDR to MDR.[14] Given that high-skill migrants embody private productive skills, the exclusiveness of human capital implies that a migration-driven increase in the stock of human capital in MDR is proportional to a decrease in the stock of human capital in LDR. In Figure 3, high-skill labour migration increases from L_H^m to L_{HB}^m (middle panel). Under integrated high-skill

[14]Given that the human capital embodied in skilled workers is draining out of country, in the migration literature this effect is often referred to as a 'brain drain'.

labour market equilibrium, LDR has less high-skill workers, L_{HB}^{LDRn}, with $L_{HB}^{LDRn} < L_{H}^{LDRn}$ (Figure 3, left panel). Thus, because of brain drain, the high-skill labour market integration has a strictly negative impact on human capital in LDR.

In the medium- to long-run, high-skill worker migration affects wages in LDR. By reducing the high-skill labour supply in LDR, high-skill worker emigration will exert an upward pressure on high-skill wages in LDR (assuming that labour demand does not change). This will narrow the migration-driving wage gap between LDR and MDR, implying less migration in the long-run. Thus, because of increasing skill premium in LDR, the long-run losses of human capital induced by the high-skill labour market integration may be lower compared to the short-run equilibrium.

Notice that the inter-regional labour migration affects wage rate not only in the sending regions but also in the receiving regions. Through increased labour supply of high-skill workers in MDR, emigration will exert a downward pressure on high-skill wages. Lower high-skill/low-skill wage ratio in MDR will narrow the migration-driving wage gap between LDR and MDR, which in turn will attract fewer migrants from LDR. Thus, the long-run losses of human capital induced by the high-skill labour market integration are lower compared to the short-run also because of decreasing skill premium in MDR.

Both wage effects on inter-regional distribution of labour force are shown in Figure 3, where in the long-run high-skill labour migration equalises the high-skill wage rate between LDR and MDR. High-skill labour migration reduces high-skill wage in MDR from w_{Ho}^{MDR*} to w_{H}^{m}. In contrast, in LDR high-skill wage increases from w_{H}^{m} to w_{HB}^{m} (Figure 3). Again, these findings are in line with RHOMOLO simulation results presented in Section 3.2. In the long-run, the equilibrium wage rate for high-skill labour, w_{HB}^{m}, is equalised across regions and migration equals to L_{HB}^{m}. Hence, because of LDR and MDR wage effects, the long-run losses of human capital induced by the high-skill labour market integration are lower compared to the short-run.

The high-skill labour market integration affects also the long-run education equilibrium, which determines the share of educated workforce in each region. Through high-skill worker emigration, the high-skill labour market integration induces changes in the relative wages in LDR, which in turn affects education incentives. Given that in the high-skill labour market integration scenario only high-skill workers can migrate or, alternatively, more high-skill workers migrate than low-skill workers, $L_{H}^{LDR}/L_{L}^{LDR} \leqslant L_{H}^{m}/L_{L}^{m}$, the ratio of high-skill/low-skill workers will decrease in LDR. A declining supply of

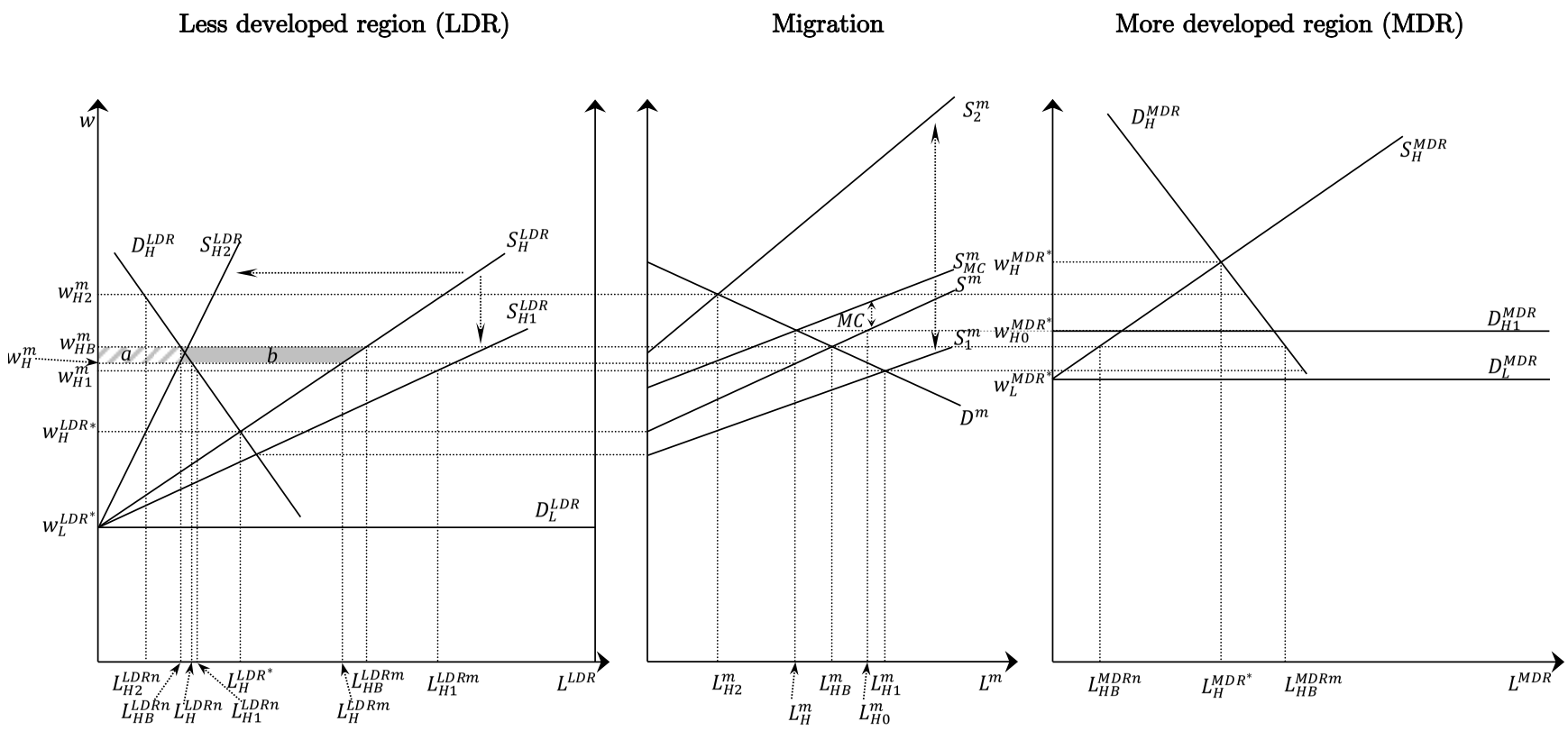

Figure 3: The impact of high-skill migration on education

high-skill labour will exert an upward pressure on high-skill wage rate in LDR. Increased high-skill/low-skill wage gap will provide incentives for additional low-skill workers to enter the education system, to acquire skills. Thus, through wage adjustments in LDR, the high-skill labour market integration will increase the long-run education equilibrium in LDR.

The education effect of high-skill/low-skill wage ratio is shown in Figure 3. In the segmented high-skill labour market baseline, the equilibrium wage of high-skill labour in LDR is w_H^m and the equilibrium wage of low-skill labour is w_L^{LDR*} (Figure 3, left panel). The high-skill labour market integration reduces migration costs, MC. To simplify the graphical exposition, we assume that migration costs, MC, are reduced to zero. As a result, the excess supply of high-skill labour increases from S_{MC}^m to S^m and the equilibrium high-skill wage in LDR increases to w_{HB}^m, implying that the wedge between high-skill and low-skill wage in LDR increases (Figure 3, middle panel).[15] Because of higher skill premium, more workers acquire education under the high-skill labour market integration. The amount of LDR workers that acquire education increases from L_H^{LDRm} to L_{HB}^{LDRm}.

4.2.2. Macroeconomic effects

In this Section, as an example, we show and explain one specific macroeconomic effect triggered by skill mobility – the impact on government budget revenue through household taxes. Through the high-skill worker emigration, the high-skill labour market integration reduces the number of taxpayers and hence the tax revenue in LDR. Given that, on average, high-skill workers are higher net contributors to government budget than low-skill workers, government revenue decreases both due to fewer tax contributors and less taxpayers of high taxes.[16] On the other hand, higher high-skill/low-skill wage ratio (due to an upward pressure on high-skill wages) increases government tax revenue per high-skill worker. Thus, because of smaller government budget (larger per capita budget), the impact of the high-skill labour market integration may be either decreasing or increasing on the accumulation of human capital.

The fiscal impact of the high-skill labour market integration is shown in Figure 4. The

[15]The exact magnitude of this wage ratio effect depends on the elasticity of low-skill labour demand. In Figure 3 the elasticity of low-skill labour demand is assumed to be infinitely elastic implying no unskilled wage effect.

[16]Because on average the wage rate for high-skill work is higher than for low-skill and the unemployment rate among high-skill workers is lower, per capita, high-skill workers contribute more to tax revenue than low-skill workers.

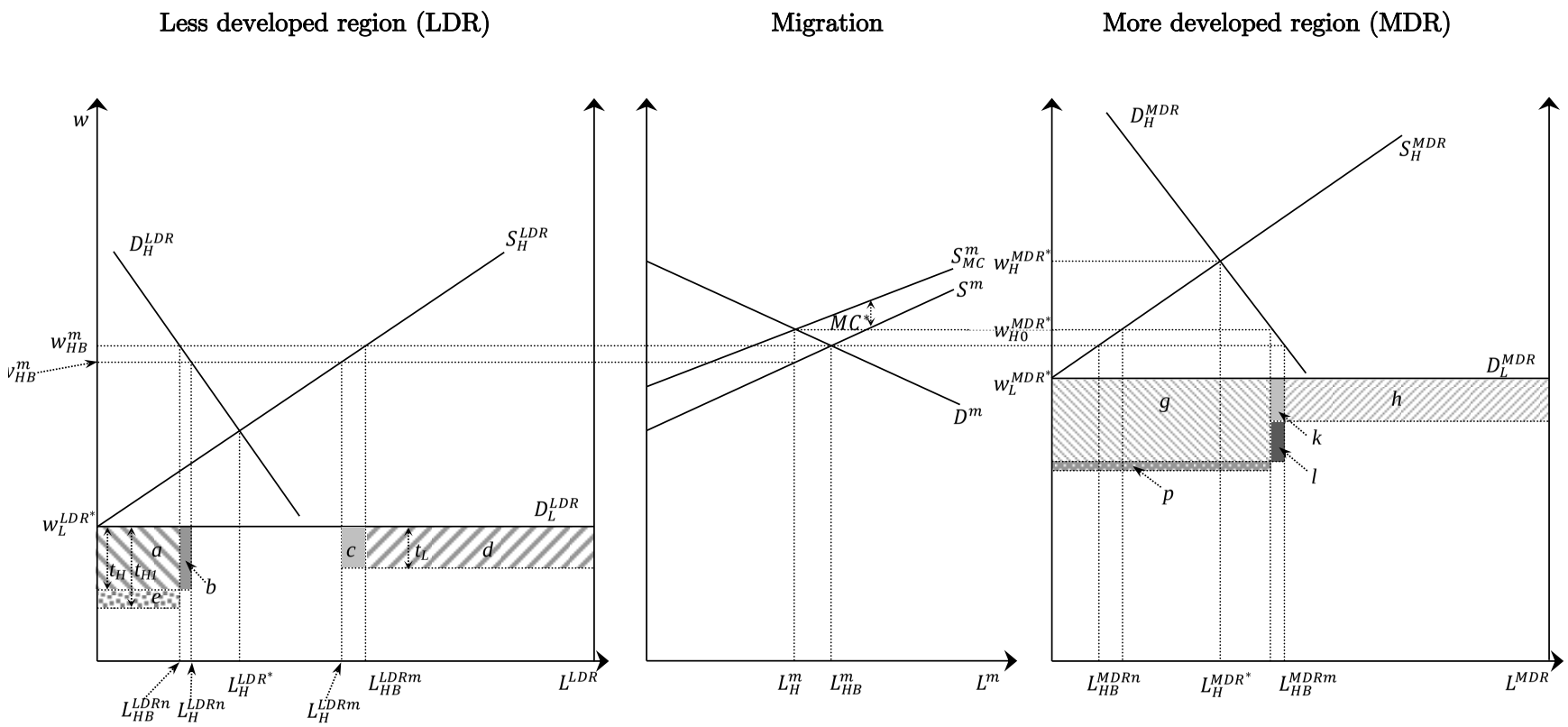

Figure 4: The budgetary effect of high-skill migration

income taxes paid by high-skill and low-skill workers under segmented high-skill labour markets are t_H and t_L, respectively, where $t_H > t_L$. If taxes are paid as a fixed rate of gross wages, then the absolute value of taxes paid by high-skill labour increases under market integration, t_{H1}, because of higher wage, $t_H < t_{H1}$. The total tax revenue under segmented high-skill labour markets is equal to area *abcd*, and to area *ade* under the integrated high-skill labour market. The high-skill labour market integration reduces the number of individuals who pay taxes in LDR by $L_H^{LDRn} - L_{HB}^{LDRn}$ for high-skill labour and by $L_{HB}^{LDRm} - L_H^{LDRm}$ for low-skill labour, which reduces tax revenues by area *bc*. Because the high-skill wage increases with free migration, the tax revenue increases by area *e*. If area *bc* is larger than area *e*, then tax revenue declines, otherwise, it increases due to the high-skill labour market integration. Thus, the total impact of high-skill labour market integration on government budget depends on the relative size of these areas, which in turn depends on the brain drain effect in LDR, low-skill labour productivity effect and the above discussed remittance effect.

Analogous budgetary effects occur in MDR. The total tax revenue under segmented high-skill labour markets is equal to area *gkhp*, and to area *gkhl* under integrated high-skill labour markets. The high-skill labour market integration decreases the number of low-skill labour in MDR, which reduces tax revenues by area *k*. Low-skill labour is replaced by high-skill labour, which increases tax revenues in MDR by area *kl*. Further, high-skill wage decreases, which reduces tax revenue by area *p*. If area *l* is larger than area *p*, then tax revenue in MDR increases, otherwise it decreases due to the high-skill labour market integration (Figure 4).

Note that the budgetary effects shown in Figure 4 take into account only changes in income tax revenues induced by the high-skill labour market integration. They do not account for other macroeconomic effects or budgetary costs & revenues, such as changes in welfare transfers, unemployment payments, or education costs. The reason for neglecting them is to simplify the exposition of the diagrammatic analysis, while focusing on the direct budgetary effects of high-skill labour integration. As explained above, RHOMOLO considers all the induced budgetary costs and benefits in a holistic general equilibrium framework, which however cannot be captured in a simple diagrammatic framework.

5. Conclusions

In the age of globalisation and the knowledge economy, skill mobility is perceived as one of the key factors for fully unlocking the labour market potential. Assessing the social and macroeconomic impacts of increased skill mobility is an important though also challenging task, which requires a holistic approach. This study presents the dynamic spatial general equilibrium approach taken in the Regional Holistic Model (RHOMOLO) to better understand the relationship between education, skills, migration and growth. Two key channels of labour market adjustment – *upward skill mobility* and *spatial skill mobility* – are presented and explained in two different ways: performing numerical simulations with the RHOMOLO model, and undertaking conceptual analysis in a diagrammatic framework. The two approaches are complementary and are presented in a non-formal way to intuitively explain the potential impacts of a hypothetical policy scenario related to labour market integration, which is simulated as migration cost reduction, e.g. through a full EU-wide recognition of qualifications for high-skill workers. In this hypothetical example, high-skill workers become fully mobile across EU regions, and have a perfect information about skill demand and supply in every EU region. The social and macroeconomic impacts of the high-skill labour market integration are assessed against the segmented labour market baseline.

RHOMOLO is a dynamic spatial general equilibrium model developed by Directorate-General Joint Research Centre of the European Commission for policy impact assessment and provides sector-, region- and time-specific support to EU policy makers on structural reforms, growth and human capital policies. In RHOMOLO, labour market captures all the key interactions between labour demand and labour supply. On the labour supply side, each region is populated by workers, who are differently skilled. The RHOMOLO model distinguishes between three skill levels of workers: low-skill, medium-skill and high-skill, which correspond to three levels of education: primary and lower-secondary education, upper-secondary and post-secondary education, and tertiary education. On the labour demand side, the relative price of labour together with the demand for the the final demand goods and services determine the total 'labour demand. Note that, in addition to policies related to education, skills and migration, RHOMOLO can also answer policy questions related to the labour market participation and employment. These questions, however, are beyond the scope of the study, they are detailed in Brandsma *et al.* (2014); Persyn *et al.* (2014).

The results from the numerical simulations and the conceptual analysis suggest that

a holistic approach is indeed required for capturing all the direct and indirect, short- and long-run effects of labour market adjustments. The holistic approach taken in RHOMOLO has a wider potential for assessing the macroeconomic and social effects of policies aiming at integration e.g. of marginalised communities, such as Roma or refugees, into the EU labour markets. Indeed, the policy interventions such as Country Specific Recommendations (CSRs), which the European Commission has issued to promote the participation of Roma children in quality inclusive early childhood and school education for several Member States, aim to facilitate *upward skill mobility*.[17] In RHOMOLO they could be simulated by reducing monetary participation costs in education, e.g. by subsidising fees for early childhood care and education, physical participation costs, e.g. by providing transport to and from the schools, or social participation costs, e.g. by providing integrated education, increases primary, secondary and tertiary educational attainment rates. The RHOMOLO model allows to holistically assess region-, skill- and sector specific social and macroeconomic effects in the short-, medium- and long-run.

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Annex 1: Skill and education correspondence in RHOMOLO

Low-skill: Primary and lower secondary education (ISCED 0-2)

Medium-skill: Upper-secondary and post-secondary education (ISCED 3-4)

High-skill: Tertiary education (ISCED 5-6)

ISCED 0: pre-primary education

ISCED 1: primary education or first stage of basic education

ISCED 2: lower secondary education or second stage of basic education

ISCED 3: upper secondary education

ISCED 4: post-secondary non tertiary education

ISCED 5: first stage of tertiary education (not leading directly to an advanced research qualification)

ISCED 6: second stage of tertiary education (leading to an advanced research qualification)

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